ORIGINAL ARTICLE

# Costs of Management of Occupational Exposures to Blood and Body Fluids

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OBJECTIVE. To determine the cost of management of occupational exposures to blood and body fluids.

DESIGN. A convenience sample of 4 healthcare facilities provided information on the cost of management of occupational exposures that varied in type, severity, and exposure source infection status. Detailed information was collected on time spent reporting, managing, and following up the exposures; salaries (including benefits) for representative staff who sustained and who managed exposures; and costs (not charges) for laboratory testing of exposure sources and exposed healthcare personnel, as well as any postexposure prophylaxis taken by the exposed personnel. Resources used were stratified by the phase of exposure management: exposure reporting, initial management, and follow-up. Data for 31 exposure scenarios were analyzed. Costs were given in 2003 US dollars.

SETTING. The 4 facilities providing data were a 600-bed public hospital, a 244-bed Veterans Affairs medical center, a 437-bed rural tertiary care hospital, and a 3,500-bed healthcare system.

RESULTS. The overall range of costs to manage reported exposures was $71-$4,838. Mean total costs varied greatly by the infection status of the source patient. The overall mean cost for exposures to human immunodeficiency virus (HIV)–infected source patients ($n = 19$, including those coinfected with hepatitis B or C virus) was $2,456 (range, $907-$4,838), whereas the overall mean cost for exposures to source patients with unknown or negative infection status ($n = 8$) was $376 (range, $71-$860). Lastly, the overall mean cost of management of reported exposures for source patients infected with hepatitis C virus ($n = 4$) was $650 (range, $186-$856).

CONCLUSIONS. Management of occupational exposures to blood and body fluids is costly; the best way to avoid these costs is by prevention of exposures.

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Occupational exposures to blood through needle sticks and other injuries from sharp objects, contact with mucous membranes, and splashes to nonintact skin are frequently reported by healthcare personnel.[1,2] The Centers for Disease Control and Prevention (CDC) has estimated that approximately 1,000 injuries from sharp objects are sustained daily in US hospitals.[2] Up to 50% of some types of surgery result in a mucocutaneous contact with blood,[3-7] and at least half of these exposures in operating rooms are from blood-hand contacts.[4,6] Exposures such as these have the potential for transmission of bloodborne viruses such as hepatitis B virus (HBV), hepatitis C virus (HCV), and human immunodeficiency virus (HIV).[1,8,9] The risk of infection transmission is greatest through percutaneous exposures to blood, that is, from needle sticks or cuts or punctures from sharp objects.[4-6] Although needle sticks and other injuries from sharp objects have been associated with the transmission of up to 30 different pathogens,[10] the 3 pathogens of greatest concern for healthcare personnel—HBV, HCV, and HIV—are all bloodborne.[1,8,9]

Transmission rates for HBV,[8] HCV,[1,11-13] and HIV[9] vary by pathogen but are estimated to be 6%-30% for HBV and 0.3% for HIV after a percutaneous exposure. HCV transmission rates have been reported to be between 0.5% and 10%, with an average of approximately 1.8%.[1,11-13] In addition, transmission rates vary by type and severity of exposure; for example, the HIV transmission rate is estimated to be 0.3% for a percutaneous exposure, 0.1% for a mucous membrane exposure, and even lower for a nonintact skin exposure.[9] Although seroconversion is an infrequent event, healthcare employers have a responsibility to their personnel to prevent

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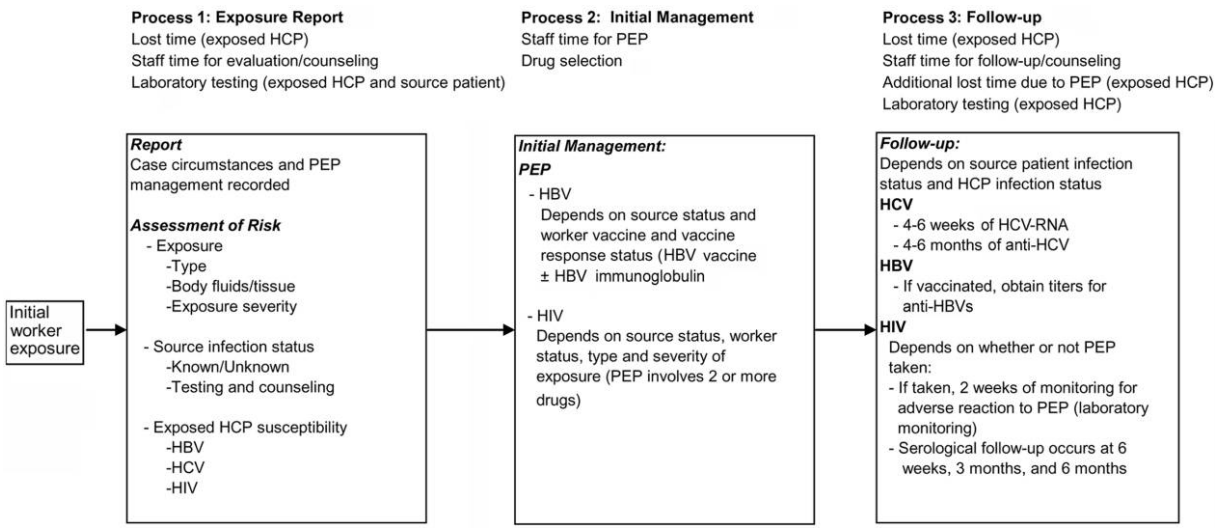


