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Viral Hepatitis Transmission in Ambulatory Health Care Settings

I. T. Williams, J. F. Perz, and B. P. Bell

Epidemiology Branch, Division of Viral Hepatitis, National Center for Infectious Diseases, Centers for Disease Control and Prevention, Atlanta, Georgia

In the United States, transmission of viral hepatitis from health care–related exposures is uncommon and primarily recognized in the context of outbreaks. Transmission is typically associated with unsafe injection practices, as exemplified by several recent outbreaks that occurred in ambulatory health care settings. To prevent transmission of bloodborne pathogens, health care workers must adhere to standard precautions and follow fundamental infection-control principles, including safe injection practices and appropriate aseptic techniques. These principles and practices need to be made explicit in institutional policies and reinforced through in-service education for all personnel involved in direct patient care, including those in ambulatory care settings. The effectiveness of these measures should be monitored as part of the oversight process. In addition, prompt reporting of suspected health care–related cases coupled with appropriate investigation and improved monitoring of surveillance data are needed to accurately characterize and prevent health care–related transmission of viral hepatitis.

The potential for the spread of bloodborne pathogens to workers and patients during the delivery of health care has long been recognized. Therapeutic injections, which are commonly overused and administered in an unsafe manner in developing countries, are estimated to account for >21 million new hepatitis B virus (HBV) infections and approximately 2 million new hepatitis C virus (HCV) infections each year worldwide [1]. In the United States, epidemiologic data suggest that health care–related exposures are not currently a primary source of HBV or HCV transmission [2–4]. Recently, 4 outbreaks of HBV and HCV infections in ambulatory care settings have been reported, all of which resulted from failures to adhere to basic principles of aseptic technique for the preparation and administration of parenteral medications. [5] These outbreaks have raised concerns that some health care workers (HCWs) do not consistently adhere to fundamental infection control principles, aseptic techniques, and safe injection practices. Moreover, infection-control guidelines and recommendations that focus on the outpatient setting have been lacking [6–8]. In this article, we will review health care–related viral hepatitis transmission, with particular attention to ambulatory care settings, and examine strategies to prevent transmission of bloodborne pathogens in health care settings.

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Reprints or correspondence: Dr. Ian Williams, Div. of Viral Hepatitis, MS G-37, National Center for Infectious Diseases, Centers for Disease Control and Prevention, 1600 Clifton Rd., Atlanta, GA 30333 (iwilliams@cdc.gov).

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HBV AND HCV TRANSMISSION CHARACTERISTICS

The probability of infection after exposure of a susceptible person to HBV or HCV depends on the route of exposure, the concentration of infectious virions in the implicated body fluid, and the volume of infective material transferred [9]. Transmission of HBV and HCV may result from percutaneous or mucosal exposures to blood. Some body fluids also are considered potentially infectious, including CSF, synovial fluid, pleural fluid, peritoneal fluid, and amniotic fluid. Feces, nasal secretions, saliva, sputum, sweat, tears, urine, and vomitus are not considered potentially infectious unless they contain blood. HBV and HCV do not spontaneously penetrate intact skin, and airborne transmission does not occur [10].

HBV can be present in blood and body fluids, including saliva, semen, and vaginal secretions, with concentrations ranging from a few virions to 10^9 virions/mL [11]. The highest concentrations are present in individuals whose serum has detectable hepatitis B e antigen (HBeAg), which is indicative of active HBV replication. The concentration of HBV in body

fluids such as semen and saliva is generally 1000–10,000 times lower than that found in blood [12]. HBV is resistant to drying, simple detergents, and alcohol, and it has been found to survive at room temperatures for ⩾7 days [10]. Inactivation of HBV can be achieved using several intermediate-level disinfectants, including 0.1% glutaraldehyde and 500 p.p.m. free chlorine from sodium hypochlorite (i.e., 2 tablespoons [~30 mL] of household bleach in 1 gallon [3.8 L] of water) [10, 13]. Because infected patients can have high concentrations of HBV in blood or body fluids and HBV is stable at ambient temperatures, transmission of HBV can occur in health care settings through inapparent modes, such as exposure to contaminated environmental surfaces or equipment that have been inadequately disinfected or through exposures of nonintact skin (i.e., skin that is chapped or abraded) [9, 14].

