Occupationally Acquired Human Immunodeficiency Virus (HIV) Infection: National Case Surveillance Data During 20 Years of the HIV Epidemic in the United States •
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Source: *Infection Control and Hospital Epidemiology*, Vol. 24, No. 2 (February 2003), pp. 86-96
Published by: The University of Chicago Press on behalf of The Society for Healthcare Epidemiology of America
Stable URL: http://www.jstor.org/stable/10.1086/502178
Accessed: 15/05/2014 01:40

OCCUPATIONALLY ACQUIRED HUMAN IMMUNODEFICIENCY VIRUS (HIV) INFECTION: NATIONAL CASE SURVEILLANCE DATA DURING 20 YEARS OF THE HIV EPIDEMIC IN THE UNITED STATES

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ABSTRACT

OBJECTIVE: To characterize occupationally acquired human immunodeficiency virus (HIV) infection detected through case surveillance efforts in the United States.

DESIGN: National surveillance systems, based on voluntary case reporting.

SETTING: Healthcare or laboratory (clinical or research) settings.

PATIENTS: Healthcare workers, defined as individuals employed in healthcare or laboratory settings (including students and trainees), who are infected with HIV.

METHODS: Review of data reported through December 2001 in the HIV/AIDS Reporting System and the National Surveillance for Occupationally Acquired HIV Infection.

RESULTS: Of 57 healthcare workers with documented occupationally acquired HIV infection, most (86%) were exposed to blood, and most (88%) had percutaneous injuries. The circumstances varied among 51 percutaneous injuries, with the largest proportion (41%) occurring after a procedure, 35% occurring during a procedure, and 20% occurring during disposal of sharp objects. Unexpected circumstances difficult to anticipate during or after procedures accounted for 20% of all injuries. Of 55 known source patients, most (69%) had acquired immunodeficiency syndrome (AIDS) at the time of occupational exposure, but some (11%) had asymptomatic HIV infection. Eight (14%) of the healthcare workers were infected despite receiving postexposure prophylaxis (PEP).

CONCLUSIONS: Prevention strategies for occupationally acquired HIV infection should continue to emphasize avoiding blood exposures. Healthcare workers should be educated about both the benefits and the limitations of PEP, which does not always prevent HIV infection following an exposure. Technologic advances (eg, safety-engineered devices) may further enhance safety in the healthcare workplace (*Infect Control Hosp Epidemiol* 2003;24:86-96).

Early in the human immunodeficiency virus (HIV) epidemic, occupationally acquired HIV infection was recognized as a risk to healthcare workers,[1] leading to numerous efforts to collect data on occupational HIV exposures and infections in the United States. Prospective studies of HIV-exposed healthcare personnel conducted in the early years of the epidemic focused on defining and quantifying the risk for HIV infection associated with different types of occupational exposures (eg, percutaneous or mucocutaneous).[2-6] Serologic surveys estimated the prevalence of and risk for HIV infection among different occupational groups.[7-10] In the 1980s, national surveillance data on the acquired immunodeficiency syndrome (AIDS) were reviewed in an initial attempt to identify potentially unrecognized cases of occupationally acquired HIV infection; on the basis of that review, no specific occupational exposures could be implicated as the source of infection for any of the healthcare workers with AIDS reported at that time.[11]

Although occupationally acquired HIV infection was thought to be rare in the United States, it was clear that descriptive information from ongoing case surveillance was needed to understand how occupational HIV exposure and infection occur. This information was needed to develop effective prevention strategies and to keep the strategies relevant as medical technology and work practices change over time in healthcare settings. Thus, in 1991 the then Centers for Disease Control developed a standardized protocol for state and local health departments to investigate cases of AIDS reported in healthcare workers with no identified risk for HIV.[12] The objectives of the surveillance for occupational HIV transmission among healthcare workers were to monitor occupational HIV transmission and to identify circumstances that may have led to such transmission.

Over time, data from case surveillance efforts in the United States have remained important in understanding occupationally acquired HIV infection and have been wide-

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The authors thank the HIV/AIDS surveillance personnel at state and local health departments for their valuable roles in monitoring cases of occupationally acquired HIV infection and Drs. Elise Beltrami, Adelisa Panlilio, and Denise Cardo and Ms. Linda Chiarello for their helpful comments on this manuscript.

ly used in that context. The data have been valuable in the development of infection control measures, which have been shown to be effective at reducing the frequency of healthcare workers' occupational exposures to blood, a potential source of infection with HIV and other bloodborne pathogens.[13-21] Surveillance data from the United States were included in an international case–control analysis that examined the risk factors for occupationally acquired HIV infection.[22] Selected case reports of occupationally acquired HIV infection have been published, highlighting special circumstances of interest; the published information on these case reports was summarized in a review article.[23] In addition, information on cases of occupationally acquired HIV infection has been disseminated regularly by the Centers for Disease Control and Prevention (CDC) through an HIV/AIDS surveillance report and fact sheet.[24,25]

Despite the wide use of surveillance data, some details, particularly on the circumstances of occupational HIV transmission, have not been described previously. We summarize here the national surveillance data on HIV infection and AIDS among healthcare workers in the United States reported through December 2001, focusing on those with documented occupationally acquired HIV infection. The updated surveillance information may be helpful in refining occupational HIV prevention strategies for healthcare workers and may add to the current general understanding about occupationally acquired HIV infection.