FIGURE 1. Three processes involved in resource allocation for management of occupational exposures to blood and body fluids. HBV, hepatitis B virus; HCP, healthcare personnel; HCV, hepatitis C virus; PEP, postexposure prophylaxis.

and manage exposures. The United States Public Health Service (USPHS) first published guidelines for management of occupational exposures to HIV in 1985.[14] Comprehensive guidelines for management of occupational exposures to HBV, HCV, and HIV were published in 2001,[15] and updates to the management guidelines for HIV exposure were published in 2005.[16] The 2001 guidelines give practice recommendations for the management of occupational exposures to bloodborne pathogens and advise an administration-level approach for establishing an exposure-management protocol in a healthcare institution.[15]

The flow of resources used to implement the management practices recommended by the guidelines is illustrated in Figure 1. The processes involved in exposure management include (1) exposure reporting and assessment of infection risk, including assessment of the type and severity of exposure and bloodborne infection status of the source patient; (2) initial wound management and postexposure prophylaxis (PEP); and (3) follow-up and counseling for the exposed personnel.[15] Appropriate management of occupational exposures can require expenditures by healthcare institutions. Furthermore, exposure management, including testing, treatment, and counseling, can have physical and emotional side effects for the exposed healthcare personnel.[17,18] In assessing the costs borne by a healthcare institution, one can consider both dollars and time expended not only by the exposed employee but also by all staff involved in the management of an exposure. An injured healthcare personnel exposed to a bloodborne virus should have initial testing, counseling, and follow-up. This may require labor by occupational healthcare personnel (eg, physicians, nurses, pharmacists, laboratory workers, and phlebotomists); likewise, the source patient must be counseled and tested, which requires additional labor, testing, and supplies.

Previous studies have addressed the costs involved in exposure management.[19-36] A review of these studies found that the estimated average cost per exposure (to the healthcare institution) ranged from $51 to $3,766 (in 2002 US dollars) and that the variability in costs was a result of differences in study methodology and/or the protocols for exposure management in the study institutions.[36] Limitations of these studies include reliance on information from only a single facility, use of multiple assumptions about salaries, and limited information on both the type of pathogen to which the healthcare personnel were exposed as well as exposure severity.[19-36] Also, many of these studies are more than 10 years old. We therefore assessed recent costs of management of occupational exposures to blood and body fluids and the effect of factors such as exposure type, healthcare worker type, and exposure severity on costs to the hospital. This cost analysis was done from the perspective of hospital administrators (ie, excluding costs resulting from possible disease transmission and the societal costs resulting from any morbidity and mortality attributable to the exposure), because they are usually ultimately responsible for making the decisions regarding commitment of resources to exposure management. These data are important for evaluation of the benefits (cost savings) of interventions to prevent occupational exposures (eg, the adoption of needle devices with engineered safety features) and can be combined with data on the incidence of injury to estimate the cost to the healthcare institution.[37,38]

## METHODS

Data were collected in 2003 from a convenience sample of 4 different facilities: a 600-bed public hospital, a 244-bed Veterans Affairs medical center, a 437-bed rural tertiary care hospital, and a 3,500-bed healthcare system. Facilities with

