

# ESTIMATE OF THE ANNUAL NUMBER OF PERCUTANEOUS INJURIES AMONG HOSPITAL-BASED HEALTHCARE WORKERS IN THE UNITED STATES, 1997-1998

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## ABSTRACT

**OBJECTIVE:** To construct a single estimate of the number of percutaneous injuries sustained annually by healthcare workers (HCWs) in the United States.

**DESIGN:** Statistical analysis.

**METHODS:** We combined data collected in 1997 and 1998 at 15 National Surveillance System for Health Care Workers (NaSH) hospitals and 45 Exposure Prevention Information Network (EPINet) hospitals. The combined data, taken as a sample of all U.S. hospitals, were adjusted for underreporting. The estimate of the number of percutaneous injuries nationwide was obtained by weighting the number of percutaneous injuries at each hospital by the number of admissions in all U.S. hospitals relative to the number of admissions at that hospital.

**RESULTS:** The estimated number of percutaneous injuries sustained annually by hospital-based HCWs was 384,325 (95% confidence interval, 311,091 to 463,922). The number of percutaneous injuries sustained by HCWs outside of the hospital setting was not estimated.

**CONCLUSIONS:** Although our estimate is smaller than some previously published estimates of percutaneous injuries among HCWs, its magnitude remains a concern and emphasizes the urgent need to implement prevention strategies. In addition, improved surveillance could be used to monitor injury trends in all healthcare settings and evaluate the impact of prevention interventions (*Infect Control Hosp Epidemiol* 2004;25:556-562).

Needlesticks and other percutaneous injuries pose the greatest risk of occupational transmission of blood-borne viruses to healthcare workers (HCWs).<sup>1,2</sup> The risk of acquiring hepatitis B virus (HBV), hepatitis C virus (HCV), or human immunodeficiency virus (HIV) in the healthcare setting is well documented. Hadler et al.<sup>3</sup> showed that the HBV infection rate among hospital workers was related to the frequency of contact with blood and needles. Cases of occupationally acquired HCV following a percutaneous injury have been reported.<sup>4,7</sup> By December 2001, the Centers for Disease Control and Prevention (CDC) had received reports of 57 U.S. HCWs with documented HIV seroconversion temporally associated with an occupational HIV exposure; 48 of these involved percutaneous exposures.<sup>8</sup> Although percutaneous injuries clearly pose a risk of transmission of infectious diseases to HCWs, there is uncertainty about not only the magnitude of percutaneous injuries occurring among HCWs, but also the number of infections resulting from these injuries.

Estimates of the number of percutaneous injuries sustained annually in the United States by HCWs, gener-

ated using a variety of methods, have ranged from 100,000 to 1 million.<sup>9</sup> The objective of this study was to construct a single, more reliable estimate using data from the two U.S. surveillance systems that collect information on percutaneous injuries among hospital-based HCWs: the National Surveillance System for Health Care Workers (NaSH) and the Exposure Prevention Information Network (EPINet). This national estimate could be used to evaluate interventions that reduce percutaneous injuries and ultimately reduce the risk of disease transmission and other adverse events.

## METHODS

### Sources of Data

To derive a national estimate, data on percutaneous injuries sustained by HCWs in hospitals participating in NaSH and EPINet were used as a sample of percutaneous injuries in all U.S. hospitals. NaSH comprises mostly large hospitals, whereas hospitals in EPINet tend to be smaller. We describe characteristics of hospitals in these two surveillance systems and the exclusion criteria. Data from a few hospitals were excluded because of one or more of

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the following reasons: unavailability of data on percutaneous injuries, inconsistency between data from 1997 and 1998, or unavailability of denominator data.

### **NaSH**

NaSH is a multi-component system that was initiated by the CDC in 1995 to monitor occupational exposures to blood and blood-borne viruses, vaccine-preventable diseases, and tuberculosis.<sup>10</sup> Participating hospitals collect detailed data on percutaneous injuries and mucocutaneous exposures reported by HCWs. Information collected on a percutaneous injury includes the circumstances and severity of the injury, the device involved, and whether the source-patient is known and is or might be infected with HBV, HCV, or HIV. In addition, a survey of selected occupational groups of HCWs is conducted periodically to assess the degree of underreporting of percutaneous injuries.

At the time of the analysis, NaSH data for 1995 to 1998 were available. Because NaSH data collection commenced in 1995 with a small sample of five hospitals, we limited our analysis to data collected in 1997 and 1998 to include a larger and more representative sample of NaSH facilities and to base our estimate on the most recent data available.