METHODS

In the United States, data on HIV infection and AIDS among healthcare workers have been collected through two major surveillance mechanisms, the HIV/AIDS Reporting System and the National Surveillance for Occupationally Acquired HIV Infection. These surveillance mechanisms provided information for characterizing HIV-infected healthcare workers, evaluating the role of HIV infection related to occupational exposures, and describing the exposures that may have led to infection.

The HIV/AIDS Reporting System

HIV/AIDS surveillance efforts in the United States began with the reporting of the first case of AIDS to the Centers for Disease Control in 1981.[26] Since that time, policies have been implemented nationwide to require the confidential reporting by name of AIDS cases by healthcare providers to state and local health departments; AIDS cases are reported from state and local health departments to the CDC without names or other identifying information. Currently, the CDC receives AIDS case reports from all 50 states, the District of Columbia, and U.S. trusts and territories. Past employment in healthcare settings is recorded on the surveillance case report form. Those who indicate employment in a healthcare, clinical, or HIV production or research laboratory setting at any time since 1978, including students and trainees, are defined as healthcare workers.

Unlike AIDS reporting, the reporting of HIV infection (without AIDS) has not yet been fully implemented in all areas in the United States. Recognizing the importance of timely HIV surveillance data to ongoing prevention efforts, the CDC has published guidelines for conducting case surveillance for HIV infection.[27] An increasing number of areas in the United States are implementing reporting requirements for HIV infection.[24] However, because the national surveillance data on HIV infection remain incomplete, information in this report is based primarily on national surveillance data on AIDS.

The National Surveillance for Occupationally Acquired HIV Infection

Healthcare workers with AIDS who are reported without any known risk for HIV infection are investigated by state and local health departments using a standardized protocol, which was developed and implemented in 1991. In addition, the Centers for Disease Control requested that health departments also investigate other reports (eg, from physicians or from published sources of information) of healthcare workers who may have occupationally acquired HIV infection even if they did not meet the criteria of the AIDS surveillance case definition and the state does not have formal requirements for HIV infection reporting.[12]

The protocol for investigating potential cases of occupationally acquired HIV infection includes a review of medical records, discussions with the worker's healthcare providers, and an interview with the worker by health department staff. The objectives of the interview are to obtain information about possible exposures to HIV, including behavioral and transfusion risks, and to evaluate past occupational exposures. Information regarding previous serologic testing for HIV antibodies; details about the source patient (the patient whose blood or body fluid was the source of the healthcare worker's occupational exposure); history of an illness compatible with primary HIV infection and of antiretroviral prophylaxis; and details about the circumstances of the occupational exposure, including type of device and procedure being performed, are also collected. Incident reports and employee health records are reviewed when available.

On the basis of the results of these investigations, healthcare workers with no other HIV risk exposure may be classified as having possible or documented occupationally acquired HIV infection.[12] Individuals classified as having *possible* occupationally acquired HIV infection have no identified behavioral or transfusion risk for HIV infection and have a history of percutaneous occupational exposures, mucocutaneous occupational exposures, or both to blood or body fluids of patients or to laboratory specimens containing HIV. However, the time and source of HIV infection for these healthcare workers could not be documented, and seroconversion to HIV as a result of an occupational exposure could not be definitively established.

Healthcare workers are classified as having *documented* occupationally acquired HIV infection if they have evidence of HIV seroconversion in temporal association

TABLE 1
CHARACTERISTICS OF HEALTHCARE WORKERS WITH DOCUMENTED AND POSSIBLE OCCUPATIONALLY ACQUIRED HUMAN IMMUNODEFICIENCY VIRUS (HIV) INFECTION REPORTED TO THE U.S. NATIONAL SURVEILLANCE FOR OCCUPATIONALLY ACQUIRED HIV INFECTION AS OF DECEMBER 2001

Characteristic	Surveillance Categories for Occupationally Acquired HIV Infection*: Documented (n = 57)	Possible (n = 138)
Median age, y (range)	33 (22 to 62)	38 (22 to 68)
Gender		
Female	45 (79%)	56 (41%)
Male	12 (21%)	82 (59%)
Reported clinical status†		
AIDS	26 (46%)	121 (88%)
Not AIDS	31 (54%)	17 (12%)
Occupation		
Nurse	24 (42%)	35 (25%)
Laboratory technician, clinical	16 (28%)	17 (12%)
Physician, nonsurgical	6 (11%)	12 (9%)
Laboratory technician, nonclinical	3 (5%)	—
Housekeeper/maintenance worker	2 (4%)	13 (9%)
Technician, surgical	2 (4%)	2 (1%)
Embalmer/morgue technician	1 (2%)	2 (1%)
Health aid/attendant	1 (2%)	15 (11%)
Respiratory therapist	1 (2%)	2 (1%)
Technician, dialysis	1 (2%)	3 (2%)
Dental worker, including dentist	—	6 (4%)
Emergency medical technician/paramedic	—	12 (9%)
Physician, surgical	—	6 (4%)
Technician/therapist, other than listed above	—	9 (7%)
Other healthcare occupations	—	4 (3%)