TABLE 1. Characteristics of Facilities and Occupational Exposures to Blood and Body Fluids Studied

| Characteristic | Facility 1 | Facility 2 | Facility 3 | Facility 4 | Total |
|---|---|---|---|---|---|
| Facility setting | Urban | Urban | Rural | Urban | |
| No. of beds | 600 | 3,500 | 437 | 244 | |
| Facility type | Public | Healthcare system | Tertiary care | Veterans Affairs | |
| No. of exposures | 7 | 6 | 9 | 9 | 31 |
| Exposure type | | | | | |
| Percutaneous | 4 (57) | 4 (67) | 4 (44) | 5 (56) | 17 (55) |
| Mucosal | 0 | 2 (33) | 1 (11) | 2 (22) | 5 (16) |
| Nonintact skin | 2 (29) | 0 | 3 (33) | 2 (22) | 7 (23) |
| Intact skin[a] | 1 (14) | 0 | 1 (11) | 0 | 2 (6) |
| Exposure severity[b] | | | | | |
| Less severe | 3 (43) | 5 (83) | 5 (71) | 7 (88) | 20 (71) |
| More severe | 4 (57) | 1 (17) | 2 (29) | 1 (12) | 8 (29) |
| Exposure volume[c] | | | | | |
| Small | 6 (86) | 4 (67) | 4 (57) | 9 (100) | 23 (79) |
| Large | 1 (14) | 2 (33) | 3 (43) | 0 | 6 (21) |
| Infection status of source patient | | | | | |
| HIV positive only | 3 (43) | 0 | 1 (11) | 3 (33) | 7 (23) |
| HIV and HBV positive | 2 (28) | 0 | 0 | 0 | 2 (6) |
| HIV and HCV positive | 1 (14) | 2 (33) | 1 (11) | 0 | 4 (13) |
| HIV, HBV, and HCV positive | 0 | 0 | 5 (56) | 1 (11) | 6 (19) |
| HCV positive only | 0 | 1 (17) | 0 | 3 (33) | 4 (13) |
| Unknown or not infected | 1 (14) | 3 (50) | 2 (22) | 2 (22) | 8 (26) |

NOTE. Data are no. (%) of exposures, unless otherwise indicated. HBV, hepatitis B virus; HCV, hepatitis C virus; HIV, human immunodeficiency virus.

[a] Intact skin exposures were considered to be negligible risks for virus transmission.

[b] Information on exposure severity was missing for 2 of the surveys from facility 3 and 1 of the surveys from facility 4.

[c] Information on exposure volume was missing for 2 of the surveys from facility 3.

varying organizational characteristics were chosen to capture the costs across different organizations. A standardized data-collection form was used to collect information about a variety of exposures that differed in type and severity. Severity was classified on the basis of exposure type, volume of exposure (small or large), and the infection status of the source patient, which is consistent with CDC/USPHS guidelines.[15,16] Detailed information on actual costs (eg, of tests and supplies), time spent, and salary for all involved, including both the exposed personnel and the staff who managed the exposure, was collected. Each facility was asked to provide information for up to 9 hypothetical exposure scenarios (see Table A in the Appendix for a description of scenarios) and to supply actual costs (rather than charges) whenever possible. Facility-specific data supplied to us were based on expert opinion and/or matched our scenarios to actual cases from their records. Lastly, each facility was asked to provide a description of its protocol for exposure management.

### Detailed Data Description

The data-collection form was designed to identify all the costs associated with postexposure management that could accrue for the facility, including lost wages for the exposed healthcare personnel from evaluation, testing, and treatment; additional lost wages for the exposed healthcare personnel from work days lost as a result of follow-up appointments and side effects from the treatment; wages of all staff involved in postexposure management (from reporting through follow-up); all laboratory costs for the exposed healthcare personnel and the source patients; and all drug costs associated with PEP for HBV and HIV exposures.

For each of these categories—cost, time expended, and wages—the following data were provided: range (minimum-maximum), probability of extremes, most frequent response, and probability of most frequent response. Personnel salaries were based on real wage figures at each of the facilities, and a weighted average from the frequencies of the actual wages was calculated for use in our cost computation. Time costs were subdivided into time costs for the exposed employee and time costs for all other staff involved in the exposure management. Time cost for the exposed employee included time for initial reporting and treatment, time spent for follow-up appointments, and additional work time missed due to side effects of PEP. Time cost for staff involved in the exposure management process included time for initial reporting, initial source testing, source patient testing and counseling, and follow-up appointments and counseling for the exposed employee. Total cost components were computed as wages (including benefits) lost to PEP adverse events, costs of source tests, laboratory costs, costs of PEP, personnel wages, and wages of the exposed healthcare personnel. Data on costs for management of seroconversion for healthcare personnel, workers' compensation fees, and other peripheral costs were not collected.

