Occupational Exposure of Health Care Personnel to Hepatitis B and Hepatitis C: Prevention and Surveillance Strategies

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• Bloodborne pathogens

Health care personnel represent a vital workforce that aims to preserve and improve the health of others. Among the 35 million health care personnel employed worldwide, percutaneous injuries have been estimated to result in approximately 16,000 hepatitis C and 66,000 hepatitis B virus infections annually.[1] Within the United States, an estimated 14.4 million workers are employed in the health care industry, with more than 5.7 million employed in hospitals alone.[2] The landscape of health care delivery is changing, and increases in staff workload and patient complexity may have an impact on the likelihood of occupational injuries. Ensuring health care personnel safety is a challenge that must be met with multifaceted approaches to prevention.

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In the context of health care–associated occupational bloodborne pathogen risks, the US Public Health Service (USPHS) defines health care personnel as persons (eg, employees, students, contractors, attending clinicians, public safety workers, or volunteers) whose activities involve contact with patients or with blood or other body fluids from patients in a health care, laboratory, or public safety setting.[3] Injuries involving needles and other sharps in health care are associated with the transmission of many pathogens, but the pathogens of most immediate concern during patient care activities are hepatitis B virus (HBV), hepatitis C virus (HCV), and HIV.[4–6] These infections are associated with chronic disease and significant morbidity and mortality.

The majority of exposures to bloodborne pathogens in health care personnel are preventable.[4,7] Protection from bloodborne pathogen exposures is fundamental to health care personnel and patient safety. The prevention of sharps injuries is an important aspect of eliminating the transmission of bloodborne pathogens to health care personnel, and contributes to establishing safe workplace environments. This review describes the epidemiology of HBV and HCV in health care personnel, with a focus on current prevention and postexposure management strategies and provides examples of surveillance programs used to monitor and manage these exposures.

RISK OF HEPATITIS B AND HEPATITIS C VIRUS EXPOSURES IN HEALTH CARE PERSONNEL

The probability of acute HBV or HCV infection after the exposure to a susceptible person depends on the route of exposure, the concentration of infectious virions in body fluids, the volume of infective material transferred, and the immune status of the recipient.[8] HBV is primarily transmitted by percutaneous and mucosal exposure to blood and body fluids. Risk of contracting HBV depends on the degree of exposure to infectious fluids and the presence of hepatitis B surface antigen, anti–hepatitis B core antibody, or hepatitis B e antigen, the latter being a marker for increased viral replication and infectivity. Positive hepatitis B e antigen status is indicative of high viral titers (eg, 10^7–10^9 virions/mL).[9,10] The highest titers of HBV are found in blood and, as such, contribute to the increased risk of transmission from sharps injuries. Other body fluids are not as conducive to the transmission of HBV.[3]

HBV can persist in the environment for prolonged periods and can remain infective in dried blood at room temperature for more than a week.[8,11] Transmission of HBV may also occur in health care settings through exposures to nonintact skin from contaminated environmental surfaces or equipment that has been inadequately cleaned and disinfected.[8] Infective concentrations of HBV have been detected on environmental surfaces in the absence of visible blood. Its ability to remain stable outside the human host supports other evidence that HBV infection may occur through direct and indirect means of transmission.[3] HCV in dried blood samples has been shown to remain infective for 16 hours.[12] Environmental exposures to HCV in health care settings seem to have a limited role in the transmission of HCV and likely pose a low risk. HBV and HCV are enveloped viruses and are sensitive to the appropriate Environmental Protection Agency–registered disinfectants and sterilants, and when employed correctly can be an effective measure to reduce environmental contamination.[13]

The risk of HBV seroconversion after a percutaneous injury ranges from 23% to 62% in unvaccinated persons and is dependent on the hepatitis B e antigen status of the source.[8] Surveys performed in the 1990s of unvaccinated US health care personnel showed that serologic evidence of past or current HBV infection was present in approximately 22% of respondents, a figure typically three to five times greater than in the US general population. Among respondents, surgeons reported the highest HBV seroprevalence of 28% among unvaccinated personnel.[14–16] Survey

data from the 1990s suggest that 13% of surgeons have evidence for current or past HBV infection, but 64% also received the HBV vaccine.[17] The estimated number of HBV infections in health care personnel has decreased from greater than 10,000 in 1983 to fewer than 400 in 2002 after the integration of routine HBV immunization through facility-based occupational health and safety policies, USPHS guidelines, and regional Occupational Safety and Health Administration (OSHA) mandates.[3,18,19] The seroprevalence of HBV in health care personnel is now fivefold less than in the US population (approximately 4%).[7,16,19]