AIDS = acquired immunodeficiency syndrome.
*Documented occupationally acquired HIV infection refers to healthcare workers with documented seroconversion after occupational exposure or other laboratory evidence of occupational infection. Possible occupationally acquired HIV infection refers to healthcare workers without identifiable behavioral or transfusion risks who had a history of occupational exposures to blood, other body fluids, or laboratory solutions containing HIV, but HIV seroconversion specifically resulting from an occupational exposure was not documented.
†As of December 2001.

with an occupational exposure and have had no other known exposure to HIV. Seroconversion was defined as a serum specimen negative for HIV antibodies up to 1 year before or 1 month after the occupational exposure, and a subsequent serum sample that was positive for HIV antibodies within 1 year of the exposure. Those with documented occupationally acquired HIV infection also included individuals infected with HIV strains that are shown to be related to the occupational source through DNA sequencing techniques.[28] Healthcare workers with a history of high-risk behaviors (eg, male–male sexual contact, injection drug use, or heterosexual contact with a known HIV-infected individual) are classified as having documented occupationally acquired infection if the health departments' epidemiologic investigation concluded that an occupational contact was the only exposure to HIV during the period when HIV seroconversion occurred, or if DNA sequencing results showed that the viruses of the healthcare worker and the occupational source were closely related.

RESULTS

Healthcare Workers With AIDS

Through December 2001, 23,951 cases of AIDS among healthcare workers were reported to the CDC, representing 5% of the 469,850 adults or adolescents with AIDS for whom information on healthcare employment was indicated on the surveillance case report form used in the HIV/AIDS Reporting System. Information on healthcare employment was missing or unknown for 337,225 reported adult or adolescent cases of AIDS. Most (91%) of the healthcare workers with AIDS reported non-occupational risks for HIV infection (eg, sexual contact, injection drug use, or transfusion). The remaining 9% includes healthcare workers with AIDS who had documented occupationally acquired HIV infection (n = 26), possible occupationally acquired HIV infection (n = 122), or no history of any recognized risk related to occupational or non-occupational exposure (n = 51); the investigation to identify risk exposures is ongoing for 1,410 and is incomplete for 640 healthcare workers (due to special circumstances such as death, loss to follow-up, or declining participation in the investigation).

When reports from AIDS surveillance and from the surveillance for occupationally acquired HIV infection are combined, a total of 57 HIV-infected healthcare workers (with or without AIDS) were determined to have documented occupationally acquired infection and 138 were determined to have possible occupationally acquired infection. Some of the characteristics of healthcare workers in these categories are summarized in Table 1. This article focuses on those for whom evidence for occupationally acquired HIV infection was documented.

Documented Occupationally Acquired HIV Infection

Because documented evidence of seroconversion or genetically similar strains of viruses is necessary for classification as documented occupational HIV infection, no case before 1985 (the year serologic testing for HIV became available) could be categorized as such (Fig. 1).

Forty nine (86%) of the healthcare workers were exposed to blood, 3 had contact with concentrated HIV in production or research laboratories, 1 was exposed to a visibly bloody exudative fluid from a skin lesion, and 4 were

exposed to unspecified body fluids. One healthcare worker was exposed to 2 different HIV-infected patients within 10 days; therefore, both patients were potential sources of infection. Of 55 known source patients, 38 (69%) had AIDS, 2 (4%) had symptoms related to HIV infection but did not meet the definition for AIDS, and 6 (11%) were asymptomatic. The clinical status of the remaining 9 (16%) is unknown. Information on the source patient's HIV viral titer at the time of occupational exposure was available from only one recent case involving an AIDS patient with a viral titer of more than 750,000 RNA copies per milliliter. Fifteen of the source patients were reportedly taking antiretroviral medication at the time of the occupational exposure.

The specific work settings or locations for the 58 occupational exposures (sustained by 57 healthcare workers) varied. Substantial proportions of exposures occurred in a hospital room (22%), an intensive care unit (21%), an outpatient clinic (12%), a hospice or a long-term–care setting (9%), an emergency department (7%), and a clinical or research laboratory setting (7%). Occupational exposures also occurred in an operating room (n = 2) or a preoperative area (n = 1), a home care setting (n = 2), a morgue or an autopsy area (n = 2), a dialysis unit (n = 1), and an outside area near a hospital trash container (n = 1). Of two other occupational exposures, one occurred in an unspecified hospital location and the other in an unspecified clinical setting.

