American Journal of Infection Control
AJIC
Volume 22 Number 3 June 1994

Compliance with universal precautions and needle handling and disposal practices among emergency department staff at two community hospitals

Keith Henry, MD
Scott Campbell, RN, MSPH
Phyllis Collier, RN, MSN, MPH
Carol O'Boyle Williams, RN, MS, CIC
St. Paul, Minnesota

Background: To describe rates of needle disposal and barrier use within the emergency departments at two privately owned community hospitals in two suburbs of Minneapolis, a study was conducted. This study consisted of direct observation of a cohort of emergency department personnel providing patient care followed by a self-administered survey of the same personnel.
Methods: From June through August 1990, seven specially trained registered nurses observed emergency department personnel for a total of 400 hours. The observers documented the appropriate rates of use of gowns, goggles, masks, and gloves. Observers also noted methods of needle disposal and frequency of needle recapping. After observation, surveys that included items requesting estimates of rates of use for each barrier, as well as estimates of the rates and methods of needle recapping and disposal, were distributed. For each observed and corresponding self-reported behavior, 95% confidence intervals were calculated and compared.
Results: A total of 1822 procedures were recorded. Gloves were observed to be used when appropriate 67.2% of the time, followed by goggles (50.7%), masks (16.0%), and gowns (15.3%). Self-reported barrier rates were slightly higher in all cases except for goggle use. About one third (34.4%) of the needles were recapped; 78.1% of these were recapped two-handed.
Conclusions: Previous studies have documented low universal precautions compliance rates at urban teaching hospitals. Our data indicate less than optimal levels of compliance also at community hospitals, and show that personnel are less than fully aware of their own noncompliance. (AJIC Am J Infect Control 1994:22:129-37)

Concern about the risk of occupational infection by blood-borne pathogens (BBPs) increased after the initial description of AIDS and the identification of HIV. Prospective studies have documented a transmission rate for HIV of approximately 0.3% after percutaneous exposure to HIV-infected

From HIV/AIDS Programs, Section of Infectious Diseases, Department of Medicine, St. Paul-Ramsey Medical Center, St. Paul.

Supported by a grant from the National Institute of Occupational Safety and Health through Educational Research Consortium, incorporated to the University of Minnesota (Grant U60-CCU902886-02).

Presented at the Seventh International Conference on AIDS, Florence, Italy, June 16 through 21, 1991, as "Observed and Self-Reported Compliance with Universal Precautions among Emergency Department Personnel at Two Suburban Community Hospitals" [Abstract M.D.58].

Reprint requests: Keith Henry, MD, HIV/AIDS Programs, Section of Infectious Diseases, Department of Medicine, St. Paul-Ramsey Medical Center, 640 Jackson St., St. Paul, MN 55101.

0196-6553/94 $3.00 + 0 **17/46/53835**

blood.[1-6] The risk for HIV transmission after mucocutaneous exposure is much lower, although transmission has occurred.[7-8]

In an effort to minimize health care worker (HCW) exposure to HIV and other BBPs, the Centers for Disease Control and Prevention (CDC) formulated the concept of "universal precautions" (UP), in which an effort is made to prevent HCW exposure to blood and body fluids of *all* patients. UP evolved to further delineate appropriate barrier use (gloves, goggles, masks, and gowns) and appropriate needle disposal techniques.[9-12]

Two major questions regarding the utility of UP have emerged: first, the efficacy of UP in the prevention of BBP transmission; and second, the frequency of HCW compliance with UP guidelines. The answer to the first question is not settled and is related directly to the issue of compliance. HCWs' UP compliance in emergency departments (EDs) has been studied, and the results have generally demonstrated poor compliance in the absence of a mandate.[13-15] Because most previous studies involved compliance with UP at major academic centers in areas with high HIV caseloads, we decided to study the compliance of ED HCWs in two suburban community hospitals in an area of low HIV seroprevalence. We focused our study on needle handling and disposal because needles represent the major risk of BBP transmission to HCWs.[1, 4, 7]