TABLE 2. Mean Costs of Management of Occupational Exposures to Blood and Body Fluids, According to Infection Status of Source Patient or Exposure Type

| Cost type | Mean cost (% of total cost), by infection status of source patient | | | | | | Mean cost (% of total cost) for all HIV exposures[b] | Mean cost (% of total cost), by exposure type | |
|---|---|---|---|---|---|---|---|---|---|
| | HIV negative[a] | HCV positive only | HIV positive only | HIV and HBV positive | HIV and HCV positive | HIV, HBV, and HCV positive | | Less severe exposures | More-severe exposures |
| No. of exposures | 12 | 4 | 7 | 2 | 4 | 6 | 19 | 20 | 8 |
| Wages of exposed HCP | $68 (18) | $136 (21) | $344 (13) | $196 (7) | $182 (8) | $201 (9) | $249 (10) | $148 (12) | $307 (10) |
| Wages of staff involved | $118 (31) | $191 (29) | $366 (14) | $523 (19) | $424 (18) | $263 (11) | $362 (15) | $239 (20) | $412 (14) |
| Additional wages[c] | $21 (6) | $0 | $451 (18) | $279 (10) | $163 (7) | $289 (13) | $321 (13) | $100 (8) | $514 (17) |
| Lab costs for exposed HCP | $78 (21) | $189 (29) | $561 (22) | $656 (23) | $547 (24) | $678 (30) | $605 (25) | $323 (26) | $676 (22) |
| Lab costs for source patient | $25 (7) | $104 (16) | $159 (6) | $102 (4) | $25 (1) | $66 (3) | $96 (4) | $65 (5) | $133 (4) |
| Costs of PEP | $66 (17) | $30 (5) | $692 (27) | $1,054 (38) | $975 (42) | $790 (34) | $820 (33) | $349 (28) | $999 (33) |
| Total cost | | | | | | | | | |
| Mean[d] | $376 | $650 | $2,577 | $2,810 | $2,316 | $2,291 | $2,456 | $1,225 | $3,042 |
| Range | $71-$860 | $186-$856 | $907-$4,838 | $2,644-$2,973 | $1,663-$2,945 | $1,649-$3,703 | $907-$4,838 | $71-$2,945 | $1,663-$4,838 |

NOTE. Costs are given in 2003 US dollars. HBV, hepatitis B virus; HCP, healthcare personnel; HCV, hepatitis C virus; HIV, human immunodeficiency virus; Lab, laboratory testing; PEP, postexposure prophylaxis.

[a] HIV-negative status refers to any exposure in which the source patient was not found to be HIV positive and includes exposures to source patients who were only HCV positive, source patients with unknown infection status, source patients with no infection, and source patients with unknown infection status.

[b] All HIV exposures includes exposures to source patients positive for only HIV, source patients positive for HIV and HBV, source patients positive for HIV and HCV, and source patients positive for HIV, HBV, and HCV.

[c] These additional wages were for lost time due to PEP adverse events.

[d] The mean total cost may vary slightly from the sum of the cost components because the mean total cost often included negligible costs of supplies and the cost of medications for the side effects of HIV postexposure prophylaxis (eg, antimotility medications).

### Costs Versus Charges and Unit Cost

Costs were assessed from an institutional perspective and thus were considered in terms of actual costs rather than charges. Further, costs were "unit costs," which included in each unit a fixed, proportioned-per-service cost for overhead—for example, room allocation or facility maintenance. This was done to ensure consistency across the 4 facilities.

The time frame of the analysis (the length of time associated with a treatment or an intervention) corresponds to the length of time in which hospital personnel and resources are used for postexposure management. Consistent with the hospital-level perspective of this cost analysis, the analytic horizon of the analysis (the time period during which the costs of postexposure management accrue) considers only these hospital costs and does not consider the potential costs associated with seroconversion. Although the costs saved by prevention of disease (especially HIV) can be substantial, these benefits are more diffuse and can accrue to parties other than the hospital. Because this study is a cost analysis of postexposure management (as opposed to a cost-effectiveness analysis), these cost savings were not measured.[39]

## RESULTS

We analyzed data for 31 reported exposure scenarios: 5 (16%) mucosal exposures, 9 (29%) cutaneous exposures (2 involving intact skin and 7 involving nonintact skin), and 17 (55%) percutaneous exposures. The characteristics of these exposures are summarized in Table 1. The exposure management protocols for each of the 4 facilities were consistent with USPHS guidelines.[15]