Forty eight (84%) of the healthcare workers sustained 49 percutaneous injuries that may have resulted in HIV infection (1 healthcare worker sustained 2 percutaneous injuries within 10 days). Two other healthcare workers had concurrent percutaneous and mucocutaneous exposures. Six had mucocutaneous exposures. One healthcare worker, who worked with concentrated HIV in a laboratory setting, had an unknown route of exposure; however, the source of infection was confirmed by DNA sequencing.[29]

Percutaneous Injuries

Of 51 percutaneous injuries (including 2 healthcare workers with concurrent percutaneous and mucocutaneous exposures to HIV and 1 with 2 percutaneous injuries within 10 days), 45 (88%) were caused by hollow-bore needles. For 30 needles with a known gauge, the median gauge was 20 (range, 14 to 26 gauge). Nearly half of the injuries involving hollow-bore needles were caused by needles used in phlebotomy or blood sampling from a vascular line, with vacuum-tube device needles accounting for the largest number of these injuries. However, hypodermic needles, used in a wider variety of procedures, were the most frequently reported needle type overall (Table 2). The largest proportion of injuries caused by needles used in blood collection (45%) occurred in a hospital room, whereas the largest proportion of those caused by needles used for vascular access (45%) occurred in an intensive care unit (Fig. 2).

The circumstances associated with the 51 percutaneous injuries are summarized in Table 3. The largest proportion of injuries (41%) occurred after a procedure.

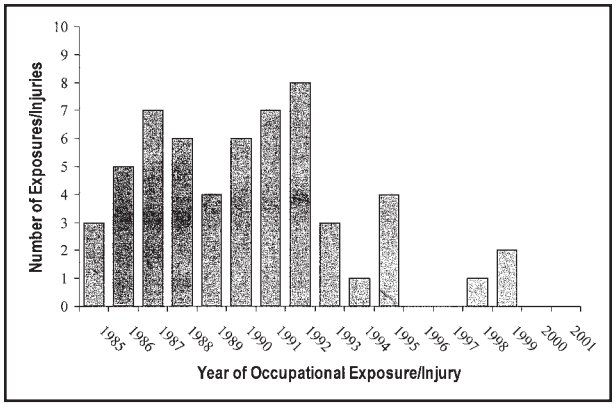

FIGURE 1. Number of occupational exposures or injuries sustained by 56 of 57 healthcare workers with documented occupationally acquired human immunodeficiency virus (HIV) infection, by year of exposure or injury, reported to the National Surveillance for Occupationally Acquired HIV Infection as of December 2001. The year of injury or exposure was unknown for 1 healthcare worker infected with a research laboratory strain of HIV. Another healthcare worker sustained 2 percutaneous injuries within 10 days.

Unexpected circumstances (eg, sudden movements by patients, coworkers, or medical equipment), which can occur during or after a procedure, accounted for 10 (20%) of the injuries. None of the percutaneous injuries was described as superficial; 23 (45%) were described as moderate (penetrated the skin and blood appeared) and 20 (39%) as deep (puncture or wound with or without bleeding) injuries. The depths of 8 injuries were not characterized. Twenty nine (62%) of 47 healthcare workers with percutaneous exposure to blood reported that there was visible blood on the needle at the time of their injury. Twenty-nine injuries occurred through gloves, and 2 of these (scalpel injuries) occurred through 2 pairs of gloves.

Mucocutaneous Exposures

Of the eight mucocutaneous exposures, one occurred while the healthcare worker was applying pressure hemostasis with an ungloved hand, described as chapped with small lacerations.[30] Concentrated virus splashed an HIV production laboratorian in the face, resulting in HIV exposure to the eyes, nose, mouth, and nonintact facial skin. In another case, an apheresis machine spilled a large amount of blood on a healthcare worker's arms and hands, and blood may have contacted an area of dermatitis on the ear.[30] Splatters from blood-collection tubes accounted for three mucocutaneous exposures: one to a healthcare worker's face and mouth[30]; one to a healthcare worker's hand, whose skin was described as chapped with cuts and open cracks[31]; and one to another healthcare worker's hand, where the glass fragments from the broken blood-collection tube also caused a percutaneous injury. Blood splashed another healthcare worker in the eye and on an upper extremity, which was abraded during a struggle to restrain a combative patient. In a more recent case, the healthcare worker, whose hands were chronically chapped and abraded, had a history of exposures to diarrheal stools, urine, and coffee ground emesis from a patient

TABLE 2
SHARP DEVICES OR OBJECTS CAUSING 51 PERCUTANEOUS INJURIES AMONG 50 HEALTHCARE WORKERS WITH DOCUMENTED OCCUPATIONALLY ACQUIRED HUMAN IMMUNODEFICIENCY VIRUS (HIV) INFECTION REPORTED TO THE U.S. NATIONAL SURVEILLANCE FOR OCCUPATIONALLY ACQUIRED HIV INFECTION AS OF DECEMBER 2001*

