Report on Blood Drawing: Risky Procedures, Risky Devices, Risky Job

by Janine Jagger, M.P.H., Ph.D.

Introduction

The United States has the largest number of recognized cases of occupationally acquired HIV in the world. Although no surveillance system in the U.S. or elsewhere identifies all, or even most, occupationally infected health care workers, the number of recognized cases alone is cause for serious concern. A review of international literature through June 1993 identified 176 documented or probable cases of occupationally acquired HIV infection worldwide[1,2]; two-thirds of those were in the United States. One use that can be made of these unfortunately large, and growing, numbers is to identify transmission patterns, which can lead in turn to focused and effective prevention measures.

The Centers for Disease Control and Prevention (CDC) identified 123 documented or possible cases of occupationally acquired HIV in the United States through December 1993.[3] Two professional categories, nurses and clinical laboratory workers—primarily phlebotomists—ranked first among HIV-infected health care workers, accounting for 24% each of the 123 reported cases. Physicians ranked next, accounting for 12% of cases. The high number of cases among nurses is consistent with the fact that they comprise the largest group of health care workers in the U.S., numbering 2.2 million (source: American Nurses Association). Similarly, the number of HIV-infected physicians is consistent with the smaller number of physicians—approximately 670,000—in the U.S. workforce (source: American Medical Association). The number of infected phlebotomists, however, is disproportionate to their numbers in the workforce: there are fewer than 100,000 phlebotomists employed in the U.S., according to the National Phlebotomy Association and the American Society of Phlebotomy Technicians, less than 1/20th the number of nurses.

A notable difference between nurses and phlebotomists is that the latter consistently perform blood drawing procedures, while nurses perform a wider variety of procedures. When a phlebotomist sustains a needlestick, the device causing injury is most likely to be a blood-filled needle. In contrast, a nurse may be stuck by a needle used for an intramuscular injection or intravenous infusion, which would not be blood-filled, and less often by a needle used for blood drawing.

Needles used for different purposes appear to carry different risks for transmitting HIV.[4] The same may be true for other bloodborne pathogens, such as hepatitis B and hepatitis C, but there is insufficient surveillance data to confirm this. In a report by the CDC on the exposure circumstances of workers with occupationally acquired HIV infection, those who were exposed by needlestick had all been stuck by hollow bore, blood-filled needles. Furthermore, phlebotomy was the procedure most frequently associated with HIV exposures.[5] Similar conclusions have been drawn from data reported in other countries.[1,2]

This evidence suggests that (a) blood drawing presents a high risk of exposure to bloodborne pathogens and that (b) the risk profiles of different professional groups are in part linked to the frequency with which they perform blood drawing procedures. These are compelling reasons to focus prevention efforts on the devices, procedures, and professional groups involved in blood drawing.

Two reports are presented here. The first describes the patterns of percutaneous injuries associated with blood drawing procedures in a

Table 1.1 Job Classification of Health Care Workers Reporting Needlesticks Associated with Blood Drawing (58 Hospitals, 1 Year)

Job	Number	Percent
Nurse	157	33.3%
Phlebotomist	150	31.8%
Respiratory Therapist	43	9.1%
Clinical Lab Worker	40	8.5%
Physician*	39	8.3%
Attendant (non-surgical)	14	3.0%
Other	28	5.9%
Total	471	100%

*30/39 reported needlesticks were to residents

Table 1.2 Place of Occurrence of Needlesticks Associated with Blood Drawing (58 Hospitals, 1 Year)

Location	Number	Percent
Patient room	251	53.3%
Emergency department	66	14.0%
Intensive/critical care	39	8.3%
Outpatient facility	24	5.1%
Clinical laboratory	21	4.5%
Operating room	13	2.8%
Venipuncture	12	2.5%
Procedure room	9	1.9%
Other	36	7.6%
Total	471	100%

national network of hospitals. The second presents the results of a survey conducted at a national phlebotomy conference, which looked at blood exposure patterns and risks among phlebotomists.