Serum concentrations of HCV generally range from 10^5 to 10^8 genome equivalents per milliliter [15]. HCV RNA concentrations are relatively stable in individual patients with chronic infection [16], and there is no serologic marker that is indicative of higher virus levels or active HCV replication. Although HCV may be detected in the saliva and semen and other body fluids of some infected patients, these are not believed to be efficient vehicles of transmission [9]. Data on survival, disinfection, sterilization, and decontamination procedures for HCV are lacking because a cell culture system that can assess viability of HCV has not yet been developed [13]. A recent study suggests that HCV in dried plasma can cause infection in experimental animals when left at room temperature for ⩾16 h but not longer than 4 days [17]. However, epidemiologic data indicate that environmental contamination is not a common route of transmission [9, 18]. Conventional sterilization processing, such as steam autoclaving or use of chemical germicides that are capable of producing at least an intermediate level of disinfection activity, are thought to be suitable for inactivating HCV [13].

TRANSMISSION TO HCWs

Over the past several decades, substantial effort has been devoted to preventing occupational exposures to bloodborne viruses and immunizing HCWs with hepatitis B vaccine [9, 19–22]. Among susceptible HCWs, in the absence of postexposure prophylaxis, the risk of HBV infection after a needlestick injury is 37%–62% if the source patient is HBeAg positive and 23%–37% if the patient is HBeAg negative [23]. Many of the infections that occurred before widespread vaccination of HCWs likely resulted from inapparent exposures, such as inoculation into cutaneous scratches, lesions, or mucosal surfaces [9]. The estimated number of HBV infections among HCWs in the United States has decreased from >10,000 in 1983 to ~400 in 2002 (Centers for Disease Control and Prevention [CDC], unpublished data). This decrease is attributed to the implementation of standard precautions in health care settings, use of safety devices, increasing levels of hepatitis B vaccination coverage among HCWs, and postexposure prophylaxis [9, 24].

HCV transmission occurs through occupational exposures to blood, but less efficiently than with HBV. The average rate of occurrence of seroconversion after accidental percutaneous exposure from an HCV-positive source is 1.8% (range, 0%–7%) [9]. Transmission of HCV has been reported rarely from blood splashes to the eye or exposure via nonintact skin [25–27]. The prevalence of antibody to HCV among HCWs in the United States is similar to or lower than that found in the general population, even among HCWs in specialties with a high likelihood of percutaneous exposures (e.g., surgeons), suggesting that transmission in health care settings has not been a common source of HCV infection for HCWs [18, 28–30]. Because there is currently no vaccine or postexposure prophylaxis available to protect HCWs against HCV infection, prevention efforts will continue to rely on strict adherence to standard precautions, appropriate work techniques, and use of safety devices.

TRANSMISSION TO PATIENTS FROM HEALTH CARE–RELATED EXPOSURES

In the United States, health care–related exposures are a well-recognized but relatively uncommon source of viral hepatitis transmission [2–4]. Transmission of HBV and HCV infection via transfusion and transplantation has nearly been eliminated since the advent of donor screening and viral inactivation procedures [31]. In case-control studies of acute viral hepatitis conducted in the 1980s before the availability of HCV antibody testing, no associations were observed with medical or dental care procedures [32, 33]. Health care–related cases of acute hepatitis B or hepatitis C are rarely reported to the CDC's surveillance systems [4] (CDC, unpublished data). Most instances of health care–related transmission have been identified in the context of outbreaks in which the source of infection was an infected HCW or other patient(s).

Transmission to patients from infected HCWs. There are a number of published reports of HCW-to-patient transmission of HBV, but most occurred prior to the 1990s, before the widespread use of barrier precautions and hepatitis B vaccination [19, 34]. These investigations found variable rates of transmission to patients, ranging from ⩽1% to 13%, with most reported episodes involving <10 cases [19]. The majority of instances involved invasive procedures performed by surgeons or dentists, but some reports involved HCWs with skin conditions, such as exudative dermatitis, bleeding lesions, or cuts. Factors associated with transmission from HBV-infected HCWs included HBeAg positivity and contamination of a patient's surgical wound or traumatized tissue due to either uninten-

tional injury to the HCW during invasive procedures or a major break in infection-control practices (e.g., not wearing gloves during an invasive procedure).