Sharp Device or Object	No. of Injuries
Hollow-bore needles	
For blood collection (n = 22)	
Vacuum-tube device needle	9
Hypodermic needle	6
Arterial blood gas kit needle	3
Winged steel (butterfly) needle	2
Unspecified/unknown needle type	2
For vascular access (n = 11)	
Intravenous needle	7
Dialysis needle	1
Hypodermic needle (for transvenous pacemaker insertion)	1
Trocar used for changing central line catheter	1
Hypodermic needle for flushing intravenous line	1
For vascular line connection (n = 1)	
Heparin-lock connector needle (Y-site near intravenous insertion site)	1
For sampling tissue/lesion aspirate (n = 2)	
Biopsy needle	1
Hypodermic needle	1
For other uses (n = 9)	
Specimen sampling needle on laboratory machine†	1
Needle for cleaning/dislodging debris in laboratory equipment	1
Hypodermic needle for intramuscular injection	1
Unknown use	6
Other sharp devices or objects	
Broken glass from blood-collection tubes	2
Scalpels	2
Unknown sharp devices/objects	2

*One healthcare worker sustained 2 injuries within 10 days; 2 others had concurrent mucocutaneous and percutaneous exposures to HIV.
†The needle was an attachment on a machine used to analyze laboratory specimens.

who was later confirmed as the source of the healthcare worker's infections with HIV and hepatitis C by genetic sequencing methods.[32]

Postexposure Prophylaxis

Of the 57 healthcare workers, 8 received postexposure prophylaxis (PEP), 7 of whom have been described previously.[33-36] The eighth healthcare worker, after sustaining a percutaneous injury with a 21-gauge needle from a patient with AIDS, received one dose of zidovudine approximately 2 hours after the exposure and declined further treatment (Table 4).

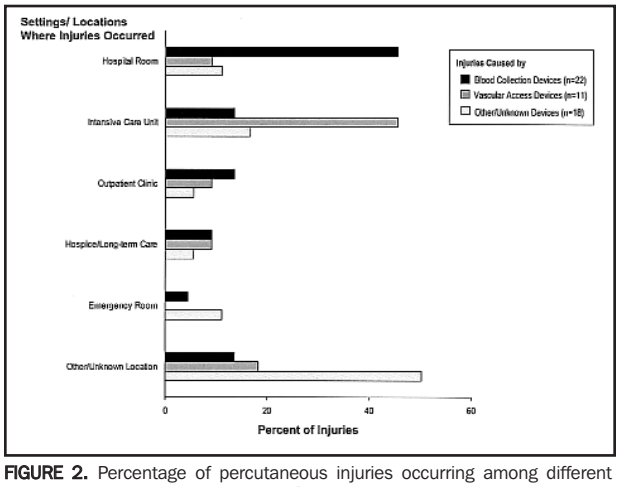

FIGURE 2. Percentage of percutaneous injuries occurring among different work settings or locations, by type of objects or devices causing the injuries to healthcare workers with documented occupationally acquired human immunodeficiency virus (HIV) infection reported to the National Surveillance for Occupationally Acquired HIV Infection as of December 2001.

Cases in the Era of Highly Active Antiretroviral Therapy

Of the reported cases of documented occupationally acquired HIV infection, three occurred after 1996 (Fig. 1), when recommendations for PEP with combination antiretroviral regimens, known as highly active antiretroviral therapy (HAART), were published.[16] One case involved a failure of PEP related to infection with multiple antiretroviral drug–resistant HIV (Table 4).[36] In the other two cases, neither healthcare worker received PEP. One healthcare worker, described above in another section, may have had an unrecognized occupational exposure and, thus, did not seek postexposure care; the source patient for this healthcare worker's concurrent infections with HIV and hepatitis C was confirmed by genetic sequencing methods.[32] The other healthcare worker, who was injured by a needle protruding from a disposal container (source patient unknown), refused PEP.

DISCUSSION

During the past 20 years, changes have occurred that may have influenced the risk for occupationally acquired HIV infection. Increasing knowledge of how HIV is transmitted and how exposures occur has led to improvements in healthcare worker safety, such as the formulation of infection control guidelines and the redesign of sharp instruments.[13-15] When properly applied, some of these measures have been shown to be effective at reducing blood exposure, potentially decreasing the risk for occupationally acquired HIV infection.[18-21] Improvements in postexposure management, including the use of PEP with combination antiretroviral regimens,[16] may also have added to the preventive effect for healthcare workers, although the measure of that effect has been difficult to determine.

TABLE 3
CIRCUMSTANCES OF 51 OCCUPATIONAL PERCUTANEOUS INJURIES ASSOCIATED WITH HUMAN IMMUNODEFICIENCY VIRUS (HIV) INFECTION, BY SETTING OR LOCATION OF INJURIES, FOR 50 HEALTHCARE WORKERS REPORTED TO THE U.S. NATIONAL SURVEILLANCE FOR OCCUPATIONALLY ACQUIRED HIV INFECTION THROUGH DECEMBER 2001*