I. Characteristics of Percutaneous Injuries Associated with Blood Drawing in a National Network of 58 Hospitals

Methods

Fifty-eight hospitals which voluntarily participated in three data-sharing networks contributed one year of data for this report.* All the hospitals use the EPINet™ system for tracking percutaneous injuries in their institutions.[6] Network A includes nine hospitals located in six states in the eastern half of the U.S.; they report their data to the University of Virginia. Network B consists of 50 hospitals in South Carolina that report their data to the Palmetto Hospital Trust Needlestick Prevention Demonstration Project in Columbia, South Carolina. Network C includes 11 Sisters of Providence hospitals in the Pacific Northwest that report their data to Johnson & Higgins of Washington, Inc., in Seattle. The hospitals represent a cross-section of institutions in diverse geographic locations; of the hospitals included in this report, 26 had an average daily census of less than 100 beds, 16 had from 100 to 299 occupied beds, and 16 had 300 or more occupied beds. Seventeen were teaching hospitals.

Data included all percutaneous injuries reported by health care workers to the employee health departments or similar designated authorities in their institutions. Data collection began in September 1992. Each participating facility provided one year of data on disk to investigators; of the 70 hospitals in the three networks, 58 with complete data at the time of this report were included.

Results

There was an overall total of 3,829 percutaneous injuries in the merged database, and a cumulative total of 11,978 occupied beds in the 58 hospitals. Needlestick incidents were selected in which the device associated with the injury was (1) a syringe used for drawing venous or arterial blood, (2) a winged steel needle (butterfly) used for blood drawing, or (3) a vacuum tube phlebotomy needle. Four hundred and seventy-one cases met these criteria—12.3% of all injuries from the 58 hospitals. **Table 1.1** shows the job categories of workers reporting needlesticks from blood drawing needles. Nurses and phlebotomists together accounted for two-thirds of cases. The remaining cases were reported primarily by respiratory therapists (a job category that does not exist in many countries), who often draw blood for arterial blood gas analysis, and by clinical laboratory technicians and physicians (mainly residents).

Table 1.2 shows the location of these incidents. Most injuries occurred in patient rooms; the next most frequent locations were emergency departments and intensive or critical care units. Less frequent locations were outpatient clinics, operating rooms, and clinical laboratories.

Figures 1.1 through 1.4 compare the mechanisms of needlestick injuries for four major needle devices used for blood drawing. This breakdown of injuries shows a profile of when the injuries occurred during the use/disposal cycle; each device has a unique profile, reflect-

Figure 1.1 Mechanism of Injury from Syringes Used for Drawing Arterial Blood

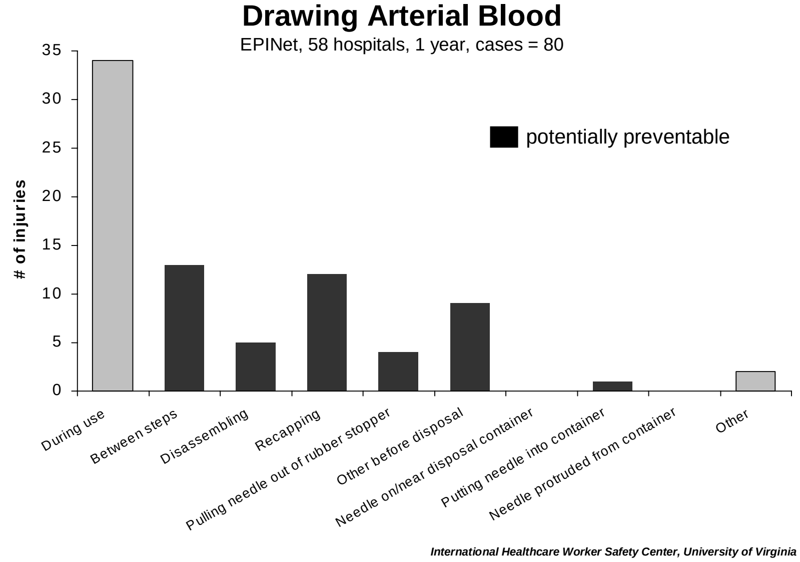


Figure 1.2 Mechanism of Injury from Syringes Used for Drawing Venous Blood
EPINet, 58 hospitals, 1 year, cases = 109

