Trends in Bloodborne Pathogen Exposure and Follow-Up at an Urban Teaching Hospital: 1987 to 1997

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Health care workers (HCWs) risk occupational exposure to bloodborne pathogens. Effective postexposure treatment and testing depend on compliance with follow-up, but compliance rates are poorly understood. We examined trends in exposure and follow-up at a large teaching hospital after interventions to improve compliance. We reviewed exposures from October 1987 to September 1988 (group 1) and July 1996 to June 1997 (group 2). Data were analyzed for HCW demographics, source patient characteristics, and follow-up outcomes. We found that group 2 source patient serologic data were obtained more often. Group 1 source patients were more likely to be positive for the human immunodeficiency virus (HIV). Group 2 HCWs were more likely to be immune to hepatitis B virus, to agree to HIV testing, and to comply with follow-up. Follow-up rates remained suboptimal, even after high-risk exposures. Non-licensed HCWs were less likely to accept postexposure testing than physicians or nurses in group 2. General and targeted interventions to improve compliance and follow-up are still needed. (J Occup Environ Med. *2001;43:370–376*)

Occupational exposure to bloodborne pathogens (BBPs) continues to be a significant hazard for health care workers (HCWs) in outpatient and inpatient settings[1] despite nearly two decades of progress in risk-reducing interventions. These include hepatitis B (HBV) immunization,[2] "universal precautions" training,[3] barrier protection,[4] safer needle designs,[5,6] and safer disposal systems.[7] HCW seroconversion has been documented for occupational exposures to HBV, hepatitis C (HCV), and the human immunodeficiency virus (HIV).[8] HCWs with potential BBP exposures frequently experience profound anxiety as they contemplate their own health risks and the potential threats to their intimate partners, unborn children, and job security.

Postexposure testing and treatment recommendations have evolved substantially over the past 10 years with the increased understanding of these diseases.[9,10] Postexposure prophylaxis after HIV exposure[11] and HBV hyperimmune globulin after HBV exposure to non-immune HCWs[12] can be effective in reducing seroconversion and morbidity. More recently, it has been suggested that early antiviral treatment may decrease morbidity after HCV seroconversion.[13] Nevertheless, effective postexposure treatment for any BBP depends primarily on how well HCWs self-refer after exposure and comply with follow-up treatment. Similarly, evaluation of the true incidence of occupational infection after exposure depends on systematic

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source patient testing and HCW compliance with follow-up testing. Data on HCW follow-up rates for testing after potential BBP exposure are sparse and suggest that compliance is frequently poor.[14,15] It is not known to what extent HCWs comply with reporting, follow-up testing, or postexposure prophylaxis recommendations or how source patient infection rates have changed over the past decade.

We hypothesized that interventions, such as BBP training, facilitation of source patient testing, and streamlining of protocols for HCW testing and treatment, should have improved compliance with recommended postexposure testing and treatment. The intent of this study is to describe and analyze trends in reporting and follow-up after potential BBP exposure over a period of 10 years, during which these interventions were progressively implemented in response to increased understanding of BBP transmission. Analysis of these changes and the demographic variables associated with better compliance rates should improve our future ability to track and treat BBP exposures in high-risk occupational groups.

To do so, we examined reporting and follow-up behaviors in two groups of HCWs, 9 years apart, who reported potential BBP exposures to the occupational medicine clinic of a large urban tertiary-care hospital over two 12-month periods: October 1987 to September 1988 (group 1) and July 1996 to June 1997 (group 2). Data were analyzed to see if the two groups differed with respect to source patient BBP status, HCW demographics, and HCW compliance with recommended follow-up testing.

Data and Methods

Design

A retrospective chart review was performed on all available records of blood/bloody fluid exposures reported to the occupational medicine clinic of the study hospital for two time periods: October 1987 to September 1988 and July 1996 to June 1997.