The infection status for the source patients in 31 exposure scenarios was as follows: 19 were HIV positive, 8 were HBV positive, 14 were HCV positive, 6 had unknown status, and 2 were not infected (Tables 1 and 2). Some of the source patients were coinfected with HIV and HBV and/or HCV (hereafter, "HIV coinfected"). Infection status was classified as unknown or not infected, HCV positive only, HIV positive only, and HIV coinfected (8, 4, 7, and 12 patients, respectively). There were no source patients infected with only HBV, but 2 were coinfected with HBV and HIV, and 6 were coinfected with HBV, HCV, and HIV. Another 4 were coinfected with HCV and HIV. Eight exposures (29%) were considered to be more severe, and 6 exposures (21%) were large-volume exposures.

Time expended by the exposed healthcare personnel and the staff involved in exposure management represented significant cost in wages lost. Figure 2 shows the mean time expenditure for both the exposed healthcare personnel and the staff involved in exposure management for exposure scenarios involving HIV-coinfected source patients ($n = 12$), HIV-infected source patients without coinfection ($n = 7$), and source patients with unknown or negative HIV-infection status ($n = 8$). Healthcare personnel exposed to HIV-coinfected source patients required the greatest amount of personal and professional attention, with a mean total time cost of 452 healthcare personnel minutes (range, 192-740 health-

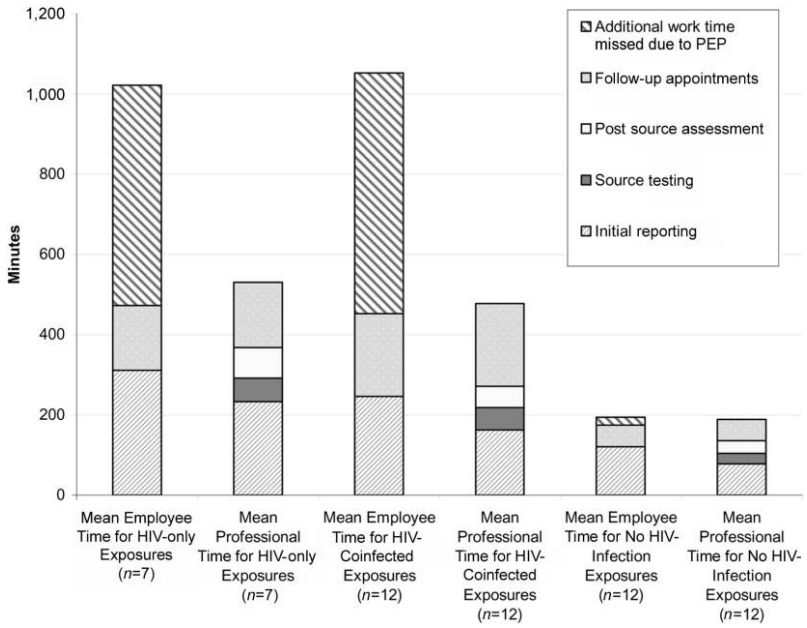


FIGURE 2. Mean time expenditure associated with management of occupational exposures to blood and body fluids. HIV, human immunodeficiency virus; PEP, postexposure prophylaxis.

care personnel minutes) and 272 professional minutes (range, 81-635 professional minutes). This time lost from work represented a mean of $194 in wages for exposed healthcare personnel (range, $118-$281) and $360 in staff wages (range, $28-$715). Additional mean costs according to type of exposure and by infection status of the source patient are shown in Table 2.

For all 31 exposures, PEP costs represented 31% of the overall mean cost, whereas laboratory costs (for tests of both the exposed healthcare personnel and the source patients) represented 30%. The wages of the exposed healthcare personnel and the staff comprised the remaining 39% of the overall total cost of management of occupational exposures to blood and body fluids, which had a mean total cost of $1,687 (range, $71-$4,838) per exposure. However, the most appropriate way to reference the most representative mean cost of exposure is to refer to the specific infection status of the source patient.