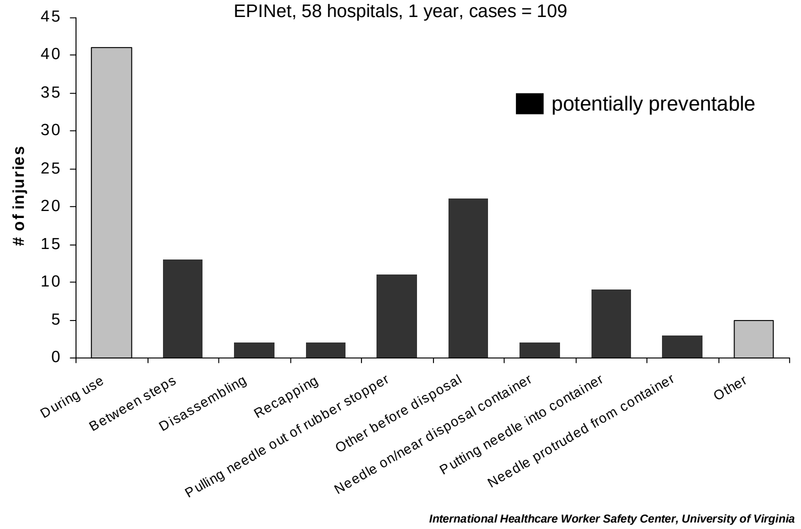


Figure 1.3 Mechanism of Injury from Winged Steel Needles Used for Drawing Blood
EPINet, 58 hospitals, 1 year, cases = 98

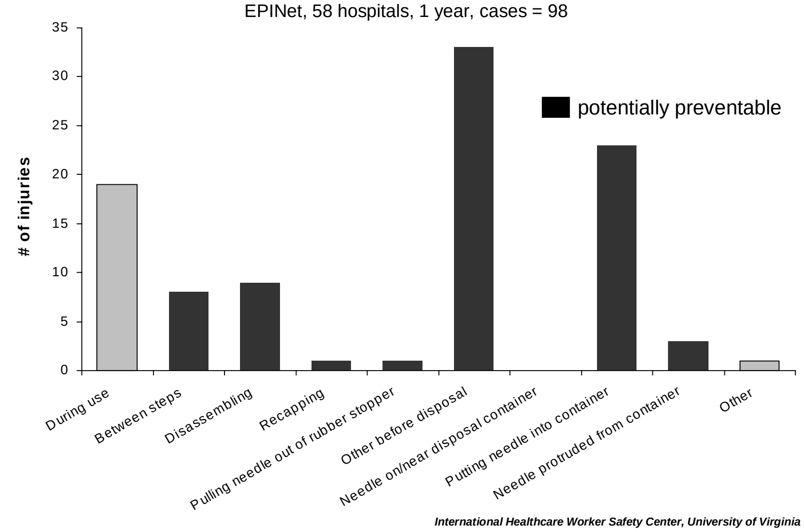
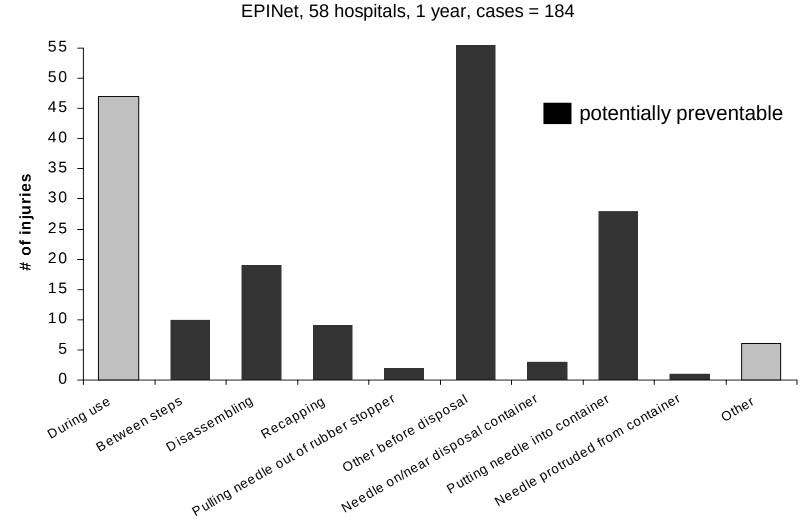


Figure 1.4 Mechanism of Injury from Vacuum Tube Phlebotomy Needles
EPINet, 58 hospitals, 1 year, cases = 184



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ing the design characteristics of the device and the handling requirements for performing specific procedures. For instance, recapping injuries are more frequently associated with syringes used for drawing arterial blood (**Figure 1.1**) than for similar syringes used for drawing venous blood (**Figure 1.2**). This may be due to the requirement for removing needles from arterial blood gas syringes before delivering the filled syringes to the laboratory. On the other hand, injuries that occur when withdrawing a needle from the stopper of a tube are more frequent with syringes used for drawing venous blood because the blood is often injected into tubes before delivery to the laboratory.