Setting

The study was conducted at a large urban teaching hospital with 6000 employees. The number of employees was stable throughout the study period. From September 1987 onward, all medical faculty and hospital staff were instructed, per standing hospital policy, to report all blood/bloody fluid exposures immediately to the occupational medicine clinic for documentation, treatment, and follow-up. The occupational medicine clinic followed standard treatment and testing guidelines as they evolved from 1987 to 1997.[10,16] During nights and weekends, HCWs with blood/bloody fluid exposures were seen in the emergency department. All HCW follow-up and source patient testing was coordinated through the occupational medicine clinic. All HCW HIV tests required written consent and were run anonymously using a system of secure code numbers kept by occupational medicine clinic staff. Source patient HIV testing required written consent or, rarely, documentation meeting Pennsylania State law for HIV testing without consent.[17] Hospital policy required that the treating physicians provide counseling and obtain consent for source patient HIV testing.

Study Population

The study population consisted of all HCWs who reported blood/bloody fluid exposures to the occupational medicine clinic between October 1987 to September 1988 (group 1) and July 1996 to June 1997 (group 2). All HCWs who reported blood/bloody fluid exposures were instructed to return for follow-up at 6 weeks, 12 weeks, and 6 months, per Centers for Disease Control protocol.[10] Reminder letters were sent. (HCWs receiving postexposure prophylaxis for HIV-exposure were asked to return for additional follow-up visits to monitor for side effects.)

Interventions

Over the study period, multiple interventions were made to improve HCW access to care and follow-up. These included:

- Ongoing HCW education regarding infection control, benefits of postexposure prophylaxis, and the need for prompt reporting and testing after exposure.
- Expedited triage protocols for HCWs reporting exposures to the emergency department or occupational medicine clinic to minimize waiting times before evaluation and treatment.
- Occupational medicine clinic protocols provided to the emergency department staff to improve exposure management.
- 24-hour consult coverage by occupational medicine physicians to provide clinical guidance to emergency department staff and counseling for exposed HCWs.
- Introduction of postexposure prophylaxis "starter packs" in the occupational medicine clinic and emergency department to minimize time to treatment, if needed. (The starter packs contain a 3-day supply of recommended first-line antiretrovirals[10] along with patient information/instructions.)
- Education for hospital physicians and house staff on the need to counsel and consent source patients for BBP testing in a timely fashion.
- Improved protocols for occupational medicine clinic staff to contact hospital physicians for source patient testing.
- Increased availability of on-site HIV testing from weekly to daily laboratory runs.
- Availability of on-site HCV testing.
- Improved protocols for reminding exposed HCWs to return for follow-up using occupational medicine software[18] to generate standardized letters.

TABLE 1
Source Patient Information*

	Group 1: 1987–1988			Group 2: 1996–1997			*P*
	Total	*n*	%	Total	*n*	%	Value
Source patient known	258	224	86.8	217	194	89.4	0.40
High-risk class	204	40	19.6	122	29	23.8	0.40
Serologic results obtained	224	142	63.4	194	178	91.8	<0.0001
HIV+	142	17	12.0	176	7	3.3	0.01
HbsAg+	ND	ND		172	6	3.5	
HCV+	ND	ND		167	25	15.0	

* HIV, human immunodeficiency virus; HBsAg+, positive for hepatitis B surface antigen; HCV+, positive for hepatitis C virus; ND, not determined.

Data Collection

All cases included in our analysis met the criteria for a potential BBP exposure. These criteria included percutaneous injury with bloody instruments, blood/bloody fluid splashes to mucous membranes, and blood splashes to non-intact skin. Charts were reviewed for source patient risk status (high or low, as assessed by the occupational medicine clinic clinician at the time of exposure); source patient BBP serologic data; HCW demographics (age, occupation, ethnicity, and gender); HCW baseline serologic results; and HCW follow-up serologic data (at 6 weeks, 12 weeks, 6 months, and 1 year). HBV surface antibody (in exposed HCWs) and HIV antibody (in sources and exposed HCWs) were tested in both cohorts. Source patient HBV antigen results and HCV antibody testing were available only for group 2. Additional studies were performed as clinically indicated but were not analyzed for the study.