In 1999, 23 hospitals participated in NaSH, ranging in size from 138 to 1,234 beds, with an average of 592 beds, which is larger than the average hospital in the United States. Data from 15 of the 23 hospitals (representing 61,111 full-time-equivalent employees) were used to compute the national estimates of percutaneous injuries. Data on percutaneous injuries were not available for 6 of the hospitals; these 6 were excluded from the analysis. The other 2 hospitals were excluded because of concerns about their consistency in reporting injuries to NaSH. For 2 hospitals that started reporting injuries to NaSH in 1997, only 1998 data were used due to discrepancies between the number of percutaneous injuries reported in 1997 and 1998. For 1 of the 8 excluded hospitals, data from a survey of HCWs were used to characterize the reporting rate. The estimated annual numbers of percutaneous injuries for 2 hospitals, which had the same name and geographic location, were combined to be consistent with data collected by the American Hospital Association (AHA) for 1997.<sup>11</sup> Percutaneous injuries that occurred before use of a device were excluded because these injuries are not likely to result in disease transmission.

### **EPINet Data Sharing Network**

The EPINet system was developed in 1991 by Dr. Janine Jagger at the University of Virginia to record information about percutaneous injuries and blood and body fluid contacts.<sup>12</sup> The EPINet system consists of report forms to record information on needlestick and other sharps injuries and blood and body fluid exposures and software for entering and analyzing the data from the forms. Whereas more than 1,500 hospitals in the United

States have acquired the EPINet system for use, a smaller network of hospitals share and compare information with other hospitals using the same system. The hospitals in the EPINet Data Sharing Network voluntarily report the same type of data on percutaneous injuries collected in NaSH hospitals. This network represents approximately 70 hospitals, but not all hospitals report data every year. Hospitals in the network average 315 beds, which, as in NaSH, is larger than the U.S. average.

The estimate of reported percutaneous injuries was based on EPINet network data from 1997; 1998 data were not available. In 1997, 55 healthcare institutions reported data to EPINet, but only 45 were included in the calculations, representing 72,485 full-time-equivalent HCWs. Ten institutions were omitted because auxiliary data, such as the number of beds, were not available; 7 of the 10 institutions excluded from the analysis might not be recognized by the AHA as hospitals.

Data from the 1997 AHA database were used to characterize hospital size, utilization, and staffing of the NaSH and EPINet network hospitals.<sup>11</sup>

### **Actual Versus Reported Percutaneous Injuries**

Data on the underreporting of percutaneous injuries also came from NaSH. We used data from the survey of HCWs conducted annually in NaSH hospitals (a similar survey is not conducted in EPINet hospitals). HCWs were asked about the number of percutaneous injuries they sustained and the number that they reported during the year preceding the survey. Additional survey questions asked about occupation and the reason(s) for not reporting percutaneous injuries.

Annual survey data were available from 12 NaSH hospitals. To compute the rate of reporting of percutaneous injuries, we considered all HCWs who indicated that they sustained at least one percutaneous injury in the preceding 12 months. Excluded from the computations were data from 133 HCWs who did not give the number of percutaneous injuries they sustained and data from 6 HCWs who indicated that they reported more percutaneous injuries than they sustained.

The number of percutaneous injuries reported at NaSH and EPINet hospitals could be used to make inferences about the number of percutaneous injuries that have been reported in all U.S. hospitals. However, because percutaneous injuries are underreported, with some studies suggesting a rate of reporting as low as 30%,<sup>13-16</sup> the number of percutaneous injuries reported by HCWs may not accurately represent the number they sustain. To estimate the number of percutaneous injuries sustained by HCWs in U.S. hospitals, we needed to adjust for underreporting.

### **Data Analysis**

The percutaneous injury data from NaSH and EPINet hospitals were combined. For NaSH hospitals, data from a 2-year period were used. Hence, we had to estimate for each hospital the average number of percuta-