The risks associated with winged steel needles (butterflies) are largely related to problems in transporting the devices safely to the disposal containers and difficulties in pushing the needles through the openings of containers (**Figure 1.3**). The coiled tubing attached to the needles makes the devices awkward to handle.

There were 184 injuries from vacuum tube phlebotomy needles (**Figure 1.4**). The circumstances of the injuries were similar to those for winged steel needles—that is, they were caused by problems in transporting needles to disposal containers and in introducing needles into the containers.

Hollow bore needles were not the only devices associated with injuries incurred during blood drawing procedures. Lancets used for fingersticks and heelsticks, glass capillary tubes, and glass vacuum tubes containing blood samples also caused injuries. Most numerous among these were 108 injuries caused by fingerstick and heelstick lancets that lacked an automatic retracting safety feature. Fifty-four percent of the injuries occurred when disengaging a disposable lancet from a reusable holder or when handling the used lancet prior to disposal. These injuries reflect the difficulty of handling such small devices which, if no protective shield is provided, require the fingers to remain close to the exposed point as the device is disassembled and discarded.

Eighteen injuries were caused by glass capillary tubes used to contain small-volume blood samples following fingerstick or heelsticks. Injuries occurred during all phases of handling. Force must be applied when pushing the tubes into putty to close off one end, and again the tubes are subject to significant force when they are centrifuged for hematocrit determination. Under such stresses the fragile glass easily fractures. The devices are blood-filled and have the potential to produce sizable lacerations with significant inoculation of blood.

Nine injuries were caused by broken glass vacuum tubes. Although there were relatively few such injuries when compared with the 184 from phlebotomy needles used to draw blood into the tubes, vacuum tube injuries are particularly serious because of the large amounts of blood that can be introduced into the lacerations. Breakage often occurred at the top of the tubes, when the tight-fitting stoppers were removed either to introduce or withdraw blood samples.

Preventable Injuries

The EPINet system is designed to identify the proportion of injuries that are potentially preventable through improvements in the design of sharp medical devices. Injuries are considered preventable if an alternative already exists that can eliminate the sharp device or unsafe feature. For instance, all injuries from needles used to inject fluid into or withdraw fluid from intravenous access ports are preventable, because needleless equipment can be used. All injuries caused by the breakage of glass devices for which non-breakable alternatives are available can also be prevented.

Some, but not all, needles can be eliminated. Many devices have needles that are used to pierce skin or tissue; these are necessary needles. Needlesticks that occur *after use* or *between uses* of a necessary needle, however, are potentially preventable, when a safety feature that shields the hand from the needle can be put into place. The percentage of needlesticks that occur *during* the performance of the procedure, when the needle must be exposed for use, is not included in the preventable fraction for that device.

The concept of the "preventable fraction" is intended to project a target that may be achieved by the implementation of feasible measures. It is not intended to imply that there is a limit to the potential reductions that can be achieved. It is possible that some safety devices on the market may already exceed the estimated preventable fraction in a given device category. It is also possible that in the future additional prevention strategies, such as procedure changes or new technology, may increase the preventable fraction or even eliminate injuries in a specific device category altogether.

Figures 1.1 through 1.4 highlight the preventable fraction of needlesticks for each device. They were: (1) 58% for syringes used for drawing venous blood; (2) 55% for syringes used for drawing arterial blood; (3) 80% for winged steel needles (butterflies); and (4) 71% for vacuum tube phlebotomy needles. Across all four devices, 67% (316/471) of injuries fell into the potentially preventable fraction.