With regard to the management of the 19 HIV exposures, there were 7 exposures to HIV alone; 2 exposures to HIV and HBV; 4 exposures to HIV and HCV; and 6 exposures to HIV, HBV, and HCV (Table 1). Healthcare personnel exposed to HIV spent a mean of 459 minutes (range, 192-755 minutes) for reporting exposures and engaging in follow-up for exposures, which represented a mean of $249 (range, $87-$1,051) in wages. Laboratory costs for the exposed healthcare personnel comprised 25% of the overall total cost of management of HIV exposures, whereas laboratory costs for the source patients comprised only 4%. Costs of PEP for HIV and HBV, with a mean of $820 (range, $357-$1,626), comprised the remaining 33% of the overall cost. The overall mean cost for all exposures is shown according to infection status of the source patient in Table 2.

Table 3 presents an accounting of the resource usage across the 3 processes involved in exposure management. The largest proportion of resources were consumed during postexposure follow-up (process 3 in Table 3), for which the average cost of follow-up was $848 (50% of total cost). Laboratory costs represented the largest component of follow-up costs, at $422 (50% of follow-up costs). Lost wages for the exposed employee represented the second largest component, at $300 (35% of follow-up costs), but also were the most variable (range, $6-$1,764), depending on the type of worker and the number of hours lost as a result of the exposure. Staff involved in management of exposure follow-up were limited to physicians and nurses. Time spent by staff on the initial evaluation of the exposed healthcare personnel and the source patients represented the largest proportion of the cost of process 1 (44% of mean total cost). The mean cost associated with administration of PEP was $706.

## DISCUSSION

There have been many previous studies that addressed the cost of management of exposures to blood and body fluids; however, none has measured the costs of all the elements that USPHS recommends be included in exposure management. Table 4 is a modification of a summary table from a systematic review by Lee et al.[36] of the literature on the epidemiologic and economic impact of needlestick injuries in US hospitals.

TABLE 3. Costs of Following the Guidelines for Management of Occupational Exposures to Blood and Body Fluids

| Management process, cost type | No. of exposures[a] | Cost | | |
|---|---|---|---|---|
| | | Mean | Range | Median |
| Process 1 | | | | |
| Exposed HCP time, min | 31 | 212 | 55-515 | 165 |
| Exposed HCP wages | 31 | $119 | $21-$826 | $63 |
| Staff time, min | 31 | 191 | 49-470 | 125 |
| Staff wages | 31 | $129 | $17-$310 | $96 |
| Laboratory costs | 29 | $50 | $19-$80 | $50 |
| Drug costs | … | … | … | … |
| Total monetary cost[b] | 31 | $296 | $71-$1,198 | $228 |
| Process 2 | | | | |
| Exposed HCP time, min | … | … | … | … |
| Exposed HCP wages | … | … | … | … |
| Staff time, min | 16 | 97 | 29-165 | 71 |
| Staff wages | 16 | $76 | $11-$133 | $51 |
| Laboratory costs | … | … | … | … |
| Drug costs | 23 | $706 | $71-$1,626 | $682 |
| Total monetary cost[b] | 31 | $563 | $0-$1,647 | $500 |
| Process 3 | | | | |
| Exposed HCP time, min | 28 | 158 | 4-360 | 153 |
| Exposed HCP wages | 28 | $300 | $6-$1,764 | $172 |
| Staff time, min | 27 | 157 | 15-360 | 140 |
| Staff wages | 27 | $125 | $0-$600 | $124 |
| Laboratory costs | 27 | $422 | $17-$950 | $344 |
| Drug costs | … | … | … | … |
| Total monetary cost[b] | 31 | $848 | $0-$2,724 | $412 |

NOTE. Process 1 was initial evaluation, process 2 was exposure management, and process 3 was exposure follow-up: see Figure 1. Monetary costs and wages are given in 2003 US dollars. HCP, healthcare personnel.

[a] For all cost types except total monetary costs, the number of exposures includes only observations for which the amount is greater than 0.

[b] Total monetary cost may not equal the sum of the individual mean costs because the sample includes observations with amounts equal to 0.

We expanded the table to include additional studies and the cost perspective of each study. Our study considers all possible costs of management of exposures to blood and body fluids borne by a healthcare facility, excluding the cost of management of seroconversion and the psychological toll on those involved in exposure management. Many of the other studies did not provide or describe the individual cost components, and it was difficult to determine what comprised their final cost estimate. Further, some studies did not include testing of the source patient, considered only the PEP costs for 1 type of infection, or had a cost perspective that included a broader social perspective (such as calculation of disability-adjusted life years).