HCV transmission is most efficient after percutaneous injury, with deep punctures or extensive blood exposures enhancing the likelihood of transmission.[20–22] It is unclear whether mucosal or nonintact skin exposures have a significant role in transmission, as these are rarely documented transmission events.[3,23] The risk of infection was elevated 11-fold when the HCV load of a positive source patient was greater than 10^6 virions/mL compared with patients with viral loads less than 10^4 virions/mL.[21] Approximately 50 to 150 cases of HCV transmission in health care personnel are conservatively estimated to occur each year in the United States.[24] The seroprevalence of HCV in US health care providers is approximately 0.5% to 2.0%, which is comparable to that in the general population.[14,25–28] From the available evidence, these data hold true even among provider groups that are at greater risk for exposures, such as surgical or dialysis staff.[16,29,30]

Overall, the risk of HCV transmission after percutaneous exposure is low, approximately 1.8%.[3] In contrast to the infrequent occurrence of chronic HBV infection in newly infected adults (5%–10%), chronic infection occurs in the majority (70%–85%) of persons with newly acquired HCV infection.[25,31,32] Avoidance of exposures and adherence to Standard Precautions and engineering and work practice controls remain essential to preventing occupational infection, given that no vaccination or postexposure prophylaxis measures are currently available for HCV.

Epidemiology of Sharps Injuries in Health Care Personnel

Despite increasing implementation of strategies to prevent injuries and blood exposures, more than 385,000 needlestick injuries were estimated to occur annually in US hospitals during 1997 to 1998.[26] In addition, the burden of exposures in nonhospital settings is ill defined. Other estimates, which considered under-reporting and nonhospital care, projected that the overall magnitude of sharps injuries in US health care could approach 600,000 to 800,000 per year.[27,28,33] These projections may have improved in light of the Needlestick Safety and Prevention Act, which passed in 2000.

Needlestick injuries can occur during a broad spectrum of health care activities if appropriate engineering and work practice controls or a supportive culture of safety are not present. Data from the National Surveillance System for Healthcare Workers (NaSH) indicates that the largest proportions of injuries occurred in patient rooms (35%) and operating theaters (28%). Hollow-bore needlestick injuries, which are associated with exposures to greater volumes of blood and increased transmission risks, occurred more frequently than solid sharps injuries (54% vs 40%).[7,34] The Centers for Disease Control and Prevention (CDC) estimates that at least 56% of percutaneous injuries involving hollow-bore needles are preventable.[35] Data from NaSH summarizing 30,945 reported exposures from 1995 to 2007 showed that 12.6% of source patients were infected with HBV (1.4%), HCV (8.4%), or HIV (4.5%); 1.7% were co-infected with HCV and HIV.[7] Among nurses and physicians, approximately 25% of reported hollow-bore sharps injuries were deemed to have been preventable by the use of safer devices.[36] Almost two-thirds of all reported injuries occurred with devices without safety features. Among the 3316 injuries involving sharps devices

that were equipped with safety features, 23% involved a failure to activate the safety feature and 41% involved an injury that occurred before the safety component was meant to be activated.[7]

Risk Groups for Exposure

According to NaSH, 82% of blood and body fluid exposures were from percutaneous injuries, with the largest proportions of exposures reported in nurses (41%) and physicians (30%). Nursing staff generally outnumber other health care professionals who provide direct patient care and represent the occupational group most affected by percutaneous injuries, a reflection of their close and repeated contacts with patients.[35,37–39]