Seventy-four percent of injuries from fingerstick or heelstick lancets fell into the preventable fraction. Nearly *all* injuries, however, caused by such lancets are preventable, because there are safety lancets presently on the market with a built-in spring action that automatically withdraws the sharp point into a shielded position immediately after being discharged. The sharp lancet retracts so quickly that it is highly improbable that a health care worker could sustain a puncture injury after performing a fingerstick or heelstick procedure. The percentage of preventable injuries, therefore, is likely to be significantly greater than 74%. The safest retracting lancets are those that do not permit a contaminated lancet to be inadvertently discharged a second time.

An additional advantage of the safety lancets is that they reduce the potential for patient-to-patient cross-contamination, because when the used lancet is disposed of, all parts of the device that have come into contact with the patient are automatically discarded with the lancet. The problem of cross-contamination from spring-loaded lancets was linked to an outbreak of hepatitis B and was subsequently the subject of a 1990 FDA Safety Alert.[7,8]

All injuries (100%) from glass capillary tubes used for hematocrit determination are preventable, because the use of these devices is unnecessary—unbreakable plastic capillary tubes are available, as well as a system for hematocrit determination that does not require the use of capillary tubes at all. These injuries could be eliminated tomorrow with the appropriate selection of products.

It is difficult to estimate the proportion of preventable injuries from broken vacuum tubes. A plastic vacuum tube, which would be an appropriate alternative to glass, is not yet available; the plastic would have to meet specifications both for breakage resistance and for impermeability to air, which is necessary for a tube to retain its vacuum over

Table 2.1 Frequency of Risk Factors Among Phlebotomists During Past 12 Months (cases=140)

Uses two-handed recapping of blood collection needles	7%
Does not routinely wear gloves	7%
Sometimes cuts tip off index finger of glove	16%
Hepatitis B vaccine started but incomplete	19%
Has never received Hepatitis B vaccine	20%
Uses needles to draw blood from IV, arterial, or central lines	24%
Employer did not give training to prevent blood exposures	25%
Changes needles to inoculate blood culture medium	28%
Uses glass capillary tubes	36%
Injects blood through stoppers into blood collection tubes	63%

Table 2.2 Percentage of Phlebotomists Sustaining Blood Contact to Skin or Mucosa During Past 12 Months (cases=140)

While applying pressure to a puncture site	16%
While disposing of a blood-filled specimen container	15%
While uncapping a blood-filled vacuum/specimen tube	9%
When a vacuum tube stopper blew off a vacuum tube	5%

Table 2.3 Devices Causing Injury to Phlebotomists

Device	Number	Percent
Vacuum tube phlebotomy needle	13	42.0%
Winged steel needle (butterfly) attached to vacuum tube set	10	32.3%
Winged steel needle (butterfly) attached to syringe	1	3.2%
Disposable syringe	2	6.4%
Lancet	2	6.4%
Broken capillary tube	1	3.2%
Broken vacuum tube	1	3.2%
Undetermined	1	3.2%
TOTAL	31	100%

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a long shelf life. There is, however, a redesigned vacuum tube stopper for glass vacuum tubes that is intended to reduce stresses on the top edge of the tube and thereby lower the risk of breakage if the stopper is removed. The potential effect of redesigned stoppers on reducing injuries from broken vacuum tubes cannot be estimated at present.

As a final point, the handling requirements of blood drawing equipment must be taken into consideration when implementing prevention programs or evaluating safer devices. After withdrawing a phlebotomy needle from a patient, the health care worker must apply pressure to stem bleeding at the puncture site. This leaves only one hand free to handle the exposed needle. The health care worker must either dispose of the needle with one hand or leave it on a nearby surface until he or she is free to move away from the patient. This situation points to the need for an appropriate disposal container within arm's reach of the patient. It also emphasizes the advantage of having a safety blood drawing device that requires only one hand to activate. If two hands are needed to activate a safety feature after the needle has been removed from the patient, the health care worker is in the same situation as with a conventional device, and cannot activate the needle protection feature until both hands are free.

II. Survey of Needlesticks and Other Blood Exposures Among Phlebotomists

"This survey documents the hazards we see everyday in various sites. It is evident that these hazards could be prevented if devices that have proven to be safer were used in every facility where phlebotomy is being done. For instance, employers could make improvements tomorrow if they replaced glass capillary tubes with plastic tubes, or purchased self-shielding needles, or made proper needle disposal readily available. In addition to providing safer technologies in workplaces, employers should also provide adequate training. These simple steps would go a long way to reducing the hazards for phlebotomists."