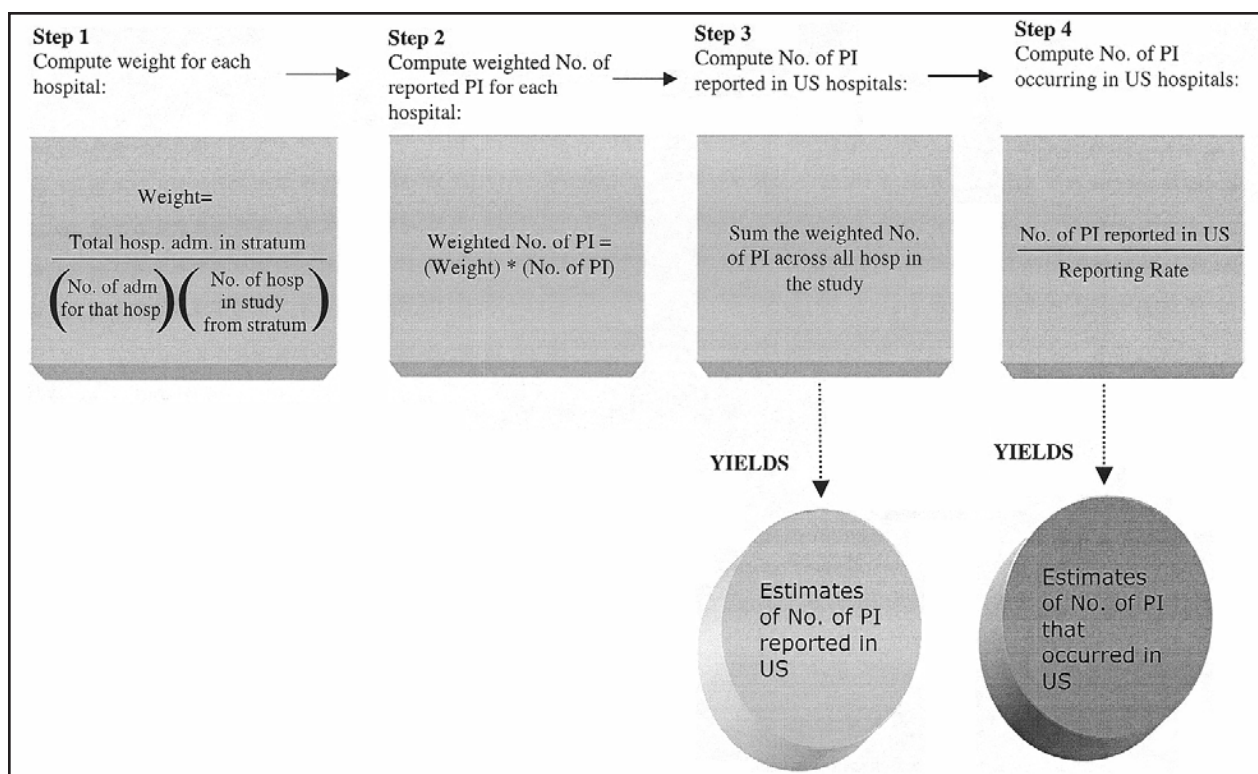


FIGURE. Derivation of the estimate of percutaneous injuries sustained annually in the United States. PI = percutaneous injuries.

neous injuries reported annually during that 2-year period. The combined data were taken as a sample of all U.S. hospitals. To arrive at an estimate for the number of percutaneous injuries occurring in U.S. hospitals, it was necessary to adjust for underreporting of these injuries. After the adjustment for underreporting, the annual number of percutaneous injuries from each hospital was weighted by the number of admissions to estimate the total number of percutaneous injuries among U.S. hospital-based HCWs (Figure).

#### Calculating the Underreporting Adjustment Factor

The reporting rate was computed by occupation and by hospital. For a given subgroup (ie, an occupation or a hospital), the reporting rate was obtained by dividing the number of percutaneous injuries that they recalled reporting by the total number of percutaneous injuries that they recalled occurred. That is, the reporting rate was the number of percutaneous injuries reported divided by the number of percutaneous injuries that occurred.

Table 1 gives the reporting rate and 95% confidence interval ( $CI_{95\%}$ ) by occupation. Estimates of the reporting rate by hospital are given in Table 2. The overall reporting rate of 43.4% was used to adjust for underreporting. Because the occupation of exposed personnel was known for NaSH data only, we were unable to use occupation-specific reporting rates.

#### Annualizing Percutaneous Injury Data

Whereas EPINet data represent the number of percutaneous injuries reported from each participating hospital for all of 1997, NaSH data reflect injuries reported during more or less than 1 year, depending on when a hospital started entering data into the system. All but two of the NaSH hospitals provided data for at least 12 months (range, 12 to 21 months); two provided data for only 2 months. Because the data for most NaSH hospitals represented only part of a calendar year (for either 1997 or 1998), we estimated the number of percutaneous injuries that would have been reported during a 1-year period.