In the past decade, there have been at least 10 reports of transmission from HBV-infected surgeons and none linked to HBV-infected dentists [34, 35]. There has been only 1 recent report in North America of transmission from an HBV-infected HCW in an ambulatory care setting [36]. In this outbreak, at least 75 patients acquired infection from procedures involving subdermal electrodes that were implanted by an HBeAg-positive technician. The majority of these recent reports of HBV-transmissions from HBV-infected surgeons were from the United Kingdom and involved surgeons who were carriers of a precore mutant strain of HBV that prevents expression of HBeAg, despite high concentrations of infectious virus. No instances of transmission of this strain in health care settings have been reported in the United States.

Guidelines to prevent transmission from HBV-infected HCWs have been provided by the US Public Health Service [37]. These guidelines focus on HCWs who are infected with HBV and are HBeAg positive. These HCWs should not perform exposure-prone invasive procedures unless they have sought counsel from an expert review panel and been advised under what circumstances (if any) they may continue to perform these procedures. To address the issue of precore mutant strains, a European consensus panel recently recommended that additional restrictions on HBV-infected HCWs who perform exposure-prone invasive procedures and are HBeAg negative should be considered based on results of ongoing monitoring of HBV DNA levels [35, 38]. There is no such recommendation currently in the United States.

There have been only a few reports of transmission from HCV-infected HCWs to patients, and most instances have not been associated with the performance of exposure-prone invasive procedures [2]. Rather, most reported episodes, including the single reported episode associated with an ambulatory health care setting, involved abuse of patient narcotics by the HCW. To date, there have been 3 reports of transmission from HCV-infected HCWs to patients in the United States. In the first such episode, an HCV-infected surgical technician at an ambulatory surgical center infected ~40 patients [39]. The technician admitted to self-injecting a portion of the analgesic medications, which were subsequently administered to patients. In the second episode, an anesthesiologist suspected of abusing narcotics was found to have acquired HCV infection from one patient and transmitted it to a second patient; no further transmission was identified [40]. The third episode—and the only one identified in the United States to date not associated with narcotics abuse—involved an HCV-infected cardiac surgeon; a retrospective investigation determined that, over a decade, this surgeon likely transmitted HCV to as many as 14 of 937 patients who could be evaluated (Barbara Wallace, New York State Department of Health, personal communication).

Outside the United States, the risk of transmission from infected HCWs in episodes where substance abuse by HCWs was not considered a likely means of transmission has been found to be very low ($\leq$0.6%) [41–44]. Investigations of these episodes have not identified specific factors related to the delivery of care that were associated with an increased likelihood of transmission. Presently, no organizations in the United States recommend that HCV-infected HCWs be excluded from any aspect of patient care unless they are epidemiologically implicated in the transmission of infection despite adequate precautions [19, 45]. A recent European conference on infected HCWs could not reach consensus on how to manage HCV-infected HCWs who perform exposure-prone procedures [35]. However, several countries have developed guidelines; for example, the UK Department of Health recently recommended that all HCWs who know they are HCV RNA positive should not perform exposure-prone procedures [46].

Transmission to patients from other patients. In the health care setting, HBV- or HCV-infected patients may serve as a reservoir for transmission, which can result from cross-contamination of HCWs' hands, medications, medical equipment, devices, or environmental surfaces. Patients receiving long-term hemodialysis, whose care involves repeated and prolonged vascular access in an environment that is shared with other patients, have historically been at high risk for acquiring infection in this manner [47]. The use of hepatitis B vaccine and implementation of infection-control precautions tailored to this situation have reduced the incidence of hemodialysis-associated infections, although outbreaks of HBV and HCV infection continue to occur [47, 48]. In developed countries, most instances of patient-to-patient HBV and HCV transmission in hospitals and long-term care facilities not associated with hemodialysis have involved unsafe injection or diabetes care practices, resulting in contamination of multiple-dose vials or of equipment used for blood sampling or flushing intravenous lines [49–56].