Circumstance	No. of Injuries
Injuries occurring during procedure	
During patient care procedures	
Due to unexpected movements of patient	4
Due to unexpected movements of coworker	2
By needle still being held while manipulating intravenous catheter	2
While withdrawing needle from patient	2
By intravenous needle placed on patient's bed while dressing intravenous site	1
Due to unexpected movements caused by a rubber top that suddenly came off during blood collection with a vacuum-tube device	1
During procedures not involving direct patient care	
Due to slipped scalpel during autopsy	2
Due to breaking of glass blood-collection tube while removing its cover in the laboratory	1
While removing needle from hub of syringe†	1
Due to malfunctioning automated laboratory equipment	1
By needle used to dislodge debris from a port on an unspecified laboratory machine	1
Injuries occurring after procedure, not during disposal	
While still handling a needle or device	
While recapping needle	4
While inserting used needle into a needle stopper‡	3
Due to improper handling of needle (finger on needle tip)	1
While transferring needle to instrument tray	1
Due to breaking of glass blood-collection tube while manipulating its cover (after phlebotomy)	1
Due to unexpected movements by patient	1
Due to sudden movements from tripping over an object and falling	1
Due to unexpected movements caused by a blood-collection tube that slipped from the healthcare worker's hand	1
Due to unsafe placement of sharp objects	
Needle left in immediate work area as procedure is completed	4
Needle that was left undiscarded after procedure by coworker	2
Needle that was placed in a handbag for transport (no disposal container available)	1
Previously discarded sharp object protruding from plastic trash bag	1
Injuries occurring during disposal	
By needle protruding from top of disposal container§	5
While forcefully manipulating disposal container lid	2
While uncapping needle before placing it in disposal container‖	1
While removing a needle from a disposal container¶	1
Handling of hypodermic needle device with distal index finger positioned near needle tip while placing device into disposal container#	1
Details not available	2

*One healthcare worker sustained 2 injuries within 10 days.
†This was being done in the process of removing specimen from the syringe in the laboratory setting.
‡Of the three needle stoppers, two were gel rubber stoppers from arterial blood gas kits and one was a rubber top from a blood-collection tube.
§"Disposal container" in this table refers to a puncture-resistant container designed for the disposal of sharp objects.
‖The healthcare worker was concerned there might be a penalty for recapped needles found during safety inspection.
¶The intent was to rearrange the disposed needle to make more room in the full disposal container for another sharp object.
#As the device was being placed into the disposal container, the posterior portion of the device hit against contents just inside the container, pushing the needle into the healthcare worker's index finger.

Nevertheless, it is clear that highly active combination antiretroviral therapy (ie, HAART) regimens, by dramatically improving the health and survival of HIV-infected individuals, have altered the HIV epidemic in this country.[37-39] From the healthcare worker's perspective, there may be fewer potential exposures involving patients with end-stage AIDS with high plasma viral titers in settings in which occupational HIV transmission is likely to occur, such as in intensive care units and other inpatient settings.[40] HAART can suppress the plasma viral titer to unde-

TABLE 4
CASES OF DOCUMENTED OCCUPATIONALLY ACQUIRED HUMAN IMMUNODEFICIENCY VIRUS (HIV) INFECTION AMONG HEALTHCARE WORKERS WHO RECEIVED POSTEXPOSURE PROPHYLAXIS REPORTED TO THE U.S. NATIONAL SURVEILLANCE FOR OCCUPATIONALLY ACQUIRED HIV INFECTION AS OF DECEMBER 2001

Occupational Exposure (Year of Exposure)	Postexposure Prophylaxis: Regimen/Duration	Postexposure Prophylaxis: Hours to First Dose	Onset of Acute Illness (Days After Exposure)	Time to Documented Seroconversion (Days After Exposure)	Source Patient: Clinical Status	Source Patient: Antiretroviral Therapy	Reference
1. Percutaneous, 16-gauge IV cannula (1990)	Zidovudine 1,000 mg × 8 days	3 to 7	94	93	AIDS	Zidovudine, didanosine	23, 33, 35
2. Percutaneous, 22-gauge phlebotomy needle (1991)	Zidovudine 800 mg × 10 days	0.75	14	91	AIDS	Zidovudine	23, 33, 35
3. Percutaneous, 21-gauge needle (1991)	Zidovudine × 1 dose	2	93	63	AIDS	Unknown	—
4. Percutaneous, 21-gauge needle (1992)	Zidovudine 1,000 mg × 17 days	2	38	93 to 121	AIDS	None	23, 33, 35
5. Percutaneous, 14-gauge biopsy needle (1992)	Zidovudine 1,000 mg × 65 days	0.5	23	23	AIDS	*At exposure:* didanosine *Before exposure:* zidovudine	23, 34, 35
6. Mucocutaneous (1992)	Zidovudine 1,200 mg × 3 weeks	192	96	134	Asymptomatic	Unknown	23, 35
7. Percutaneous, broken glass (1993)	Zidovudine 600 mg × 20 days	1.5	73	73	AIDS	Zidovudine	23, 35
8. Percutaneous, needle in disposal container (1999)	*Initial:* zidovudine × 1 dose, lamivudine × 1 dose; *Subsequent:* didanosine × 3 days, stavudine × 4 weeks, nevirapine × 4 weeks	2 8	33	88	AIDS	*At exposure:* saquinavir, efavirenz; *> 3 months before exposure:* didanosine, stavudine, indinavir, ritonavir	36

IV = intravenous; AIDS = acquired immunodeficiency syndrome.

tectable levels in the blood of HIV-infected patients, which would also result in exposures to lower concentrations of HIV, if occupational blood exposures were to occur.