METHODS

The two EDs selected for study are both located in hospitals with low prevalence rates of HIV (less than 50 cumulative reported cases of HIV/AIDS) in suburbs of Minneapolis and St. Paul. Both are level II trauma centers, staffed by a total of 196 physicians, physician assistants, registered nurses, and nursing assistants. Subjects were solicited for participation through special staff meetings designed to explain the presence of the observers in the treatment areas. Only the medical director and the nurse manager at each site were informed of the exact purpose of the study. The institutional review boards involved in the study requested that subjects sign informed consent forms and that subjects be informed that observations were being made to determine "current practices and behaviors" of ED personnel, with the purpose of possibly helping to set future standards for worker safety. Subjects understood that collected data were not connected with employee names and would not be used for any type of employee performance evaluation.

The ED staff members were not given any special UP instructions in relation to the study because the study's purpose was to examine usual compliance with the CDC's UP guidelines. Each hospital's standard policies regarding UP were not procedure specific. Both hospitals had presented staff training on body substance isolation (BSI)[16] and UP as described by the CDC in 1987, 1988, and 1989[10-12]: (1) gloves should be worn when contact with patient blood or body fluids is anticipated; (2) protective eyewear and masks should be worn for any procedures that generate droplets of blood or body fluids; and (3) if splashing of blood or other body fluids is likely, gowns should be worn. Judgment was left to the ED employee as to whether any procedure or situation was likely to produce exposure to patient blood or body fluids.

Gloves, gowns, masks, and goggles were readily available in more than one location within each ED. Puncture-resistant, leakproof needle-disposal units were available for use in every ED treatment room; one needle box was attached to the wall behind each treatment litter or bed and additional boxes were placed at such strategic locations as medication preparation and waste disposal areas.

The Minneapolis–St. Paul (Twin Cities) Standard Metropolitan Statistical Area consists of about 2.3 million persons. As of January 1991, more than 1000 cases of AIDS had been reported to the Minnesota Department of Health, with 87% of reported patients residing in the seven-county metropolitan area. The Minnesota Department of Health estimates the number of HIV seropositive persons in the state to range from 4409 to 17,742 persons, with most living in the Twin Cities.[17]

Observation phase

Seven registered nurses received education and training in observation methods to standardize observational assessments. This training included a reading and discussion of the CDC recommendations[10-12] and an overview of procedures to be observed. Interrater reliability was been addressed by showing to the seven observers a videotape (produced by the investigators) that demonstrated eight different scenarios for the disposal of needles and the use or potential use of barriers. After an opportunity for discussion and clarification of procedures, a written pilot test was administered intended to further standardize observer approach to documenting observations. The documentation on the pilot test was identical

Table 1. Expected barrier use by type of procedure

Major procedures observed*	Minor procedures observed†
Chest tube placement	Arthrocentesis
Endotracheal intubation	Blood gas (ABG)
Gastric lavage	Central intravenous line placement
Nasogastric tube placement	Contact with oral secretions
Pressure dressing application, profuse bleeding	Examinations or procedures involving actively bleeding patients
Wound irrigations, major wound	Foley catheter placement
Thoracotomy	Intravenous line insertion
Emergency tracheotomy	Lumbar puncture
	Pelvic examination
	Thoracentesis
	Transthoracic pacing
	Venous cutdown
	Wound dressing
	Wound irrigation, minor
	Wound suture

*Use of gloves, gown, mask, and goggles expected.
†Use of at least gloves expected.

at least 90% of the time at the end of the training period. Additionally, observers were encouraged to discuss with one of the investigators (P. C. or C. O.'B. W.) situations in which the question of the appropriateness of barrier use remained unclear to the observer. After the observation period ended (a 2- to 10-hour period), the observer and investigator reviewed and completed the observation form for that situation.