Data Analysis

Data are presented as means ± standard deviations or as frequencies and percentages. To determine the differences between cohorts, the *t* test was used for continuous data and Pearson's chi-squared or Fisher's exact test for categorical data. All analyses were performed using SAS statistical software,[19] and $P < 0.05$ was considered statistically significant.

Results

In the first exposure group (1987 to 1988), 258 blood/bloody fluid exposures were reported; 262 were reported in the second group (1996 to 1997). All charts were available for review from the first group, and 217 (83%) were available from the second. Source patient results are summarized in Table 1. The source patient was identifiable by the injured HCW in nearly 90% of reported blood/bloody fluid exposures, and no significant difference was found between the two groups. The occupational medicine clinic clinician classified the source patient as high-risk (for any BBP) in 20% of group 1 exposures and in 23% of group 2 exposures. The two exposure groups did not differ significantly for this variable. There were, however, marked differences between group 1 and group 2 with respect to source patient BBP testing in that HIV serologic results were obtained in only 63% of known source patients in group 1 but in 92% of known source patients in group 2 ($P < 0.001$). Furthermore, 12% of known source patients were HIV positive in group 1, whereas only 3.3% were HIV-positive in group 2 ($P = 0.01$). Source patient HBV and HCV serologic data were not available for review in group 1; hence, no comparisons could be made between the groups for these results. Fifteen percent of source patients in group 2 tested positive for HCV antibodies. The majority of source patients found to be HCV+ were not known to be infected at the time of admission. Six source patients (3.5%) tested positive for HBV surface antigen in group 2.

The demographic characteristics of the HCWs and the nature of the reported exposures are summarized in Table 2. Although both cohorts were predominantly female, the percentage of men reporting blood/bloody fluid exposures increased significantly in group 2. Similarly, although nurses were the largest occupational subset in both exposure groups, the percentage of physicians reporting blood/bloody fluid exposures increased significantly in group 2. The groups did not differ significantly with respect to age or ethnicity. The majority of reported blood/bloody fluid exposures were due to needlestick injuries in both cohorts; however, the number of reports due to other percutaneous exposures and surface splashes was significantly higher in the second group. No significant difference was found between the two groups with regard to percutaneous (needle and sharp instrument) versus non-percutaneous (splash) exposure ($P = 0.43$).

The two exposure groups differed markedly with respect to HCW testing and HCW compliance with follow-up (Table 3). When an exposure was reported, only 46% of HCWs in group 1 agreed to baseline HIV testing for themselves; however, more than 92% in group 2 requested base-

TABLE 2
Demographics

	Group 1: 1987–1988	Group 2: 1996–1997	*P* Value
No. of reported exposures	258	217	NA
Age	32.1 ± 9.1	32.7 ± 8.0	0.44
Female	214 ± 2.9	154 ± 71.6	0.004
Position			<0.0001
Nurse	164 ± 63.6	88 ± 41.1	
Physician	27 ± 10.5	54 ± 25.2	
Other	67 ± 26.0	75 ± 33.7	
Ethnicity			0.42
Black	50 ± 19.4	37 ± 23.6	
Caucasian	194 ± 75.2	110 ± 70.1	
Asian	12 ± 4.7	10 ± 6.4	
Exposure route			0.003
Needlestick	195 ± 75.6	133 ± 61.6	
Sharp instrument	27 ± 10.5	41 ± 19.0	
Other	36 ± 14.0	42 ± 19.4	
Exposure route			0.43
Percutaneous	122 ± 86.1	174 ± 80.6	
Nonpercutaneous	36 ± 14.0	42 ± 19.4	