There have been multiple reports from the United States of patient-to-patient transmission of HBV associated with ambulatory care settings other than hemodialysis centers. However, with the exception of recent episodes described below, the reported outbreaks all occurred >1 decade ago. Two of these were associated with acupuncture; one involved 6 infected patients, and the other involved 35 infected patients. Deficiencies related to disinfection of acupuncture needles were noted in both outbreaks [57, 58]. In a third outbreak, at least 60 patients at a weight-reduction clinic acquired HBV infection as a consequence of frequent repeated administration of medications via a jet injector device [59]. Finally, $\geq$72 patients became infected at a dermatology practice where infection-control de-

ficiencies included poor hand hygiene and unsafe injection practices involving multiple-dose anesthetic vials (e.g., syringes reused on individual patients were refilled through a needle that remained in the vial) [60].

Overall, few episodes of HCV transmission associated with ambulatory care have been identified. Recent reports of such transmission outside the United States have come from Australia and Italy. In Australia, transmission of HCV to a single patient who underwent an outpatient endoscopic procedure was attributed to contamination of a multiple-dose anesthetic vial [61]. In Italy, 15 of 29 volunteers participating in 2 consecutive pharmacokinetic studies became infected with HCV, possibly as a result of contaminated multiple-dose heparin vials used to maintain each subject's intravenous catheter [62, 63].

Recently, 4 large outbreaks of HBV and HCV infections occurred in the United States among patients in the following ambulatory care facilities: a private medical practice, a pain clinic, an endoscopy clinic, and a hematology/oncology clinic [5]. In the private medical practice, 38 patients likely acquired HBV infection from injections that typically consisted of a combination of atropine, dexamethasone, and/or vitamin B_{12} drawn from multiple-dose vials into 1 syringe in the same workspace where used needles/syringes were dismantled. The pain clinic outbreak resulted from the use of a single needle/syringe to administer intravenous anesthetic medications to multiple patients; 31 clinic-associated HBV infections and 69 clinic-associated HCV infections were identified. In the endoscopy clinic outbreak, clinic-acquired HCV infection was identified among 19 patients and most likely resulted from contamination of multiple-dose anesthetic vials from reinsertion of used needles. Finally, in the hematology/oncology clinic outbreak, syringe reuse apparently led to the contamination of common 500-mL saline bags used to flush implanted catheters, resulting in 99 identified HCV infections. All 4 outbreaks could have been prevented by adherence to basic principles of aseptic technique for the preparation and administration of parenteral medications [5].

The ambulatory care setting now accounts for most patient encounters with the health care system in the United States [64]. Increasingly complex procedures are being performed in ambulatory care settings, driven by changes in reimbursement mechanisms and advances in medical technologies [8, 64]. Unlike inpatient care, in which patient stays are typically discrete events of a limited duration, patient care in ambulatory care facilities often involves repeated visits over a period extending for several weeks to many years. If errors that allow for transmission of bloodborne pathogens are ongoing in a facility, the number of potential source-patients can increase over time as infectious patients make repeated clinic visits and infect other patients. This has the potential to result in a large number of patients becoming infected, as was observed in several recently reported outbreaks.

STRATEGIES TO PREVENT PATIENT-TO-PATIENT TRANSMISSION OF BLOODBORNE PATHOGENS IN HEALTH CARE SETTINGS

Infection control and injection safety. The implementation and widespread adoption of standard precautions has protected both HCWs and patients from infection with bloodborne pathogens in health care settings. The core elements of standard precautions [22, 65] include (1) hand washing after patient contact, (2) the use of barrier precautions (e.g., gloves, gowns, and facial protection) to prevent mucocutaneous contact, and (3) minimal manual manipulation of sharp instruments and devices and disposal of these items in puncture-resistant containers. Adherence to other fundamental infection-control principles including appropriate aseptic techniques and safe injection practices is also necessary to prevent health care–related transmission of bloodborne pathogens (table 1) [2, 14, 65–69]. These include the use of a sterile, single-use, disposable needle and syringe for each injection given and prevention of contamination of injection equipment and medication. Single-dose vials should be used rather than multiple-dose vials whenever possible, especially when medications will be administered to multiple patients.