During a period of 400 hours from June to August 1990, the seven observers documented the following behaviors among ED personnel: goggle, mask, glove, and gown use; needle recapping frequency; and needle recapping techniques. They also documented patient demographics, presenting diagnosis, procedure performed, level of bleeding, and patient cooperation as related to each procedure. Observers also documented whether or not the HCWs contaminated their gloved or ungloved hands with blood or blood-tinged fluid.

Employees at both hospitals were taught to prevent contact with body fluids as defined by BSI,[16] not merely the body fluids described by CDC in 1988.[11] Because the study was intended to assess UP compliance and not BSI compliance, however, the barrier compliance assessment was limited to an assessment of HCW behavior involving the fluids listed by the CDC rather than as defined by BSI. If the observed HCW did not put on gloves before coming into contact with a fluid such as saliva that was not visibly tinged with blood, the behavior was not counted as either compliant or noncompliant.

Self-report phase

A self-report survey (SRS) was given to all ED employees (n = 196) after the observation phase in August 1990. The SRS consisted of 50 items that solicited individual estimates of the rates of appropriate use of gloves, gowns, masks, and goggles; needle recapping and disposal practices; reasons for instances of noncompliance; knowledge of UP recommendations; and demographic information. The tool was similar to that used in a previous assessment of ED compliance with UP.[15] To provide self-assessment of compliance and recap rates, the workers were provided a scale ranging from 0% to 100%, divided into increments of 10%, and asked to circle the number that best described their overall use of the different barriers in all circumstances in which those barriers ought to be used or their overall recapping rate for various types of needles.

Definitions

All observed procedures were classified as major or minor, similar to previously published criteria.[13] *Major procedures* were those with a risk of spraying or aerosolization of body fluids; use of all four barriers (gown, mask, goggles, and gloves) was deemed appropriate. *Minor procedures* were those in which contact with blood or body fluids could be expected but splashing or aerosolization was not likely. The use of at least gloves was expected for minor procedures. Table 1 defines a list of major and minor procedures. Glove use was not viewed as a requirement for phlebotomy at the time of the study because the CDC's 1988 update

stated that although gloves should be available for all phlebotomies their use depended on a variety of factors.[11] Observers did, however, document the frequency of glove use for phlebotomy.

Level of bleeding was defined as previously described by Kelen and associates.[13] *Profuse bleeding* was bleeding sufficient to drip off the litter onto the floor or the presence of active spraying such as from arterial bleeding. *Active bleeding* was nonprofuse bleeding with blood visible on the patient.

Statistical analysis

For each of the observed measures of HCW behaviors (gowning, masking, gloving, goggle use, needle recapping, and recapping techniques), the overall rate was handled as a point estimate and 95% confidence intervals (CIs) were calculated. For self-reported behaviors, mean point estimates and 95% CIs were also calculated for the behaviors described.[18] To assess the differences between the observed and self-reported compliance for each behavior, the 95% CI for each observed behavior was compared with the corresponding 95% CI for each self-reported behavior. Because comparison of the rates of compliance between observed behavior (dichotomous) and self-reported compliance (provided as a percentage estimate) did not lend itself to a t test or χ^2 analysis, the difference in the corresponding rates was deemed "significant" if the 95% confidence intervals did not overlap.

Other variables thought potentially to affect compliance rates were separately analyzed by contingency tables: patient gender (male vs female), patient ethnicity (white vs nonwhite), and level of bleeding (none visible vs active vs profuse). The survey also included an item that requested the respondents to indicate which of several factors listed seem to affect their UP compliance.

To assess the potential effect of patient demographics on barrier use, a stepwise regression analysis was computed for each of the four barriers (mask, gown, glove, goggles). Five potential independent patient variables were entered into each model: age, gender, white versus nonwhite, cooperative versus noncooperative, and level of bleeding (none versus active versus profuse). Additionally, χ^2 analysis was employed to examine selected patient and procedure variables (major or minor procedure, profuse or nonprofuse bleeding, male or female patient, white or nonwhite patient) in relation to each of the four barriers.

Significance was set at $\alpha < 0.05$. An association was described as a trend for $\alpha < 0.1$.