-Diane Crawford, President, CEO, Nationa Phlebotomy Association, Inc.

In most countries there is no specific professional group dedicated to blood drawing. Usually nurses, but also physicians and other health care workers, draw blood as one of their many responsibilities. In North America, however, the specialized job category of phlebotomist has been established, although, of course, other health care professionals draw blood as well. Because phlebotomists as a group are at high risk for occupationally acquired bloodborne pathogens, it is important to understand the risk patterns and exposure mechanisms associated with their work. Such an understanding may help reduce their risk as well as that of other health care workers who draw blood.

Methods

On July 30, 1994, a survey was conducted of phlebotomists attending the annual conference of the National Phlebotomy Association in New York City. The survey instrument was designed by the International Health Care Worker Safety Research and Resource Center at the University of Virginia, in collaboration with the Service Employees International Union. Of approximately 200 registrants, 152 phlebotomists responded to the survey; 12 of the responses were excluded because the respondents either were currently unemployed, were students, or provided incomplete information. A total of 140 respondents were included in the final analyses.

Results

Fifty-four percent of the respondents worked in hospitals, 16% were employed by private laboratories, 11% worked in free-standing clinics, 5% worked as private contractors, 4% were employed by health maintenance organizations, and 10% were employed in other settings. The average work week was 37.3 hours, and the average number of blood drawing procedures performed in a typical eight-hour work day was 32.

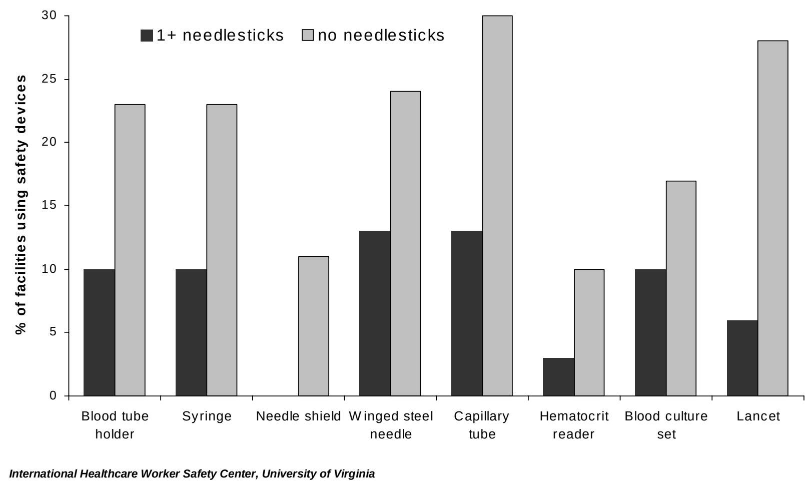
Respondents were asked questions relating to risk factors for blood exposures and percutaneous injuries during the previous 12 months. **Table 2.1** shows the frequency of those risk factors. Overall, there was a high frequency of unsafe procedures and use of unnecessarily hazardous equipment. Two-thirds of the respondents injected blood through stoppers into blood collection tubes, a hazard which can be eliminated by using equipment that draws blood directly into vacuum tubes, or by using a large-volume syringe with a safety shield that can be locked in place, allowing blood tubes to be inserted into the shield so that the needle is covered as blood is injected.

Over one-third of the respondents used glass capillary tubes frequently or occasionally; this is an unnecessary risk since unbreakable alternatives exist. Respondents also indicated that the use of unnecessary needles is commonplace: 24% used needles to draw blood from intravenous, arterial, or central lines, although needleless systems allow blood to be drawn directly from lines into specimen containers; and 28% changed needles for injecting blood into blood culture medium, even though extra needle manipulation increases the risk of needlestick and has not been shown to reduce bacterial contamination of blood samples.[9]

Twenty percent of respondents had not been vaccinated against hepatitis B, and another 19% had started but not completed the vaccine series—a serious shortcoming in a group at such high risk for exposure to bloodborne pathogens. Twenty-five percent of employers had never provided safety training to the phlebotomists on the prevention of bloodborne pathogen transmission.