Training and oversight. The occurrence of the recent outbreaks of infection described above suggests that some health care personnel do not always adhere to fundamental infection-control principles, aseptic techniques, and safe injection practices required to prevent patient-to-patient transmission of bloodborne pathogens [5]. A recent US survey of HCWs who provide medications through injection found that 1–3% reuse the same needle and/or syringe on multiple patients [70, 71]. To ensure that all HCWs are aware of and understand these principles and adhere to recommended practices, these concepts need to be reinforced in training programs and incorporated into institutional policies. Relevant training programs include in-service, continuing education and recertification programs for health care staff, including those in ambulatory care settings. The effectiveness of these training programs should be monitored as part of the institutional oversight process. Professional associations should also offer related training and information to members regarding potential modes of bloodborne pathogen transmission, infection-control principles, and safe injection practices.

Oversight of personnel that deliver direct patient care is essential to prevent transmission of bloodborne pathogens in health care settings. In the recently reported outbreaks of HBV and HCV infections in ambulatory care settings, deficiencies related to oversight of personnel and failures to follow-up on reported breaches in infection-control practices apparently resulted in delays in correcting the implicated practices [5]. Provision of necessary oversight of all staff involved in direct patient care in ambulatory settings poses significant challenges.

Table 1. Recommended infection-control and safe injection practices to prevent patient-to-patient transmission of bloodborne pathogens.

Injection safety
Use a sterile, single-use, disposable needle and syringe for each injection and discard intact in an appropriate sharps container after use.
Use single-dose medication vials, prefilled syringes, and ampules when possible. Do not administer medications from single-dose vials to multiple patients or combine leftover contents for later use.
If multiple-dose vials are used, restrict them to a centralized medication area or for single patient use. Never reenter a vial with a needle or syringe used on one patient if that vial will be used to withdraw medication for another patient. Store vials in accordance with manufacturer's recommendations and discard if sterility is compromised.
Do not use bags or bottles of intravenous solution as a common source of supply for multiple patients.
Use aseptic technique to avoid contamination of sterile injection equipment and medications.
Patient-care equipment
Handle patient-care equipment that might be contaminated with blood in a manner that prevents skin and mucous membrane exposures, contamination of clothing, and transfer of microorganisms to other patients and surfaces.
Evaluate equipment and devices for potential cross-contamination of blood. Establish procedures for safe handling during and after use, including cleaning and disinfection or sterilization as indicated.
Work environment
Dispose of used syringes and needles at the point of use in a sharps container that is puncture-resistant and leak-proof and that can be sealed before completely full.
Maintain physical separation between clean and contaminated equipment and supplies.
Prepare medications in areas physically separated from those with potential blood contamination.
Use barriers to protect surfaces from blood contamination when blood samples are obtained.
Clean and disinfect blood-contaminated equipment and surfaces in accordance with recommended guidelines.
Hand hygiene and gloves
Perform hand hygiene (i.e., hand washing with soap and water or use of an alcohol-based hand rub) before preparing and administering an injection, before and after donning gloves for obtaining blood samples, after inadvertent blood contamination, and between patients.
Wear gloves for procedures that might involve contact with blood and change gloves between patients.
Administrative
Infection-control measures should be tailored to the individual practice setting.
Responsibility for oversight and monitoring should be clearly designated.
Periodic reviews of staff practices should be conducted.
Procedures and responsibilities should be established for reporting and investigating breaches in infection-control policy.

Small practices and private office settings may not have any explicit procedures for oversight of staff infection-control practices. For outpatient facilities housed in or affiliated with institutions, such as hospitals, that have formal mechanisms that provide oversight, the relevant procedures often are not clearly or consistently applied to the affiliated ambulatory practices. Approaches to providing the necessary oversight in all ambulatory settings need to be identified and implemented. These include not only having an appointed representative who is responsible for ensuring that the facility or practice is in compliance with all legal and infection-control accreditation standards and other current guidelines and infection-control recommendations, but also that the means by which staff are supervised and the procedures by which potential problems or errors are reported are explicit and clear.

Finally, written policies and procedures to prevent patient-to-patient transmission of bloodborne pathogens should be established and implemented among all staff involved in direct patient care. These should include (1) infection-control measures tailored to the individual practice setting; (2) periodic reviews of staff practices, including assignment of responsibility for oversight and monitoring; and (3) procedures and responsibilities for reporting and investigating breaches in infection-control measures. Policies and procedures should be maintained and updated periodically.