We deliberately collected cost estimates from different types of healthcare facilities and for a variety of scenarios, to get a more complete picture of the range of costs of exposure management for a hospital. To aggregate costs among the facilities, we captured unit costs instead of charges from each facility. Further, we have described the allocation of resources and costs across the work processes that comprise exposure management, providing a picture of where costs accrue as the various tasks are performed. This gives a more complete picture of the real costs of management of exposures to blood and body fluids at the hospital level. It is important to note, however, that our data are not necessarily generalizable to all healthcare facilities. Our data overall represent the more extreme end of the exposure spectrum, because 19 (61%) of 31 observations involved HIV exposure and only 8 (25%) involved source patients who were uninfected or had unknown infection status. In the CDC's occupational exposure surveillance system (NaSH), only approximately 5% of reported exposures to blood and body fluids involved source patients infected with HIV, and approximately 12% involved any bloodborne pathogen (A.L.P., unpublished CDC data). Moreover, 12 of our observations involved source patients positive for more than 1 pathogen, which further inflates the mean total cost. So, our mean total costs may be overestimates because of the overrepresentation of exposures to infected source patients. Thus, we caution against looking at the total mean costs; instead, one should look at our report of the total costs stratified by pathogen and by process components of the management protocol.

Nonetheless, management of exposures to uninfected source patients or exposures in which the source is unknown still accrues an average cost of $376 (range, $71-$860; 8 exposures), thus, these exposures still require expenditure by

TABLE 4. Overview of Literature on the Costs of Exposures to Blood and Body Fluids

| Study, year | Study perspective | Study setting | Cost components included | | | | | | | | Cost[b] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Laboratory tests | Testing of source patient | HBV PEP | HIV PEP | Staff or technician labor | Counseling | Lost productivity[a] | Treatment of infection | |
| Ruben et al.,[19] 1983 | Institutional | Single facility | Yes | No | No | No | Yes | No | Yes | No | $54-$104 |
| Jagger et al.,[21] 1990 | Institutional | Single facility | Yes | Yes | Yes | No | Yes | No | No | No | $390-$456 |
| Sellick et al.,[23] 1991 | Institutional | Single facility | Yes | NC | Yes | No | No | No | No | No | $62 |
| Laufer and Chiarello,[33] 1994 | Institutional | Multicenter facility | Yes | No | Yes | Yes | Yes | Yes | No | No | $363 |
| Orenstein et al.,[24] 1995 | Institutional | Single facility[c] | Yes | Yes | Yes | No | Yes | No | No | No | $789 |
| Friedland et al.,[25] 1996 | Patient, payer, and provider | NA | NC | NC | NC | NC | NC | NC | Yes | Yes | $521 |
| Pinkerton and Holtgrave,[26] 1997 | Societal | None; model | No | No | No | Yes | No | Yes | No | No | $721 |
| Mendelson et al.,[29] 1998 | Institutional | Single facility | Yes | Yes | No | Yes | NC | Yes | Yes | No | $636, or $230 per 1,000 patient-days |
| Jagger et al.,[28] 1998 | Institutional | Multicenter facility | Yes | Yes | Yes | Yes | NC | No | NC | No | $0-$1,232[d] |
| Dale et al.,[27] 1998 | Institutional | Single facility | Yes | No | Yes | No | Yes | No | No | No | $311-$561 |
| Swotinsky et al.,[30] 1998 | Institutional | Single facility | Yes | No | No | Yes | Yes | Yes | No | No | $669 |
| Roudot-Thoraval and Montagne,[31] 1999 | Institutional | Single facility | Yes | Yes | No | Yes | No | No | Yes | Yes | $4,000 per injury prevented |
| Holodnick and Barkauskas,[35] 2000 | Institutional | Single facility | Yes | Yes | Yes | Yes | Yes | No | No | Yes | $141-$1,699 |
| Kallenborn et al.,[32] 2001 | Institutional | Single facility | Yes | No | No | Yes | No | No | Yes | No | $466 |
| Dziekan et al.,[34] 2003 | Societal | Multicenter facility | No | No | No | No | No | No | No | Yes | Measured in DALY |
| Present study | Institutional | Multicenter facility | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | $1,687 |

NOTE. "Yes" indicates that a cost component was definitively included in the total cost; "no" indicates that a cost component was definitively excluded from the total cost. DALY, disability-adjusted life years; HBV, hepatitis B virus; HIV, human immunodeficiency virus; NA, not applicable; NC, not clear whether a cost component was included in the cost; PEP, postexposure prophylaxis. Modified from Lee et al.[36]

[a] Few of these studies explained whether "lost productivity" included only initial employee time or included additional time lost due to, for example, treatment, follow-up, and/or postexposure counseling.