Although all health care staff who provide direct patient contact are at-risk for exposure to blood and body fluids, surgical and obstetrics staff are often cited as a particularly vulnerable occupational group.[40–43] NaSH data have shown that 28% of injuries were reported in operating theaters.[7] In other studies examining the risk of injury in operating theaters, 93% of injuries were sharps related, and in half of those injuries, suture needles were implicated.[43,44] According to one study from the 1990s, percutaneous injuries were reported in 7% to 10% of all gynecologic surgeries.[17] In a survey of medical students, 30% of reported needlesticks occurred frequently in operating theaters.[45] An increased likelihood of percutaneous injuries are associated with surgeries that take longer than 6 hours, surgeries with patient blood losses greater than 1000 mL, and many personnel crowding the surgical field.[44]

PROTECTING HEALTH CARE PERSONNEL FROM EXPOSURE TO BLOOD AND BODY FLUIDS

Measures to Prevent Exposures (Primary Prevention)

Prevention of blood and body fluid exposures represents a cornerstone of occupational programs in health care. The OSHA Bloodborne Pathogens Standard issued in 1991 established provisions to minimize bloodborne exposures to health care personnel.[46,47] The Standard focused on adherence to universal precautions (subsequently incorporated into Standard Precautions), which was intended as the standard of care for all patients in all health care facilities, regardless of their known or suspected infectious status.[48,49] Precautions include measures to protect health care personnel and patients from exposures to blood and body fluids. Other key provisions of the OSHA Bloodborne Pathogens Standard require employers to provide hepatitis B vaccine to staff, involve staff in the selection of safer needle devices, develop an exposure control plan and postexposure protocols, and provide engineering and work practice controls, personal protective equipment, and annual training. The Standard was revised and expanded by the Needlestick Safety and Prevention Act of 2000, which explicitly mandated the use of engineered safety devices to eliminate the risk of sharps injuries.[48] The updated Standard also requires employers to maintain a log of injuries from contaminated sharps.[47]

Vaccination

Hepatitis B vaccine became available in 1982, and in that same year was recommended for US health care personnel by the Advisory Committee on Immunization Practices.[50] Three intramuscular doses of hepatitis B vaccine induce a protective antibody response in more than 90% of healthy recipients.[2,31] Adults who develop a protective antibody response are protected from clinical disease and chronic infection. The duration of vaccine protection is under investigation, but available evidence indicates that nearly all vaccinated persons who respond have lifelong immunity against HBV

infection.[31] Health care personnel who do not respond to the primary vaccine series should receive a second three-dose series; non-responders should be evaluated for chronic infection.[3] Booster doses of hepatitis B vaccine are not necessary, and periodic serologic testing to monitor antibody concentrations after completion of the vaccine series is not recommended.[3]

Adherence to the Advisory Committee on Immunization Practices guidelines was bolstered by the 1991 OSHA Bloodborne Pathogens Standard where employers were required to provide hepatitis B vaccination at no cost, and resulted in increased coverage levels in US health care personnel. For example, 51% of health care personnel were vaccinated for hepatitis B in 1992. This figure rose to 67% in 1995. As of 2003, it was estimated that 75% of health care personnel were vaccinated for HBV, with the highest coverage levels among staff physicians and nurses.[51–53] Since US recommendations for hepatitis B vaccination of infants and children were published in 1991, more than 90% coverage of children with the complete HBV immunization series has been achieved. Universal infant immunization with hepatitis B vaccine is expected to lead to increased levels of HBV immunity in persons now entering the health care workforce.[54–56]

There is currently no vaccine to prevent HCV infection. Instead, efforts continue to focus on prevention activities, such as adherence to Standard Precautions, safe work practices, counseling, and education for health care personnel.[8]

Hierarchy of Controls

A concept widely promoted in industrial hygiene, the ''hierarchy of controls'' principle, has been applied to bloodborne pathogen exposure prevention by providing structure and priority setting for key interventions. The hierarchy establishes priorities for hazard reductions in the workplace. The first priority is the elimination or reduction of sharps use. Examples of this strategy include switching, to the extent possible, to needleless intravenous delivery systems; oral, noninjectable medications; and glues or other adhesives in place of traditional sutures.[57–59]

If a potential hazard cannot be removed, the next priority is to mitigate the hazard through the use of engineering controls. Examples of this second strategy include making sharps disposal containers accessible at their point of use and using engineered safety devices.[60,61] Such devices can have active or passive safety mechanisms to prevent sharps injury; devices requiring activation typically require users to engage the safety feature after use whereas more passive devices operate by self-sheathing, self-blunting, or automatically retracting after use.[4]