Table 2.2 shows the percent of phlebotomists sustaining blood contact to skin or mucosa during the previous year under a variety of circumstances. Thirty-four percent of all respondents experienced one or more of these incidents; blood contact occurred most frequently when disposing of a blood-filled specimen container or while applying pressure to a puncture site. The problem of blood exposures due to stoppers popping off of vacuum tubes emphasizes the hazard of injecting blood into vacuum tubes, which can create a positive pressure inside the tube, thus dislodging the stopper.

Figure 2.1 Percent of Facilities Using Safety Devices for:
Workers Reporting Needlesticks in Past Year (31 cases)
vs.
Workers Reporting No Needlesticks in Past Year (109 cases)



Thirty-one respondents reported a total of 47 percutaneous injuries during the previous year. When adjusted for an average 40-hour work week, the **average injury rate was .36 injuries per full-time phlebotomist per year**. The injury rate per procedure was 12.5 injuries per 100,000 blood-drawing procedures.

The 31 respondents who experienced at least one percutaneous injury in the previous year were asked to provide details about their most recent injury. The locations of the injuries were as follows: patient room, 45.2%; venipuncture facility, 19.4%; clinical laboratory, 9.7%; outpatient office, 6.4%; emergency department, 3.2%; procedure room, 3.2%; other settings, 12.9%. The procedures performed at the time of injury included: drawing venous blood, 74.2%; fingersticks, 6.4%; blood culture, 3.2%; other or no response, 16.2%. Devices causing the injuries are shown in **Table 2.3**.

Four of the 31 injuries occurred before use of the device. Of the remaining 27 injuries, 17 (68%) fell into the potentially preventable fraction—that is, they could potentially have been prevented by eliminating an unnecessarily hazardous product (such as glass capillary tubes) or by utilizing devices with integrated safety features that shield the hands from used needles.

Comparisons were made between phlebotomists who had sustained injuries during the previous year and those who had not, in order to identify possible risk factors for percutaneous injuries. An important difference between the two groups was found in one area: *phlebotomists who had had percutaneous injuries during the previous year worked in facilities that provided fewer safety devices than phlebotomists who had had no injuries*. This pattern was consistent across every category of safety device listed. Figure 2.1 shows the percent of facilities providing safety devices in each device category, comparing phlebotomists who had injuries during the past year to those who did not. The differences between the two groups of phlebotomists were statistically significant in two device categories—"needle shield" and "lancet" ($p<.05$ Fisher's exact test, χ^2, respectively). The enclosed

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poster provides complete descriptions of the specific safety devices identified on the survey.

Recommendations

These findings suggest that phlebotomists are routinely exposed to risks that are preventable *today*. A number of steps should be taken to minimize the risks they face:

- Every effort must be made to insure that all susceptible phlebotomists are fully vaccinated against hepatitis B.
- All unnecessary hazardous devices should be eliminated from use, including glass capillary tubes and needles used for drawing blood from intravenous, arterial, and central lines. In addition, the practice of changing needles for blood culture phlebotomy should be abandoned.
- The practice of injecting blood through a stopper into a vacuum tube with an exposed needle should be stopped. Methods of drawing blood directly into vacuum tubes or other specimen containers should be preferentially employed; alternatively, syringes with a needle shield locked in place over the needle may reduce risk of needlestick and contain blood splatter from dislodged tube stoppers when injecting blood into tubes.
- Blood drawing devices with integrated safety features designed to prevent percutaneous injuries should be rapidly implemented and closely monitored for user and patient safety and for reliability of laboratory values.
- Automatically retracting fingerstick or heelstick lancets should be used in place of manual or non-retracting spring-loaded lancets.
- All facilities should provide puncture-resistant disposal containers within arm's reach of the phlebotomist for blood drawing procedures.
- All facilities should comply with the Occupational Safety and Health Administration (OSHA) Bloodborne Pathogen Standard and provide annual in-service training for phlebotomists on appropriate methods for reducing occupational transmission of bloodborne pathogens.[10] Hazardous practices still employed by phlebotomists such as two-handed recapping and cutting off the tip of the index finger of gloves should be explicitly prohibited.

These prevention strategies are important not only for phlebotomists but for all health care workers who perform blood drawing procedures. Because of the disproportionately high risk of infection from bloodborne pathogens among health care workers who perform such procedures, and the potential for substantially reducing this risk, we should strive to implement all possible prevention measures as quickly as possible.

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