Detection of health care–related cases of viral hepatitis. Despite their size, the 4 recent outbreaks of viral hepatitis in the United States described above were not identified by current surveillance systems; instead, the public health investigations were triggered by alert clinicians who reported clusters of infected patients [5]. Because most patients with acute HBV or HCV infection are asymptomatic, many newly acquired infections may not come to the attention of health care providers. When acute infections are identified, it is important to obtain a complete history of potential risk factors for infection during the incubation period, including information on contact with the health care system (guidelines for viral hepatitis surveillance and case management can be obtained from http://www.cdc.gov/ncidod/diseases/hepatitis/resource/surveillance.htm).

Health care–related transmission should be suspected when cases of acute viral hepatitis without traditional risk factors for infection are identified. When a suspected case or cluster of

health care–acquired HBV or HCV infection is identified, it should be reported promptly to appropriate public health authorities and to staff at the relevant institution who are responsible for infection control. A preliminary investigation including a review of records to evaluate whether other infected patients can be identified should be conducted. Temporal or other clustering among infected patients should be evaluated. Potential exposures in the health care facility that could result in transmission, including surgical procedures and other percutaneous exposures, especially those involving multiple-dose vials, should be assessed. To improve detection of outbreaks, state and local health authorities in the United States should also consider strategies to improve case identification, such as targeting intensive follow-up to individuals who typically are at low risk of infection (e.g., persons aged >60 years).

CONCLUSIONS

The delivery of health care has the potential to transmit HBV and HCV to both HCWs and patients. However, health care–related transmission of viral hepatitis currently appears to be a relatively infrequent event in the United States. This can be attributed to the widespread adoption by HCWs of standard precautions, appropriate work techniques, and use of safety devices and of fundamental infection-control principles, including safe injection practices and appropriate aseptic techniques. However, as demonstrated by recent outbreaks in the United States, the prevention of transmission of viral hepatitis in ambulatory health care settings warrants increased attention and efforts. The challenge remains to ensure that HCWs always adhere to infection-control practices and aseptic technique, including appropriate use of needles, syringes, and multiple-dose vials.