[b] Cost is per exposure unless otherwise indicated. Costs were not always reported by dollar year (note that the study year is given in the first column).

[c] Cost analysis did not include events outside of the study units, which were 6 inpatient units, 3 general medical units, 2 surgical units, and 15 surgical/trauma intensive care units.

[d] Several costs per exposure were reported; shown here is the overall average.

hospitals, albeit less than for exposures to infected source patients. Further, as shown in Table 3, the mean cost of process 1 ($296) is lower than the mean costs of the other 2 processes ($563 for process 2 and $848 for process 3). Because most exposures managed by facilities are likely to be exposures to uninfected source patients, the costs from processes 2 and 3 would contribute little to the total costs of exposure management for a large number of exposures.

The primary economic impact of occupational exposures to blood and body fluids is from the costs of HIV PEP, the costs of all laboratory tests, and all time lost by the exposed healthcare personnel and the staff involved in exposure management. More than 50% of the final mean cost came from HIV PEP, laboratory tests, and follow-up appointments, which shows that it is more expensive to manage exposures to HIV-positive source patients than exposures to HIV-negative source patients. These cost data could be used to perform a cost-effectiveness analysis of adopting measures for prevention of exposures, including the use of safety devices or the provision of safety training for sharp instruments.

The guidelines for exposure management do not provide much leeway for economizing; that is, it is difficult to shift resources between personnel and materials to reduce costs. Because personnel costs represent a smaller component of the total costs, the avoidance of severe exposures and the costs associated with PEP will achieve a greater reduction of the costs of exposure management. As illustrated in Table 3, even exposures to uninfected source patients or source patients whose infection status is unknown require expenditures by healthcare facilities, albeit less than for exposures to infected source patients.

Because the data were collected from a small convenience sample of hospitals, the results may not be generalizable to all exposures in all hospitals. It is also difficult to estimate the mean costs for certain situations; in particular, we did not have any cases of exposure to HBV only. Moreover, because our analysis took a narrower cost perspective, we did not collect data on the costs of seroconversion in employees, the costs of recommended worker's compensation insurance, or the emotional or psychological costs to the involved personnel. Lastly, although our data were not randomly selected nor independently made observations, they nevertheless may be worthwhile for assessment of factors that may affect the overall cost of management of occupational exposures to blood and body fluids.

Management of occupational exposures to blood and body fluids is expensive, even if the source patient is not infected. To avoid these costs, healthcare facilities should investigate whether there are cost-effective interventions that can prevent or reduce exposures and help avoid the physical, emotional, and fiscal toll of exposure management.

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## APPENDIX

### Hypothetical Scenarios of Occupational Exposure to Blood and Body Fluids

Scenarios are summarized in Table A. We assumed that the hospitals' exposure-management protocols did not vary for exposure to HBV and HCV but did vary for exposure to HIV. Hospitals were asked to provide an outline (not policy) of the general elements of exposure management in their facility. Additionally, they were asked about the types of exposure for which they would give 2 or 3 drugs for HIV PEP, their routine for serologic testing for HIV and HCV after exposure, and their routine schedule for monitoring of laboratory abnormalities in healthcare workers receiving PEP.

TABLE A. Scenarios of Occupational Exposure to Hepatitis B Virus (HBV), Hepatitis C Virus (HCV), and Human Immunodeficiency Virus (HIV)

| Scenario | Exposure type | Exposure details | Additional notes on exposure scenario |
|---|---|---|---|
| 1 | Insignificant | Insignificant risk of virus transmission | Requires only counseling and reassurance and no testing; HBV vaccine may need to be given if exposed individual is unvaccinated |
| 2 | Nonintact skin | Small volume, short duration | None |
| 3 | Nonintact skin | Large volume, long duration | None |
| 4 | Mucous membrane | Small volume | Will not need to take action if exposure management is the same as for scenario 2 |
| 5 | Mucous membrane | Large volume | Will not need to take action if exposure management is the same as for scenario 3 |
| 6 | Percutaneous injury | Superficial injury with a solid-bore sharp object | None |
| 7 | Percutaneous injury | Superficial injury with a hollow-bore needle | Source patient is HIV infected without an elevated viral load |
| 8 | Percutaneous injury | Deep puncture | Source patient is HIV infected and has symptomatic infection |
| 9 | Percutaneous injury | Deep puncture | Source patient is antiretroviral-treatment experienced and HIV infected, with a high viral load |

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