The federal OSHA standard and several state-based regulations have required that devices with engineered sharps injury prevention features must be provided by employers. When applied correctly, safety devices have had dramatic effects on the rates of injury to health care personnel.[39,62,63] For example, increased uptake of safety-engineered devices reduced the incidence of percutaneous injuries from 34/1000 full-time equivalents to 14/1000 full-time equivalents after their implementation in one hospital.[64] Activities that had the most significant impact from the switch to safer devices were catheter insertion procedures, with nursing staff reporting the largest reduction in injuries.[64]

When sharps elimination and engineering control strategies are not available or are insufficient, the use of work practice controls and personal protective equipment represents important adjunct prevention activities. Work practice controls are often used during surgical and obstetric procedures when the use of exposed sharps cannot be avoided. In operating rooms, these controls include using instruments to grasp needles, retract tissue, and unload/load needles and scalpels; giving verbal

announcements when passing sharps; using a basin or neutral zone to avoid hand-to-hand passing of sharps; opting for noninvasive procedures when possible (eg, endoscopy, laser, or electrocautery procedures); and using round-tipped scalpel blades and blunt suture needles.[65] In surgical settings, the practice of double gloving can significantly reduce the volume of blood exposure from sharps injuries compared with wearing single gloves.[4,66–72] To support the effective implementation of the hierarchy of controls for sharps injury prevention, comprehensive training on the use of safety-engineered devices, work practice controls, and personal protective equipment are essential.[36]

Standard Precautions

Standard Precautions are a series of recommended practices that establish the standard of care for all patients in health care. It encompasses the principles of Universal Precautions and body substance isolation that were introduced by the CDC in the 1980s after the emergence of HIV/AIDS. Standard Precautions are based on the possibility that all blood, body fluids, secretions, excretions (except sweat), nonintact skin, and mucous membranes may contain transmissible infectious agents, such as HBV and HCV.[49] The application of Standard Precautions during patient care is determined by the nature of the anticipated exposure to blood or body fluids. Hand hygiene is a critical component within Standard Precautions as an effective practice to reduce the risk of exposures to blood and body fluids and patient-to-patient transmission of bacterial and non-bloodborne viral pathogens. Personal protective equipment consists of the use of gowns; disposable gloves; and masks, face shields, or goggles for patient care when there is potential for contact with blood and body fluids. Safe injection practices were made explicit within Standard Precautions in the 2007 Guideline for Isolation Precautions: Preventing Transmission of Infectious Agents in Healthcare Settings; these recommendations were intended to clarify appropriate needle, syringe, and medication handling to prevent patient-to-patient, health care provider-to-patient, and patient-to-health care provider transmission of HBV, HCV, and other pathogens.[49]

Education and Training

In the United States, OSHA requirements mandate yearly training on the prevention of blood and body fluid exposures. Training in and responsibility for basic infection control is increasingly emphasized by accrediting and regulatory agencies, such as the Joint Commission and the Center for Medicare and Medicaid Services. The need for education was illustrated by a survey of physicians and nurses in the United Kingdom, where only 50% of nurses and 32% of physicians correctly identified the risks of acquiring HBV after a sharps injury.[73] Similarly, only 35% of nurses and 44% of physicians could correctly identify HCV transmission risks. Among this cohort, 28% of physicians did not report their needlestick injuries despite being a specialty most likely to sustain sharps injuries. NaSH data echoed these results with an estimated 30% of percutaneous injury events likely to be reported by surgeons, whereas 53% of physicians and nurses were likely to report their injuries.[7] Barriers to reporting exposures cited by personnel included lack of time and a perception of minimal risk.[32] Deficiencies in staff training and education on basic injection safety and risk assessment are associated with personnel underestimating the risk of HBV and HCV transmission, even when a patient source was known to be HBV or HCV positive.[74–78] The availability and promotion of regular training for staff is a low-cost measure that can improve adherence to Standard Precautions to safe work practices to prevent injuries and exposures.[48]