References

1. Ezzati M, Lopez AD, Rodgers A, Vander HS, Murray CJ. Selected major risk factors and global and regional burden of disease. Lancet **2002**; 360:1347–60.
2. Alter MJ. Prevention of spread of hepatitis C. Hepatology **2002**; 36: S93–8.
3. Centers for Disease Control and Prevention. Outbreaks of hepatitis B virus infection among hemodialysis patients—California, Nebraska, and Texas, 1994. MMWR Morb Mortal Wkly Rep **1996**; 45:285–9.
4. Goldstein ST, Alter MJ, Williams IT, et al. Incidence and risk factors for acute hepatitis B in the United States, 1982–1998: implications for vaccination programs. J Infect Dis **2002**; 185:713–9.
5. Centers for Disease Control and Prevention. Transmission of hepatitis B and C viruses in outpatient settings—New York, Oklahoma, and Nebraska, 2000–2002. MMWR Morb Mortal Wkly Rep **2003**; 52:901–6.
6. Academy of Pediatrics. Infection control in physicians' offices. The American Occupational Safety and Health Administration (OSHA). Pediatrics **2000**; 105:1361–9.
7. Goodman RA, Solomon SL. Transmission of infectious diseases in outpatient health care settings. JAMA **1991**; 265:2377–81.
8. Herwaldt LA, Smith SD, Carter CD. Infection control in the outpatient setting. Infect Control Hosp Epidemiol **1998**; 19:41–74.
9. US Public Health Service. Updated US Public Health Service guidelines for the management of occupational exposures to HBV, HCV, and HIV and recommendations for postexposure prophylaxis. MMWR Recomm Rep **2001**; 50:1–52.
10. Favero MS, Bolyard EA. Microbiologic considerations: disinfection and sterilization strategies and the potential for airborne transmission of bloodborne pathogens. Surg Clin North Am **1995**; 75:1071–89.
11. Hoofnagle JH. Hepatitis B. In: Haubrich WS, Schaffner F, Berk JE, eds. Gastroenterology. Philadelphia: WB Saunders, **1995**:2062–3.
12. Villarejos VM, Visona KA, Gutierrez A, Rodriguez A. Role of saliva, urine and feces in the transmission of type B hepatitis. N Engl J Med **1974**; 291:1375–8.
13. Sattar SA, Tetro J, Springthorpe VS, Giulivi A. Preventing the spread of hepatitis B and C viruses: where are germicides relevant? Am J Infect Control **2001**; 29:187–97.
14. Chiarello LA. Prevention of patient-to-patient transmission of bloodborne viruses. Semin Infect Control **2001**; 1:44–8.
15. Thomas DL, Astemborski J, Vlahov D, et al. Determinants of the quantity of hepatitis C virus RNA. J Infect Dis **2000**; 181:844–51.
16. Williams IT, Gretch D, Fleenor M, et al. Hepatitis C virus RNA concentration and chronic hepatitis in a cohort of patients followed after developing acute hepatitis C. In: Proceedings of the 10th International Symposium on Viral Hepatitis and Liver Disease. Atlanta: International Medical Press, **2003**; 341–4.
17. Krawczynski K, Alter MJ, Robertson BH, Lu L, Spelbring JE, McCaustland KA. Environmental stability of hepatitis C virus (HCV): viability of dried/stored HCV in chimpanzee infectivity studies [abstract 555]. In: Program and abstracts of the 54th Annual Meeting of the American Society for the Study of Liver Disease. Philadelphia: WB Saunders, **2003**.
18. Polish LB, Tong MJ, Co RL, Coleman PJ, Alter MJ. Risk factors for hepatitis C virus infection among health care personnel in a community hospital. Am J Infect Control **1993**; 21:196–200.
19. Beltrami EM, Williams IT, Shapiro CN, Chamberland ME. Risk and management of blood-borne infections in health care workers. Clin Microbiol Rev **2000**; 13:385–407.
20. Henderson DK. Managing occupational risks for hepatitis C transmission in the health care setting. Clin Microbiol Rev **2003**; 16:546–68.
21. Bolyard EA, Tablan OC, Williams WW, Pearson ML, Shapiro CN, Deitchmann SD. Guideline for infection control in healthcare personnel, 1998. Hospital Infection Control Practices Advisory Committee. Infect Control Hosp Epidemiol **1998**; 19:407–63.
22. Centers for Disease Control and Prevention. Update: universal precautions for prevention of transmission of human immunodeficiency virus, hepatitis B virus, and other bloodborne pathogens in health-care settings. MMWR Morb Mortal Wkly Rep **1988**; 37:377–8.
23. Werner BG, Grady GF. Accidental hepatitis-B-surface-antigen–positive inoculations: use of e antigen to estimate infectivity. Ann Intern Med **1982**; 97:367–9.
24. Mahoney FJ, Stewart K, Hu H, Coleman P, Alter MJ. Progress toward the elimination of hepatitis B virus transmission among health care workers in the United States. Arch Intern Med **1997**; 157:2601–5.
25. Beltrami EM, Kozak A, Williams IT, et al. Transmission of HIV and hepatitis C virus from a nursing home patient to a health care worker. Am J Infect Control **2003**; 31:168–75.
26. Sartori M, La Terra G, Aglietta M, Manzin A, Navino C, Verzetti G. Transmission of hepatitis C via blood splash into conjunctiva. Scand J Infect Dis **1993**; 25:270–1.
27. Ippolito G, Puro V, Petrosillo N, De Carli G, Micheloni G, Magliano E. Simultaneous infection with HIV and hepatitis C virus following occupational conjunctival blood exposure. JAMA **1998**; 280:28.
28. Thomas DL, Factor SH, Kelen GD, Washington AS, Taylor E Jr, Quinn TC. Viral hepatitis in health care personnel at The Johns Hopkins Hospital: the seroprevalence of and risk factors for hepatitis B virus and hepatitis C virus infection. Arch Intern Med **1993**; 153:1705–12.
29. Panlilio AL, Shapiro CN, Schable CA, et al. Serosurvey of human immunodeficiency virus, hepatitis B virus, and hepatitis C virus in-