RESULTS

A total of 1822 procedures were recorded. Seven of 196 ED personnel did not consent to study participation. For the postobservation survey, 103 of the 196 ED employees returned the SRS (response rate 53%). Findings were organized into three sections: (1) barrier use; (2) needle recap rates and techniques; and (3) other factors potentially affecting compliance.

Barrier use

Self-reported versus observed. Fig. 1 displays the point estimates and 95% CIs for the observed and self-reported barrier use rates. Self-reported rates were significantly higher for all cases except goggle use, in which the observed and self-reported point estimates were within 10% with overlapping CIs. Gloves were observed to be most likely used when appropriate (67.2%), followed by goggles (50.7%), masks (16.0%), and gowns (15.3%).

Blood contamination of hands or gloves. An additional observation was made concerning the frequency of hand or glove contact with visible blood. Blood contamination of both gloved and ungloved hands was observed to occur during 114 of 1563 evaluable interactions (7.3%). Blood contact with ungloved hands was observed to occur during 37 of 759 interactions (4.9%, 95% CI [3.3%, 6.4%]). Blood contact with gloved hands was observed to occur during 77 of 804 interactions (9.6%, 95% CI [7.6%, 11.6%]). This difference was significant (χ^2 12.77, degrees of freedom 1, $p < 0.001$), indicating that the workers were able to determine when hand contact with blood was more likely to occur. For those procedures in which HCWs did not appear to anticipate contact with blood or chose not to wear gloves, however, contact with blood occurred at a rate close to 1 per 20 procedures.

Needle recap rates and techniques

Observed. Complete information on needle recap technique and terminal disposal was available for 613 needles of the 651 needles observed to be used (in some instances the health care worker left the room with the needle in hand and the location of terminal disposal was therefore not determined). Of these 651 needles, the needle recap rate was 34.4% (224/651), (95% CI [30.8%, 38.0%]). Of the 224 needles observed to be recapped, most (78.1%, 175/224, 95% CI [72.7%, 83.5%]) were

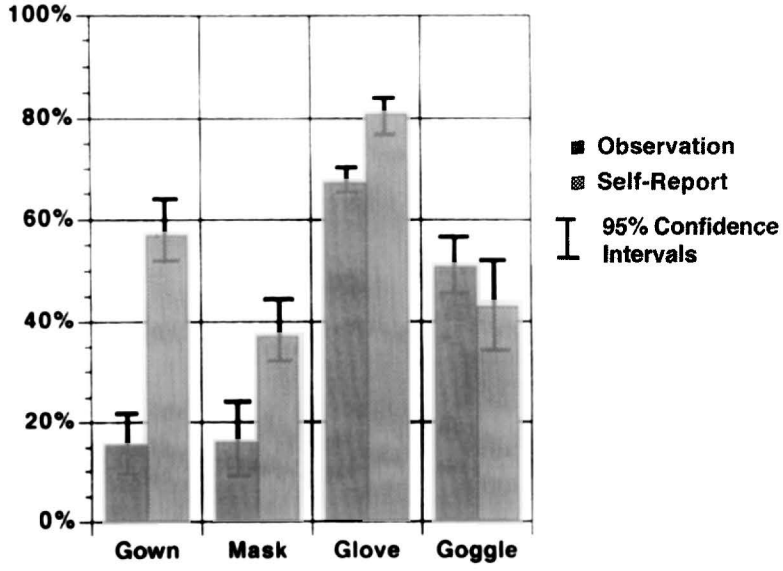

Fig. 1. Barrier use: self-reported versus observed behaviors.