line HIV testing for themselves ($P < 0.0001$). In both groups, fewer than half of all HCWs with blood/bloody fluid exposures returned for any follow-up appointments. HCWs in group 2 were significantly more likely to return for at least one follow-up visit: 19 (7%) returned at least once in group 1, whereas 107 (49%) returned at least once in group 2 ($P < 0.0001$). Even smaller numbers of both groups returned at 6 months for definitive HIV serologic tests to rule out seroconversion: 2.3% of the earlier exposure group and 29.5% of the second ($P < 0.0001$). The differences in follow-up rates were equally marked for those HCWs most likely to have been exposed to BBPs. HCWs with unknown source patients returned for at least one follow-up test in only 23% of cases in group 1 but in 57% of cases in group 2 ($P < 0.0001$). Similarly, when the source patient was known to be HIV+, only 24% of HCWs in the first cohort returned for at least one follow-up test as compared with 100% of those in group 2 ($P = 0.001$). In group 2, HCWs with known HCV exposure returned for at least one follow-up only 72% of the time.

HCWs were found to be immune to HBV, presumably from immunization, in only half of group 1 but in nearly 80% of group 2 ($P < 0.0001$). All HCWs were negative for all HIV and HCV tests performed through the occupational medicine clinic during the study period.

In group 1, gender was significantly correlated with the likelihood of a HCW's agreeing to baseline HIV testing (Table 4). Twenty-nine (66%) of 44 men agreed to testing as opposed to 42% of women ($P = 0.005$). Occupational subsets in group 1 also differed significantly with respect to HCWs' agreeing to HIV testing: 70% of physicians, 52.2% of non-licensed subjects, and only 40% of nurses agreed to testing ($P = 0.006$). Gender had no effect on the likelihood of a HCW's being HBV-immune in group 1, but occupational subset did correlate with immunity: 67% of physicians were HBV-immune, as opposed to 55% of nurses, and only 33% of other employees with blood/bloody fluid exposures ($P = 0.01$). Age and ethnicity had no significant effect on a HCW's likelihood of agreeing to HIV testing or being immune to HBV. No demographic variable correlated with the likelihood of a HCW returning for at least one follow-up visit.

In group 2, only occupational group was predictive of HCWs' willingness to undergo HIV testing: 100% of physicians and 99% of nurses agreed to HIV testing as opposed to only 86% of other hospital employees ($P = 0.001$). Age, ethnicity, occupational group, and gender were not predictive of HBV immunity or returning for follow-up in this exposure group.

Discussion

This study was designed to analyze blood/bloody fluid exposures during two time periods 9 years apart to characterize the types of BBP exposures that had occurred and to assess trends in HCW compliance with immunization, BBP testing, and follow-up. Group 2 was selected from the recent past, following the publication of results that clearly supported the use of HIV postexposure prophylaxis.[11] Group 1 was selected from an earlier time period, when HIV follow-up protocols and universal precautions had just been developed. Multiple interventions to facilitate compliance with reporting and testing were implemented over the study period. Striking improvements occurred in source patient testing rates, HCW testing and follow-up rates, and HCW HBV immunity. In addition, we identified demographic variables, primarily occupational, that were associated with follow-up and testing compliance.

Our results were notable for behavioral changes that occurred between the two time periods. The number of new blood/bloody fluid exposures reported per year, however, was essentially identical in both exposure groups within a numerically stable employee population. It is possible that this represents an increased reporting rate for a decreasing number of actual exposures. Increased reporting rates could be due to increased acceptance and/or availability of testing and postexpo-

TABLE 3
Employee Information*

	Group 1: 1987–1988			Group 2: 1996–1997			
	Total	*n*	%	Total	*n*	%	*P* Value
HBV-immune	186	94	50.5	204	158	77.5	<0.0001
Initial HIV testing	258	119	46.1	217	200	92.2	<0.0001
Follow-up testing							
If known HIV exposure	17	4	23.5	7	7	100.0	0.001
If known HCV exposure	ND		ND	25	18	72.0	
If source patient unknown	34	4	11.8	23	13	56.5	<0.008
If any follow-up	258	19	7.4	217	107	49.3	<0.0001
If follow-up at 6 months	258	6	2.3	217	64	29.5	<0.0001

* HBV, hepatitis B virus; HIV, human immunodeficiency virus; HCV, hepatitis C virus; ND, not determined.