#### Correlation Between the Number of Percutaneous Injuries and Hospital Size

The extension of NaSH-based and EPINet-based estimates to a national estimate of percutaneous injuries is based on an assumption that the number of percutaneous injuries increases with hospital size. That is, because a large hospital would be expected to treat more patients than a small hospital, the larger pool of patients would be associated with an increased potential for injuries. To determine which measure of hospital size to use in our analysis, we measured the correlation between the number of reported percutaneous injuries and each of five variables that reflect hospital size: total admissions, number of inpatient-days, number of full-time-equivalent employees, number of outpatient visits, and number of

TABLE 1

PERCUTANEOUS INJURY REPORTING RATE BY OCCUPATION, FROM UNDERREPORTING SURVEYS BY THE NATIONAL SURVEILLANCE SYSTEM FOR HEALTH CARE WORKERS, 1997-1998

Occupation	No. of Respondents	HCWs With $\geq 1$ PI	No. of PIs Reported	No. of PIs That Occurred	Reporting Rate* (CI <sub>95</sub> )
Surgical medical	2,266	404	236	881	26.8% (20.7%–32.8%)
Nonsurgical medical	1,997	249	171	316	54.1% (47.6%–60.6%)
Nursing	8,896	770	564	1,070	52.7% (48.7%–56.7%)
Technician	1,788	95	81	121	66.9% (55.9%–78.0%)
All others	8,791	176	122	316	38.6% (28.9%–48.3%)
Total	23,738	1,694	1,174	2,704	43.4% (39.5%–47.3%)

HCWs = healthcare workers; PI = percutaneous injury; CI<sub>95</sub> = 95% confidence interval.

\*Number of injuries reported divided by the number of injuries that occurred.

TABLE 2

PERCUTANEOUS INJURY REPORTING RATE FROM MODELING AND FROM DATA BY HOSPITAL COLLECTED BY THE NATIONAL SURVEILLANCE SYSTEM FOR HEALTH CARE WORKERS, 1997-1998

Hospital	No. of PIs Reported	No. of PIs That Occurred	Reporting Rate (Observed)*	HCWs With at Least 1 PI	No. of Respondents	HCWs With at Least 1 PI
Total	1,174	2,704	43.4%	1,694 <sup>†</sup>	23,738	7.1%
A	252	388	65.0%	298	2,634	11.3%
C	39	76	51.3%	60	598	10.0%
D	78	357	21.9%	156	755	20.7%
E	40	86	46.5%	56	515	10.9%
F	47	74	63.5%	60	590	10.2%
K	196	543	36.1%	303	4,039	7.5%
L	199	327	60.8%	252	7,192	3.5%
M	191	562	34.0%	323	3,607	9.0%
N	95	201	47.3%	129	3,188	4.1%
P	5	9	55.6%	9	291	3.1%
R	32	81	39.5%	48	329	14.6%

PI = percutaneous injury; HCWs = healthcare workers.

\*Number of injuries reported divided by the number of injuries that occurred.

<sup>†</sup>Data from 139 HCWs excluded: 133 HCWs did not report the number of PIs sustained and 6 HCWs claimed they reported more PIs than they sustained.

beds. Although any of the five variables would be appropriate for use in weighting national estimates of reported percutaneous injuries, the correlation was highest with total admissions (Table 3). This variable was therefore chosen to represent hospital size.

#### Weighting by Number of Admissions

Because of the significant correlation between hospital size and the number of reported percutaneous injuries, we weighted the data from each hospital proportionally to its size. From a survey standpoint, the weight computed in this manner would correspond to the inverse of the probability of selecting a hospital. The probability of selecting a given hospital would be proportional to its size. Given what we know regarding the correlation of percutaneous injuries and the size of a hospital, if we were to select a random sample of hospitals, an optimal design

would be to select those with probability proportional to size so that the larger the size of a hospital, the higher its probability of being selected. To increase the precision of the estimates (tighter confidence intervals), the hospitals in our samples were divided into the following four strata: (1) a stratum composed of all hospitals with fewer than 100 beds, (2) a stratum of hospitals having more than 100 but fewer than 200 beds, (3) a stratum of hospitals having more than 200 but fewer than 300 beds, and (4) a stratum of hospitals having more than 300 beds. The weight of a hospital was proportional to its size within its stratum.