Table 2. Observed needle discard practices

Needle type	Total	Needle not recapped; placed in correct container		Needle not recapped; placed inappropriately (bedside, trash)		Needle recapped; placed in correct container		Needle recapped; placed inappropriately (bedside, trash)	
		n	(%)	*n*	(%)	*n*	(%)	*n*	(%)
Syringes	355	201	56.6	25	7.0	96	27.0	33	9.3
Intravenous stylets	178	130	73.0	25	14.0	21	11.8	2	1.1
Phlebotomy	80	40	50.0	6	7.5	31	38.8	3	3.8
All needles	613	371	60.5	56*	9.1	148	24.1	38*	6.2

*Most of these needles were left at the bedside for another employee to dispose of, such as a nursing assistant cleaning up a procedure tray or treatment area after a procedure.

recapped with the more hazardous two-handed method. Table 2 displays the observed needle recap rates and disposal end points for 613 needles observed during the study.

Self-reported. The HCW mean estimate on the SRS for the use of the two-handed method to recap was 60.7% (95%CI [51.8%, 69.8%]), demonstrating a lack of awareness of the high frequency of use of this recap method. For all recapped needles, the two-handed method was observed to be employed most frequently for recapped needles used to give injections (92.4%; 95% CI [88.3%, 96.5%]) followed by recapped intravenous needles (48.1%; 95% CI [29.3%, 66.9%]), followed by recapped phlebotomy needles (41.0%; 95% CI [25.6%, 56.4%]). This difference was significant (χ^2 64.4, degrees of freedom 2, $p < 10^{-6}$).

Fig. 2 displays a comparison of the observed and estimated recap rates for various types of needles. There were no significant differences between observed and self-reported recap rates.

Other factors potentially affecting compliance

Patient demographics. The regression model for gown use rejected all variables. The regression model for mask use rejected all variables with the exception of age, with mask use higher as age of the patient decreased ($R^2 = 0.07$). The regression model for glove use rejected all but two variables; bleeding level, with glove use higher as bleeding increased ($R^2 = 0.05$), and gender, with glove use higher for male patients ($R^2 = 0.06$). The regression model for goggle use rejected all variables with the exception of age, with goggle use higher as age decreased ($R^2 = 0.25$). The results of the χ^2 analysis of selected patient and procedure variables are shown in Table 3.

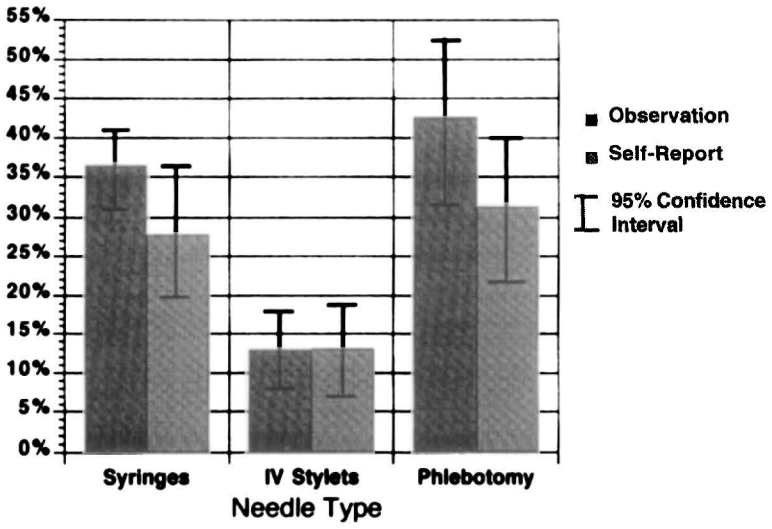

Fig. 2. Needle recap frequency: self-reported versus observed behaviors.

Table 3. Barrier compliance correlated with selected patient and procedure variables

Variable	Gloves			Gowns			Masks			Goggles		
	No.	%	*p*	No.	%	*p*	No.	%	*p*	No.	%	*p*
Major procedures	42/48	88		13/48	27		8/47	17		20/47	43	
			<0.01			<0.01			NS			NS
Minor procedures	816/1230	66		6/76	8		4/30	13		19/28	68	
Profuse bleeding	27/31	87		6/23	26		4/20	20		11/20	55	
			<0.05			NS			NS			NS
Nonprofuse bleeding	826/1239	67		13/87	15		8/54	15		27/54	50	
Male	542/767	71		11/59	19		6/36	17		19/37	51	
			<0.001			NS			NS			NS
Female	274/452	61		7/56	13		4/35	11		16/33	48	
White	710/1075	67		15/99	15		8/59	14		30/60	50	
			NS			NS			NS			NS
Nonwhite	118/166	71		4/21	19		4/15	27		7/14	50	

NS, Not significant.