TABLE 4
Health Care Worker Comparison, Group 1 (1987–1988)

	HIV Testing				HBV Immunity				At Least 1 Follow-Up Visit			
		Tested				Immune				Returned		
	Total	*n*	%	*P* Value	Total	*n*	%	*P* Value	Total	*n*	%	*P* Value
Age								0.36				0.21
<30	135	69	51	0.13	97	54	56		135	13	9	
30–39	78	36	46		57	25	44		78	2	3	
40–49	30	10	33		22	9	41		30	2	7	
>49	15	4	27		10	6	60		15	2	13	
Gender				0.005				1.0				0.33
Female	214	90	42		152	77	51		214	14	7	
Male	44	29	66		34	17	50		44	5	11	
Position				0.006				0.01				0.59
Nurse	164	65	40		119	66	55		164	14	9	
Physician	27	19	70		18	12	67		27	1	4	
Other	67	35	52		49	16	33		67	4	6	
Ethnicity				0.92				0.31				0.6
Black	50	24	48		34	13	38		50	4	8	
Caucasian	194	90	46		141	74	52		194	15	8	
Asian	12	5	42		9	5	56		12	0	0	

sure prophylaxis among HCWs. Decreased injury rates could be due to improvements in (or greater compliance with) infection control techniques to decrease total exposures. The stable number of reported exposures may also reflect an increase in patient acuity, with concomitant increases in invasive procedures and related exposures, despite improvements in infection control techniques. However, it is also possible that the true exposure rate was simply unaffected by the infection control interventions designed to decrease exposure risk in the past decade.

Between 1987 and 1997, source patients were equally likely to be known, and there were no significant changes in their risk categories. However, there was a dramatic improvement in successful source patient testing (to 92%) in group 2. Source patient testing is critical to optimal decision making about postexposure prophylaxis and follow-up testing for exposed HCWs, and it is vital to relieving postexposure anxiety for most HCWs. Pennsylvania state law[17] requires that occupationally exposed HCWs agree to HIV testing for themselves before source patients are tested. Because 92% of HCWs agreed to baseline HIV testing in the second exposure group (Table 3), this represents an excellent source patient testing rate.

Among the source patients who were tested, a significant decrease was found in the prevalence of HIV in the second cohort. This change may reflect changes in true HIV prevalence in the study hospital catchment area. However, the decrease is more likely to be due to the decreased use of hospitalization for HIV patients from 1987 to 1997 because of treatment advances and managed care constraints. The decrease could also be due to differential reporting of known or suspected HIV exposures by HCWs in the first cohort. This last interpretation is supported by the fact that inpatient HIV prevalence has never approached 12% in the study hospital.

HCV was overwhelmingly the most common BBP among source patients in the 1996-to-1997 exposure group (and probably in group 1, although HCV testing was not available then). This finding is consistent with high exposure rates in other studies.[20,21] It emphasizes the need for source patient testing and accurate follow-up testing for HCWs, particularly in the context of evolving antiviral therapy for HCV.[13,16] HCV testing has improved greatly since 1997 with the opportunity for early testing with polymerase chain reaction techniques, which we now routinely perform after known HCV exposures to facilitate early identification of seroconverters and referral for treatment.

Demographically, there was a significant increase in the number of men and the number of physicians reporting blood/bloody fluid exposures in the second cohort. It seems likely that these two variables are dependent because men represent a higher proportion of physicians (56%) and women a higher proportion of nurses (93%) in our population. This trend may represent true changes in the incidence of blood/bloody fluid exposures among groups of HCWs or, more likely, increased reporting by men (and physicians). Increased reporting by these groups could be due to increased knowledge of occupational BBP infection, increased acceptance of HCW testing, and/or the desire to access postexposure prophylaxis.