As a result of weighting in this manner, the estimate of the total number of percutaneous injuries obtained is a weighted sum of the number of injuries from each hospital. The estimates obtained with the weight would be equivalent to computing the mean rate of percutaneous injuries per hospital admission and multiplying that mean rate by

TABLE 3

CORRELATION BETWEEN NUMBER OF PERCUTANEOUS INJURIES AND AUXILIARY VARIABLES FOR NATIONAL SURVEILLANCE SYSTEM FOR HEALTH CARE WORKERS\* AND EXPOSURE PREVENTION INFORMATION NETWORK HOSPITALS

Variable	No. of PIs Reported (1997-1998)	Total No. of Admissions	Total No. of Beds	No. of FTEs	Total No. of Inpatient-Days	No. of Outpatient Visits
No. of injuries	1	0.762	0.737	0.741	0.668	0.710
Total no. of admissions	0.762	1	0.937	0.951	0.877	0.741
Total no. of beds	0.737	0.937	1	0.915	0.970	0.708
No. of FTEs	0.741	0.951	0.915	1	0.881	0.671
Total no. of inpatient-days	0.668	0.877	0.970	0.881	1	0.670
No. of outpatient visits	0.710	0.741	0.708	0.671	0.670	1

PIs = percutaneous injuries; FTEs = full-time-equivalent employees.

\*For data from the National Surveillance System for Health Care Workers, the estimated number of injuries per year is used.

the number of hospital admissions in the United States. However, treating the estimate of the number of percutaneous injuries as a weighted sum makes it easier for statistical purposes to compute the standard error for these estimates. The flowchart in the figure shows the intermediate steps for computing the estimated number of percutaneous injuries occurring in the United States per year.

#### ***Estimating the Number of Percutaneous Injuries Reported (Unadjusted for Underreporting)***

The estimate of the number of percutaneous injuries reported was the sum over hospitals of (number of percutaneous injuries in the hospital)  $\times$  (number of hospital admissions in the stratum)  $\div$  [(number of hospitals from the study in that stratum)  $\times$  (number of admissions in the hospital)], which is the same as the (average number of percutaneous injuries per admission)  $\times$  (total admissions in the United States).

#### ***Estimating the Number of Percutaneous Injuries That Occurred in U.S. Hospitals (Adjusted for Underreporting)***

The estimate of the number of percutaneous injuries that occurred in U.S. hospitals was the number of percutaneous injuries reported divided by the reporting rate.

## RESULTS

The estimated number of percutaneous injuries sustained annually by U.S. hospital-based HCWs is 384,325 (CI<sub>95</sub>, 311,091 to 463,922). The estimate using NaSH data alone is 562,522 (CI<sub>95</sub>, 374,689 to 723,026). The estimate using EPINet data alone is 334,160 (CI<sub>95</sub>, 268,390 to 405,895).

## DISCUSSION

### ***Estimate of Annual Number of Percutaneous Injuries***

Our estimate of the annual number of percutaneous injuries sustained by HCWs in U.S. hospitals is smaller

than some previously published estimates. We believe it may be a more robust number than previous estimates and certainly more robust than those based on data from either NaSH or EPINet alone. Fortunately, we were able to combine the data from the two different surveillance systems because of the similarity of data collected. The combined data set provides a larger sample size and includes more recent data (ie, 1997 and 1998) than were previously available.

The heterogeneity of the hospitals represented in the two systems may also add to the robustness of the estimate as the two surveillance systems do have some fundamental differences. NaSH hospitals tend to be large urban hospitals, whereas EPINet hospitals tend to be smaller. The average number of beds in EPINet hospitals is 315, compared with 592 beds for NaSH hospitals. The geographic distribution of the hospitals is also different. Of the 55 institutions that reported data to EPINet in 1997, 37 were located in the Southeast (34 in South Carolina and 3 in Florida) and 12 were located on the West Coast (7 in Oregon, 3 in Alaska, and 2 in Washington). In contrast, the NaSH hospitals were more scattered regionally. The Northeast was slightly overrepresented, with 9 of the 23 NaSH hospitals located in this region.

The estimates computed using only NaSH data are somewhat higher than the estimates based on the combined NaSH and EPINet data. This is not surprising because NaSH includes mostly large hospitals (14 of 15 hospitals have more than 300 beds), and the average number of injuries is higher in large hospitals. Although we adjusted for an increased number of percutaneous injuries associated with large hospitals, the higher rate of injuries in this stratum suggests that NaSH data may overestimate the number of percutaneous injuries. On the other hand, the occupation-specific reporting rates available from NaSH support a more accurate adjustment for underreporting that may partially counteract this overestimation. When the reporting rate for each occupation is used, the estimated number of percutaneous injuries for all hospitals in the United States adjusted for underreporting is

lower than the estimate that would be obtained using the overall rate of reporting (509,492). Applying an overall reporting rate of 43.42% increases the NaSH-based estimate to 562,522.