Self-reported reasons for non-compliance. Reasons for noncompliance given by HCWs (n = 103) on the SRS were numerous. These reasons are listed in Table 4.

DISCUSSION

Concern about how to best prevent BBP transmission in the health care setting has heightened since the Occupational Safety and Health Administration (OSHA) considered and mandated compliance with UP guidelines.[19] Our data demonstrate poor needle techniques and less than optimal barrier use in the time before publication of the OSHA final rule.

The question of how to best audit compliance with UP is an important practical issue. Most published studies that suggest that UP is effective in reducing BBP exposures have relied on self-reporting.[20-22] Our data show that self-reported compliance rates may approximate observed rates of compliance but in some instances overestimate actual compliance. Because our study was conducted in community hospitals with staff who had relatively little experience with HIV, we believe that our results are more representative of actual UP practices at a greater number of U.S. hospitals than studies based at academic centers with large HIV and AIDS populations. The ED is a good window to gauge UP practices because there exists a significant potential for BBP exposure[13, 23] without the structured infection control techniques used in more controlled settings such as surgical suites.

Because needle injury represents the most im-

Table 4. Self-reported reasons for noncompliance

Statement	% agreement
"There is often not enough time to use such precautions"	68
"If the patient appears to be at lower risk for HIV or HBV, I'm less likely to use UP."	59
"The gloves (or other materials) interfere with my patients skills (i.e. gloves decrease dexterity)"	57
"I often forget to take precautions when I should"	44
"I learned my skills without using UP."	33
"Material is often not immediately available."	33
"I don't always know when I should take precautions."	10

portant source of significant BBP exposure, our study focused on needle techniques and disposal. The major problem observed with needle techniques was the high rate of recapping. Although many have questioned the recommendation to avoid recapping,[24, 25] the CDC and OSHA advise that recapping be avoided whenever possible. Jagger and colleagues[26] found that disposable syringes accounted for more injuries than any other device and that recapping was the most common means of injury. Most of the recapping we observed among both nurses and physicians involved the use of two hands. Because "downstream" needlestick injury to other HCWs is a major concern, our data showing that 6.2% of needles were left unsheathed at the bedside or in the trash are particularly disconcerting.

Our observation that 7.3% of gloves or hands had visible blood contamination is also noteworthy. When HCWs elected to wear gloves, they were twice as likely to blood contamination on their gloved hands as when they did not wear gloves. The rate of observed blood contact with ungloved hands was disturbingly high at 4.9%. These rates probably underestimate the actual rates of blood exposure because the hands and gloves were not carefully inspected but simply viewed at a discreet distance. No attempt was made to identify blood penetration of gloves as a result of tears or holes.

In the absence of mandated compliance, our data demonstrate that UP is subject to differing interpretations by individual HCWs. Knowing that there is relatively low risk for HIV exposure in areas with low HIV and AIDS case rates may further reduce enthusiasm for UP. Many of the HCWs volunteered that they comply with UP only when they have time or when the patients "appear to be at risk for HIV or hepatitis B infection."

Current infection control efforts should be intended to prevent BBP infection and should not burden the HCW with unnecessary protocols that are not cost-effective. Whether current UP guidelines have reduced the number of occupational BBP infections among HCWs is not known, is difficult to measure, and is not addressed in our study. We demonstrated that compliance with UP in two community EDs in the absence of more rigorous enforcement of UP was less than optimal. Because CDC guidelines are only recommendations and are not regulatory, the recognition that compliance with UP was low and HCWs were at risk led OSHA to address the issue of BBP exposure in the workplace. OSHA, in its function as a regulatory agency, has developed standards for workplace safety and may levy fines against health care institutions for safety violations.