The types of blood/bloody fluid exposures reported also differed somewhat between the earlier and later groups. More percutaneous blood/bloody fluid exposures from sharp instruments, rather than needlesticks, were reported in group 2. This may be related to changes in patient acuity and procedure rates across a 10-year period. It may also reflect a proportional decrease in needlesticks related to the availability and use of safer needles and improved safety training to decrease events such as recapping injuries. The change may also reflect increased occurrence and/or reporting of surgical injuries. Our data do not differentiate between these possibilities; however, we do show that the incidence of percutaneous injury remained high overall and unchanged in the two groups. Because these percutaneous exposures pose a higher risk than "splash" exposures,[11] the cohorts are highly comparable with regard to exposure type and HCW demographics.

The possible reasons that HCWs may avoid follow-up after exposure to BBPs include inconvenience, denial, fear for job security, and fear of stigmatization from any breach in confidentiality. In addition, busy HCWs simply might not find time for their own medical care or might have moved to other jobs. It is also possible that some HCWs pursued subsequent BBP testing with their own physicians or at anonymous test sites in preference to the hospital occupational medicine clinic. Private follow-up would allow HCWs to seek appropriate treatment and protect their partners without the risk of publicity but with the loss of documentation for legal and epidemiologic purposes. Because HCWs from group 2 followed-up after 100% of known HIV+ exposures, the low follow-up rates after HCV+ and unknown-source exposures may be due to a lack of knowledge and concern about HCV infection rather than a fear of workplace testing. If our study population is representative of HCWs in high-risk settings across the country, national exposure rates and seroconversion rates may be significantly underestimated, particularly for HCV.

In summary, in 1987, shortly after nosocomial HIV infection was recognized, fewer than half of exposed HCWs at the study hospital agreed to baseline testing for themselves. By 1996 to 1997, the acceptance rate had risen to 92%. Follow-up rates also improved markedly, although compliance with testing after exposure to HCV+ and unknown sources remained suboptimal. During the study period, multiple interventions to improve HCW access to treatment, testing, and follow-up were implemented. Similar protocols were established in other hospitals during this time, following national guidelines and the evolving understanding of the need for timely postexposure prophylaxis[1,15] These appear to have been successful overall in improving follow-up outcomes within our study population. Nevertheless, a disquieting percentage of HCWs with unknown source patients and HCV+ source patients failed to return for follow-up, even in the 1996-to-1997 exposure group. Low follow-up rates may result in a systematic underestimation of seroconversion rates after BBP exposure in health care settings. Improved follow-up rates are critical to ensuring appropriate referral for early treatment in the case of seroconversion and to protect the HCW's partners and patients.

Study limitations included dependence on self-reporting and retrospective chart review. HCWs are known to underreport exposures to patients' blood.[22] Underreporting probably varies with occupational group,[23,24] level of training,[25] and perceived risk, so it is difficult to estimate the degree of bias in a group without prospective surveillance for exposures. In this study, prospective surveillance was not done, and HCW exposure to patients' blood/body fluids was evaluated only after a self-reported incident. Although the charts were generally clear and complete, only 83% of the total blood/bloody fluid exposures reported were available for review in the second cohort. The charts had no information regarding HCWs' reasons for compliance and non-compliance with recommendations. Despite a significant improvement in compliance outcomes, the results indicate ongoing problems with ensuring follow-up to optimize HCWs' medical care after blood/bloody fluid exposures.

This study demonstrates that postexposure testing rates for HCWs and their source patients improved with systematic interventions over a 9-year period. By 1997, only one demographic variable correlated with compliance: non-professional HCWs were less likely to agree to serologic testing for themselves. Our data support the concept of general and targeted interventions to improve access to and acceptance of postexposure testing. Additional interventions should be designed and tested to improve follow-up after known HCV exposures and unknown source exposures. Interventions to increase knowledge of BBP risks and the need for postexposure testing and treatment should be targeted to the occupational groups least likely to access testing and treatment.

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