Our estimates are similar to those published by the International Health Care Worker Safety Center at the University of Virginia using 1996 EPINet data.<sup>12</sup> Their analyses estimated the number of percutaneous injuries in U.S. hospitals to be 295,082, assuming a reporting rate of 61% (39% underreporting rate). When a reporting rate of 43.42% is applied, the estimate increases to 414,556, which is close to our estimate of 384,325.

Henry and Campbell<sup>17</sup> estimated the number of reported percutaneous injuries in U.S. hospitals to be 252,000, based on 1990 data from 65 hospitals. Their estimate was obtained by averaging the number of reported percutaneous injuries per hospital and did not account for the relationship between hospital size and number of percutaneous injuries. Applying our reporting rate of 43.42% to their data yields an estimate of 580,378 percutaneous injuries. Jagger and Pearson<sup>9</sup> estimated the number of percutaneous injuries in U.S. hospitals to be 800,000, but this estimate was based on data from only one hospital.

Because both of these estimates were derived from data collected before 1991, they may have been accurate at the time they were published. In 56 hospitals participating in EPINet, the number of percutaneous injuries reported in 1995 decreased by 32% compared with the numbers reported in 1993 and 1994.<sup>18</sup> Thus, the number of percutaneous injuries may not have been constant from 1990 to the present. The decrease in the number of percutaneous injuries may be due in part to compliance with CDC recommendations to use puncture-resistant disposal containers in patient rooms and to avoid recapping, as well as the more widespread use of safety-engineered devices.<sup>19-21</sup>

The estimate of interest is not the number of percutaneous injuries that HCWs report, but rather the number that they sustain. The precision of the estimate is reduced by the need to estimate the number of percutaneous injuries reported and the rate of reporting. In the annual NaSH survey, HCWs are asked about the number of percutaneous injuries that they sustained in the preceding 12 months. As the number of hospitals in NaSH increases, data from this survey could be used to estimate the number of percutaneous injuries directly without having to estimate the reporting rate. With an adequate sample size from each hospital and uniform administration of the survey, the estimate of the number of percutaneous injuries from the annual survey of HCWs could be used to improve the accuracy of estimates obtained from NaSH data.

There are several other limitations to our estimate. First, because the participating NaSH and EPINet hospitals are not randomly selected, the numbers of injuries reported in these two systems may not be generalizable to the entire population of U.S. hospitals. Our estimate is

only for the number of percutaneous injuries sustained by HCWs in the hospital setting; we do not know how many such injuries occur outside of hospitals. Further, although we adjusted for underreporting, we do not know whether the final estimate is an overestimate or underestimate, as a more precise figure might have been possible if we had occupational information for the entire data base. Finally, we urge caution in using our estimate to make inferences about the number of occupationally acquired HIV and HCV infections resulting from a percutaneous injury. This is particularly so because of the uncertainty about the risk of transmission of infection with a given pathogen depending on many factors, including the severity of exposure, as measured by the depth of injury, inoculum size, and viral titer in the source.

### **Needlestick Elimination Challenge**

Many programs at the CDC share a common goal of needlesstick prevention. The CDC's reorganized Hospital Infections Program, now known as the Division of Healthcare Quality Promotion, has taken on a challenge to eliminate, within the next 5 years, preventable needlessticks sustained by HCWs. The data from our estimate may be used as a baseline figure to assess progress in achieving this ambitious goal. Despite efforts to address needlesstick injuries, including state and federal legislation and the availability of safety-engineered devices, an estimated 1,000 percutaneous injuries occur daily in U.S. hospitals. Identifying interventions to prevent needlessticks and measuring the impact of those efforts is an important challenge for ensuring the safety of HCWs.

Although our estimate of the number of percutaneous injuries sustained annually by U.S. hospital-based HCWs is smaller than some previously published estimates, its magnitude remains a concern and emphasizes the urgent need to implement prevention strategies. In addition, the uncertainties about the estimate and the lack of any estimate for injuries outside the hospital setting point out the need to enhance surveillance to better monitor injury trends among HCWs in all healthcare settings, not just in hospitals, and to evaluate the impact of prevention measures.

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