OSHA has traditionally focused on safety in the manufacturing industry, where the job is often repetitive and risks arise from environmental or mechanical exposures. Safety assessment and tasks of HCWs in the clinical setting are often more difficult to categorize. The risk of BBP infection is generally quite low, so it is measured in terms of probability of exposures or infection. The OSHA standards on occupational exposure to BBPs were issued in December 1991 and implementation was required by the summer of 1992.[19]

Our data support the need for novel methods to improve the level at which HCWs practice optimal workplace infection control activities. If this study were conducted today, now that OSHA has issued its regulations amid much publicity and subsequent action on the part of health care institutions to educate and further protect their personnel, a greater level of UP compliance might be observed. Kelen and coworkers[27] demonstrated that a mandated, procedure-specific policy was effective in increasing HCW compliance rates in the ED. Our data indicate that it can be difficult to assess compliance accurately and that relying on self-reported behaviors generally overestimates actual levels. Direct observation of HCWs is labor and cost intensive and may suffer from the Hawthorne effect, in which the behavior of the observed is

changed by the mere presence of the observer. The fact that the workers were aware that a "safety study" was being conducted probably produced increased rates of observed compliance. Again, the ultimate goal of any UP program should be the reduction of BBP infections among HCWs and patients.

It should be noted that OSHA's BBP standard implies that engineering controls, not merely worker compliance with regulations, are optimal methods for achieving this goal. The OSHA compliance directive, in citation guidelines instructing OSHA compliance officers in how to enforce the new standard, makes it clear that it is "the employer's responsibility to . . . review the feasibility of instituting more advanced engineering controls,"[28] such as needleless IV [intravenous] connectors and self-sheathing needles.

Future efforts should assess the level of compliance with UP in various settings since implementation of the OSHA regulations. More important, efforts to better determine whether current practices actually reduce the numbers of BBP exposures and infections need to be made, with a focus on needle injury. In an era of rapidly increasing medical costs and a public that seeks a risk-free environment, critical studies to identify the aspects of UP that actually reduce exposure and infection need to be supported. Ongoing discussion of the merits of current UP practices should include study of other potential strategies, such as a more targeted approach involving local HIV seroprevalence data and device-related and procedure-related factors.