However, although the number of high-risk occupational exposures may have decreased, the frequency of the healthcare worker's contact with HIV-infected patients may have increased as the number of individuals living with HIV infection and requiring long-term medical care increases,[24] particularly in outpatient settings. Even among exposures involving HIV-infected patients with low plasma viral titers, the potential for transmission remains. Undetectable viral titer in the source of infection at the time of exposure has

been observed in cases of perinatally acquired as well as in at least one case of occupationally acquired HIV infection.[41-43] Among the documented cases of occupationally acquired HIV infection described here, information on viral titers at the time of occupational exposures was not generally available. However, 11% of the cases involved a source patient with asymptomatic HIV infection, which is associated with lower plasma viral titers.[44] These observations suggest that even in the era of HAART, sustained primary prevention efforts remain central to minimizing the risk for occupationally acquired HIV infection.

Because HIV is a blood-borne pathogen, avoiding exposure to blood remains the primary means of preventing occupational HIV transmission in the healthcare setting. Among the modes of occupational exposures, the estimated average risk of HIV transmission is highest with a percutaneous injury,[45] which is reflected in the high proportion (88%) of healthcare workers described here with documented occupationally acquired HIV infection who had such injuries. Thus, although it is important to minimize all modes of occupational blood exposures, prevention efforts are especially needed to reduce the frequency of percutaneous injuries.

Besides the plasma viral titer, other factors that may influence the risk for occupational HIV transmission through percutaneous injury include the depth of penetration into the skin and the size of the inoculum transferred through the injury.[22,45] These factors, in turn, may be determined by the type of needle or other sharp instrument used, the gauge of the needle or the size of the sharp instrument, and the purpose for which the needle or instrument was being used (eg, phlebotomy or injection). Of greatest concern are hollow-bore needles that have been in an artery or vein and are likely to contain residual blood; larger bore needles have the capacity to hold larger blood volumes and may deliver a larger inoculum through an injury.[22,45] Of the 51 percutaneous exposures associated with documented occupationally acquired HIV infection, almost all were due to injuries caused by hollow-bore needles, many of which were used in blood-collection procedures.

Our data on the circumstances of occupational percutaneous exposures to HIV suggest that some of the exposures would have been prevented if the recommended precautions had been followed. Needle recapping injuries, which had been a common cause of percutaneous injuries in the 1980s, have decreased.[46-49] Since 1987, when recommendations were published advising against recapping,[13] no instance of HIV infection as a result of injuries from needle recapping has been reported. However, injuries related to the disposal or unsafe placement of used sharp devices are still relatively common[15,50] and account for some of the most recent cases of occupationally acquired HIV infection. Sharp medical devices that are improperly discarded, left undiscarded, or placed in unsafe locations (eg, in a plastic trash bag, a patient's room, or a patient care area) after use have the potential to injure housekeeping or maintenance workers, laundry staff, visitors, and patients, as well as healthcare workers directly involved in patient care.[50]

Some injuries, in contrast, may have been difficult to prevent with specific work practices. Such injuries may be caused by unexpected movements by patients or coworkers, which account for 20% of the percutaneous exposures associated with documented occupationally acquired HIV infection in this article. Injuries resulting from unexpected circumstances underscore the need for engineering control measures, because such circumstances are difficult to anticipate with specific work practices or administrative measures.

Medical devices or instruments designed with safety features may enhance the safety of healthcare workers in different ways in a variety of situations. Needleless vascular access systems, for example, may reduce needlestick injuries by minimizing the need for needles associated with use of the vascular line[19]; use of a needleless system could have prevented the injury caused by a heparin-lock connecting needle (Y-site needle), which unexpectedly became disconnected while healthcare workers restrained a combative patient. The use of safety-engineered devices designed for phlebotomy procedures or for intravenous insertion has been shown to be effective at reducing the frequency of percutaneous injuries during those procedures[20,21]; such strategies also could have prevented some of the occupational HIV exposures among healthcare workers in this article. Concern over the need for engineering control measures led to the passage of the Needlestick Safety and Prevention Act, a federal law mandating that safety-engineered medical devices be evaluated and made available for use in healthcare workplaces.[51]

The use of safety-engineered devices, nevertheless, should be seen as only one component of a larger, more comprehensive program to prevent occupational HIV transmission in healthcare settings. Because circumstances of HIV exposure and infection are varied and complex, engineering control measures alone cannot fully protect healthcare workers. Safety-engineered medical devices may not always be used correctly or consistently, or they may possibly malfunction. Even when properly used, medical devices with safety features that require activation after use may not fully protect against injuries during a procedure, such as while a phlebotomy needle is being withdrawn from the patient. Puncture-resistant disposal containers, another type of safety-engineered measure, may inadvertently be left overfilled in a busy clinical setting and, as a result, may not always safely contain potentially HIV-contaminated sharp objects. Thus, it is the combination of all administrative and engineering control measures, together with the consistent use of protective equipment (eg, gloves or eyewear) and safer personal work practices, that provides the highest level of protection and is the most effective approach to preventing occupational HIV exposure and infection.[15,16,52]