Culture of Safety in the Workplace

Maintaining a culture of safety is a shared responsibility. Management and staff should collectively work to encourage and promote safety in the workplace. Every member within an organization is accountable for the safety of patients and the work environment. Development of and adherence to policies for reporting injuries and mechanisms for identifying and resolving injury hazards are important parts of this commitment. Successful safety cultures in the workplace are also contingent on every individual being accountable for safety and serving as a role model for safer work practices.[4,79] Evidence suggests that organizations that support and promote safety in the workplace may experience overall improvements in infection prevention, including reductions in occupational exposure to bloodborne pathogens. One study demonstrated that facilities with policies to discourage needle recapping practices were likely to have employed needleless intravenous systems, had infection control and safety management personnel available, had routine education on Standard Precautions, and had provisions to encourage personal protective equipment use.[48]

Regulations and Policies

Most health care workers in the United States are protected by the OSHA Bloodborne Pathogens Standard, which outlines measures that employers must take to prevent exposures in workers. As directed by Needlestick Safety and Prevention Act of 2000, OSHA issued a revision in 2001 to the original 1991 Bloodborne Pathogens Standard.[47]

More than 20 states have regulations aimed at sharps injury prevention and surveillance, often extending protections to public sector workers. California was the first state to legislate the use of engineered sharps devices as a revision to the Bloodborne Pathogens Standard in 1998.[60] State OSHA plans, the Center for Medicare and Medicaid Service, and the Joint Commission all have requirements addressing the risk of exposure among health care personnel. The CDC has provided guidelines for the management of occupational exposure to HBV, HCV, and HIV.[3,80] These regulations and guidelines have facilitated the increase in the number of health care personnel who have been vaccinated against HBV, promoted the use of devices with engineered sharps injury prevention features, and improved the provision of appropriate follow-up and treatment for injured or exposed health care personnel.

MEASURES TO PREVENT HEPATITIS B OR HEPATITIS C INFECTION AFTER AN EXPOSURE

Occupational exposures to blood and body fluids should be managed in accordance with established recommendations and guidelines (discussed previously). Health care institutions must have a written policy regarding postexposure case management that includes protocols for obtaining source patient consent to test for HIV, HBV, and HCV. Employees should be provided with information regarding the types of incidents to report, details of how to report incidents, and locations where medical evaluations, counseling, and follow-up are available. Trained personnel should always be available to a facility for postexposure management and follow-up.

Postexposure prophylaxis for HBV requires the evaluation of several factors, such as the hepatitis B surface antigen status of the source and the vaccination and HBV immunity status of the exposed health care worker. After any exposure, unvaccinated health care personnel are recommended to start the hepatitis B vaccination series. If HBV immune globulin is indicated, it should be given as soon as possible, preferably within 24 hours; the effectiveness of HBV immune globulin after 7 days post exposure is unknown (see 2001 USPHS guidelines for detailed recommendations).[3]

Currently, there is no postexposure prophylaxis available for HCV. Health care personnel who are exposed to a confirmed HCV antibody-positive (or unknown status) source should have baseline testing completed for anti-HCV and alanine aminotransferase activity.[3] These tests should be repeated in 4 to 6 months in asymptomatic health care personnel, and any positive anti-HCV should be confirmed with additional molecular diagnostics. Early detection strategies, which call for more frequent and aggressive testing to monitor exposed individuals, have been advocated; USPHS guidelines also indicate that testing for HCV RNA may be performed 4 to 6 weeks after exposure if earlier detection of infection is desired.[3,81,82] In those instances when infection is detected, antiviral therapy may be most effective if it is initiated in the early stages of infection. HCV treatment decisions are complex and underscore the need for appropriate medical referrals and counseling as part of postexposure management.

SURVEILLANCE

Data gathered from surveillance systems have provided valuable information regarding the circumstances surrounding blood exposure incidents and the occupations at risk of such exposures. In turn, this information has proved valuable in guiding prevention efforts. Several platforms for the collection of data on bloodborne pathogen exposures in health care workers are available. National data on sharps injuries in US health care personnel have primarily been reported through the CDC's NaSH and through the Exposure Prevention Information Network (EPINet), based at the International Healthcare Worker Safety Center (**Box 1**). EPINet began data collection in 1992 and currently collects similar data from a network of approximately 33 facilities concentrated in several geographic areas around the country.[28]