References

1. Marcus R, The Cooperative Needlestick Surveillance Group. Surveillance of health-care workers exposed to blood from patients infected with human immunodeficiency virus. N Engl J Med 1988;319:1118-23.
2. McCray E, The Cooperative Needlestick Surveillance Group. Occupational risk of the acquired immunodeficiency syndrome among health care workers. N Engl J Med 1986;314:1127-32.
3. Tokars J, Marcus R, Culver D, McKibben P, Bell D, The Cooperative Needlestick Surveillance Group. Zidovudine (AZT) after occupational exposure to HIV-infected blood [Abstract]. In: Programs and abstracts of the sixth international conference on AIDS, San Francisco, June 20–24, 1990:Ab SC766.
4. Henderson DK, Fahey BJ, Willy M, et al. Risk for occupational transmission of human immunodeficiency virus type 1 (HIV-1) associated with clinical exposures: a prospective evaluation. Ann Intern Med 1990;113:740-6.
5. Gerberding JL, Littell CG, Chambers HF, et al. Risk of occupational HIV transmission in intensely exposed health-care workers: follow-up [Abstract]. In: Program and abstracts of the twenty-eighth interscience conference on antimicrobial agents and chemotherapy (Los Angeles). Washington, DC: American Society for Microbiology, 1988:169.
6. Elmslie K, Mulligan L, O'Shaughnessy M. National surveillance program: occupational exposure to human immunodeficiency virus (HIV-1) infection in Canada [Abstract]. In: Program and abstracts of the fifth international conference on AIDS, Montreal, June 4–9, 1989:148.
7. Centers for Disease Control. Update: human immunodeficiency virus infections in health-care workers exposed to blood of infected patients. MMWR 1987;36:285-9.
8. Haley CE, Reff VJ, Murphy FK. Report of a possible laboratory acquired HIV infection [Abstract]. In: Program and abstracts of the fifth international conference on AIDS, Montreal, June 4–9, 1989:148.
9. Centers for Disease Control. Recommendations for preventing transmission of infection with human T-lymphotropic virus type III/lymphadenopathy–associated virus in the workplace. MMWR 1985;34:681-6, 691-5.
10. Centers for Disease Control. Recommendations for prevention of HIV transmission in health-care settings. MMWR 1987;36(Suppl 2S):3-12.
11. Centers for Disease Control. Update: universal precautions for prevention of transmission of human immunodeficiency virus, hepatitis B virus, and other bloodborne pathogens in health-care settings. MMWR 1988;37:377-82, 387-8.
12. Centers for Disease Control. Guidelines for prevention of transmission of human immunodeficiency virus and hepatitis B virus to health-care and public-safety workers. MMWR 1989;38(Suppl. S6):3-37.
13. Kelen GD, DiGiovanna T, Bisson L, Kalainov D, Sivertson KT, Quinn TC. Human immunodeficiency virus infection in emergency department patients: epidemiology, clinical presentations, and risk to health care workers – The Johns Hopkins experience. JAMA 1989;262:516-22.
14. Baraff LJ, Talan DA. Compliance with universal precautions in a university hospital emergency department. Ann Emerg Med 1989;18:654-7.
15. Henry K, Campbell S, Maki M. A comparison of observed and self-reported compliance with universal precautions among emergency department personnel at a Minnesota public teaching hospital: implications for assessing infection control programs. Ann Emerg Med 1992;21:940-6.
16. Lynch P, Jackson MM, Cummings J, Stamm WE. Rethinking the role of isolation practices in the prevention of nosocomial infections. Ann Intern Med 1987;107:243-6.
17. Acquired immunodeficiency syndrome and human immunodeficiency virus infection in Minnesota: update and projections of AIDS cases through 1992. Minneapolis: Minnesota Department of Health, Sept 1990.
18. Kuzma J. Basic statistics for the health sciences. 1st ed. Palo Alto, California: Mayfield Publishing, 1984:91, 138.
19. Occupational Safety and Health Administration. Occupational exposure to bloodborne pathogens: final rule. Federal Register 1991;56(Dec 6):64004-182.
20. Wong ES, Stotka JL, Chinchilli VM, Williams DS, Stuart CG, Markowitz SM. Are universal precautions effective in reducing the number of occupational exposures among health care workers? JAMA 1991;265:1123-8.
21. Fahey BJ, Koziol DE, Banks SM, Henderson DK. Frequency of nonparenteral occupational exposures to blood

and body fluids before and after universal precautions training. Am J Med 1991;90:145-53.
22. Klein RS. Universal precautions for preventing occupational exposures to human immunodeficiency virus type I. Am J Med 1991;90:141-4.
23. Kelen GD, Green GB, Purcell HR, et al. Hepatitis B and hepatitis C in emergency department patients. N Engl J Med 1992;326:1399-404.
24. Jagger J, Hunt EH, Pearson RD. Recapping used needles: is it worse than the alternative? [Letter] J Infect Dis 1990;162:784-5.
25. Huber K, Sumner W. Recapping the accidental needlestick problem. AM J INFECT CONTROL 1987;15:127-30.
26. Jagger J, Hunt EH, Brand-Elnaggar J, Pearson RD. Rates of needle-stick injury caused by various devices in a university hospital. N Engl J Med 1988;319:284-8.
27. Kelen GD, Green G, Hexter DA, et al. Substantial improvement in compliance with universal precautions in an emergency department following institution of policy. Arch Intern Med 1991;151:2051-6.
28. US Department of Labor. OSHA instruction CPL 2-2.44C: enforcement procedures for occupational exposure to bloodborne pathogens standard, 29 CFR 1910.1030. Washington, DC: Office of Health Compliance Assistance, March 6, 1992:16.