In the era of HAART, the availability of PEP may influence the healthcare worker's attitude toward safety, which, in turn, may influence his or her work practices. Before HAART was widely available, the use of zidovudine following occupational exposure was associated with a decreased

risk for occupationally acquired HIV infection.[22] Because of the success of HAART as a treatment for HIV, public concern over the risk for HIV infection may have lessened.[53-56] However, the actual impact of PEP on preventing HIV infection is not certain. What is clear is that antiretroviral agents may cause adverse side effects but do not always prevent HIV infection following an occupational exposure.[33-36,43,57,58] Of the 57 healthcare workers with documented occupationally acquired HIV infection, 8 (14%) became infected despite taking antiretroviral PEP, one of whom received HAART. The emergence of antiretroviral drug–resistant strains of HIV certainly adds to the concern over the potential for PEP failure.[35,59] Therefore, although more data are needed to determine the optimal use of PEP, avoiding blood exposure should continue to be the focus for preventing occupational HIV transmission in healthcare settings.

Surveillance data on occupationally acquired HIV infection, although useful, have some limitations to consider. The surveillance system relies on the willingness of healthcare workers and their healthcare providers to report potential cases. The actual number of healthcare workers with occupationally acquired HIV infection is probably underestimated, because healthcare workers do not always seek care following exposures,[60] and individuals with occupationally acquired infection are not always reported to health departments, possibly due to confidentiality concerns.[61,62] Furthermore, although most healthcare workers with AIDS reported non-occupational risk factors for HIV infection, the possibility that some may have been infected occupationally cannot be entirely excluded.

Similarly, the mode of HIV transmission could not be definitively established for healthcare workers with possible occupationally acquired HIV infection because it was not possible to document the time and source of infection for these individuals. As a result, there is also the potential for misclassifications. The striking gender difference between healthcare workers with documented and those with possible occupationally acquired infection may suggest that some individuals in the latter category had non-occupational risks for HIV infection that were unreported or unrecognized (Table 1). Among healthcare workers with *possible* occupationally acquired HIV infection, 59% were men, more closely resembling the gender makeup of adult or adolescent AIDS cases (83% male among those reported in 2001) than that of healthcare workers in the general U.S. population (80% female estimated for 2001).[63] However, similar to healthcare workers in the general U.S. population, those with *documented* occupationally acquired HIV infection were predominantly (79%) female.

Delayed reporting may further add to the limitations of the surveillance system. Potential cases of occupationally acquired HIV infection are investigated retrospectively; therefore, details regarding risks, circumstances, and test results at the time of occupational exposure may be difficult or impossible to document among those who have already progressed to AIDS or who have died. The lack of timeliness may explain why most (88%) of the cases of possible occupationally acquired HIV infection, in which it is difficult to establish the time of infection and obtain details about specific occupational exposures, are seen among healthcare workers already reported as having AIDS rather than with more recently diagnosed HIV infection (Table 1). The lack of timeliness in reporting may also, in part, explain the apparent decline in the annual number of healthcare workers with documented occupationally acquired HIV infection (Fig. 1).

Given the above limitations, a combination of different approaches to surveillance is needed to more efficiently identify cases of occupationally acquired HIV infection and obtain more timely data for prevention. With well-established guidelines for managing occupational HIV exposures, the opportunity exists for prospectively identifying potential cases of occupationally acquired HIV infection. On the basis of the Occupational Safety and Health Administration's standards, healthcare facilities are required to provide a mechanism for healthcare workers to report occupational exposures and receive follow-up care.[64] As a result, data on occupational HIV exposures and infection are available at the facility level; such data, if obtained through active surveillance, may be less subject to delayed reporting than the data described in this article. Nevertheless, a surveillance approach that relies solely on facility-based HIV/AIDS reporting may not be sufficient, because healthcare workers may follow up with their private physician rather than with their facility of employment after an occupational exposure. Thus, the CDC's effort to integrate the population-based surveillance systems monitoring HIV infection and AIDS among healthcare workers (ie, the HIV/AIDS Reporting System and the National Surveillance for Occupationally Acquired HIV Infection) with an active, facility-based surveillance system (the National Surveillance System for Health Care Workers[65]) may help to improve the monitoring of occupationally acquired HIV infection in the United States.

Surveillance data on occupationally acquired HIV infection remain an indispensable source of information that contributes to the understanding of how occupational HIV transmission occurs. However, the value of surveillance data continually depends on the reporting of individual instances of occupational HIV transmission. Healthcare workers must continue to be educated about their risks of acquiring infections with blood-borne pathogens, ways to effectively reduce those risks, and the benefit of timely, confidential reporting and follow-up of occupational exposures. Employers also have an important role by demonstrating a concern for the safety of healthcare workers, actively monitoring for work-related injuries and exposures to blood-borne pathogens, and continually assessing the need for preventive measures.

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