NaSH compiled data from 1995 to 2007 with 64 participating hospitals at its peak in 2000. A total of 81 health care facilities contributed data over 12 years of voluntary surveillance, resulting in more than 30,000 reports of blood and body fluid exposures.[7] The NaSH system and user support were discontinued in December 2007 to focus on

Box 1
Supplemental resources: tools and guidance for prevention of occupational exposures to bloodborne pathogens

CDC. Division of Healthcare Quality Promotion: http://www.cdc.gov/ncidod/dhqp/index.html

CDC. Division of Viral Hepatitis: http://www.cdc.gov/hepatitis/

CDC. National Institute for Occupational Safety and Health: http://www.cdc.gov/niosh/topics/bbp

CDC. Division of Healthcare Quality Promotion. Workbook for Designing, Implementing, and Evaluating a Sharps Injury Prevention Program: http://www.cdc.gov/sharpssafety

CDC. National Healthcare Safety Network: http://www.cdc.gov/nhsn/hps_bbf.html

International Healthcare Worker Safety Center. The Exposure Prevention Information Network: http://www.healthsystem.virginia.edu/Internet/epinet/

OSHA. Bloodborne pathogens and needlestick prevention: http://www.osha.gov/SLTC/bloodbornepathogens/index.html

U.S. Department of Veterans Affairs. Needle safety: http://www1.va.gov/vasafety/page.cfm?pg=119

Commonwealth of Massachusetts, Office of Health and Human Services, Department of Public Health. Occupational Health Surveillance Program, Sharps Injury Surveillance and Prevention Project: http://www.mass.gov/dph/ohsp

the development of the Healthcare Personnel Safety Component of the CDC National Healthcare Safety Network (NHSN) and no longer accepted data as of January 2008.

Several states conduct sharps injury surveillance, although some are limited to public sector workers or the private sector. Although most of these are voluntary systems, Massachusetts hospitals licensed by the Department of Public Health report to the Department of Public Health sharps injuries among health care personnel. This surveillance system has captured data from all licensed hospitals since 2002, and as of 2008, there were more than 23,000 recorded percutaneous injuries among health care personnel in 99 licensed hospitals (Massachusetts Department of Public Health. Massachusetts Sharps Injury Surveillance and Prevention Project. Boston: Occupational Health Surveillance Program, unpublished data, 2009).

NHSN incorporates aspects of NaSH in a new Healthcare Personnel Safety Component was launched in August 2009 for facility enrollment and data collection. The Blood and Body Fluids Exposure Module will collect data on exposure events, risk factors, and devices causing injury; health care worker demographics; details on exposure follow-up and required prophylaxis; and relevant laboratory results. Participating facilities will have the option of collecting details on longitudinal exposure management. This module integrates many features from the NaSH system but offers increased functionality, technical support, and access to real-time data and reporting. The Blood and Body Fluids Exposure Module will allow users to calculate rates of exposure, and seroconversion, and assist in the management of injuries and allow facilities to track injuries within their facility and compare injury rates against aggregated NHSN data.

SUMMARY

Prevention strategies to eliminate occupational exposures to HBV and HCV in health care have a growing evidence base to support their adoption. In the United States, dramatic reductions in HBV infection in health care personnel followed successful efforts to vaccinate health care personnel. Further efforts to increase vaccination coverage and monitor the long-term effectiveness of hepatitis B immunization are warranted. Collectively, the use of Standard Precautions, engineering controls, and other workplace strategies can substantially reduce or even eliminate the risk of percutaneous and mucous membrane exposures to HBV and HCV. Surveillance systems (eg, NHSN and EPINet) to track and monitor trends of blood and body fluid exposures are useful for improving understanding of the circumstances that contribute to occupational exposures to HBV and HCV and for developing solutions—technologic or educational—to close the gap on preventable exposures.

Further research is needed to better define the impact of knowledge, attitudes, and current practices in at-risk health care personnel on their risk of bloodborne pathogen exposures. With the availability and wider implementation of engineering controls, such as sharps with safety features, there is a need to evaluate their efficacy as a component for prevention but also explore the challenges to their appropriate implementation. In summary, exposure to infectious blood and body fluids represents an important occupational hazard for health care providers. A comprehensive approach to HBV and HCV prevention is needed in all health care settings to assure basic worker and patient protections (see **Box 1**).

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