fection among hospital-based surgeons. Serosurvey Study Group. J Am Coll Surg **1995**; 180:16–24.
30. Shapiro CN, Tokars JI, Chamberland ME. Use of the hepatitis-B vaccine and infection with hepatitis B and C among orthopaedic surgeons. The American Academy of Orthopaedic Surgeons Serosurvey Study Committee. J Bone Joint Surg Am **1996**; 78:1791–800.
31. Alter HJ, Houghton M. Clinical Medical Research Award. Hepatitis C virus and eliminating post-transfusion hepatitis. Nat Med **2000**; 6:1082–6.
32. Alter MJ, Coleman PJ, Alexander WJ, et al. Importance of heterosexual activity in the transmission of hepatitis B and non-A, non-B hepatitis. JAMA **1989**; 262:1201–5.
33. Alter MJ, Gerety RJ, Smallwood LA, et al. Sporadic non-A, non-B hepatitis: frequency and epidemiology in an urban US population. J Infect Dis **1982**; 145:886–93.
34. Alter MJ. Epidemiology and prevention of hepatitis B. Semin Liver Dis **2003**; 23:39–46.
35. Gunson RN, Shouval D, Roggendorf M, et al. Hepatitis B virus (HBV) and hepatitis C virus (HCV) infections in health care workers (HCWs): guidelines for prevention of transmission of HBV and HCV from HCW to patients. J Clin Virol **2003**; 27:213–30.
36. An outbreak of hepatitis B associated with reusable subdermal electroencephalogram electrodes. Hepatitis B Outbreak Investigation Team. CMAJ **2000**; 162:1127–31.
37. Centers for Disease Control and Prevention. Recommendations for preventing transmission of human immunodeficiency virus and hepatitis B virus to patients during exposure-prone invasive procedures. MMWR Recomm Rep **1991**; 40:1–9.
38. Schalm SW, Buster EH. Management of hepatitis B virus infected health care workers based on HBV DNA levels. J Clin Virol **2003**; 27:231–4.
39. Sehulster L, Taylor J, Hendricks K, VanEgdom M, Whitely S, Manning S. Hepatitis C outbreak linked to narcotic tampering in an ambulatory surgical center. In: Program and abstracts of the 1997 Interscience Conference on Antimicrobial Agents and Chemotherapy. Washington, DC: American Society for Microbiology Press, **1997**:293.
40. Cody SH, Nainan OV, Garfein RS, et al. Hepatitis C virus transmission from an anesthesiologist to a patient. Arch Intern Med **2002**; 162:345–50.
41. Duckworth GJ, Heptonstall J, Aitken C. Transmission of hepatitis C virus from a surgeon to a patient. The Incident Control Team. Commun Dis Public Health **1999**; 2:188–92.
42. Ross RS, Viazov S, Gross T, Hofmann F, Seipp HM, Roggendorf M. Transmission of hepatitis C virus from a patient to an anesthesiology assistant to five patients. N Engl J Med **2000**; 343:1851–4.
43. Ross RS, Viazov S, Roggendorf M. Phylogenetic analysis indicates transmission of hepatitis C virus from an infected orthopedic surgeon to a patient. J Med Virol **2002**; 66:461–7.
44. Ross RS, Viazov S, Thormahlen M, et al. Risk of hepatitis C virus transmission from an infected gynecologist to patients: results of a 7-year retrospective investigation. Arch Intern Med **2002**; 162:805–10.
45. Centers for Disease Control and Prevention. Recommendations for prevention and control of hepatitis C virus (HCV) infection and HCV-related chronic disease. MMWR Recomm Rep **1998**; 47:1–39.
46. New guidance on hepatitis C infected health care workers. CDR Weekly **2002**; 1–2.
47. Centers for Disease Control and Prevention. Recommendations for preventing transmission of infections among chronic hemodialysis patients. MMWR Recomm Rep **2001**; 50:1–43.
48. Hutin YJ, Goldstein ST, Varma JK, et al. An outbreak of hospital-acquired hepatitis B virus infection among patients receiving chronic hemodialysis. Infect Control Hosp Epidemiol **1999**; 20:731–5.
49. Allander T, Gruber A, Naghavi M, et al. Frequent patient-to-patient transmission of hepatitis C virus in a haematology ward. Lancet **1995**; 345:603–7.
50. Drescher J, Wagner D, Haverich A, et al. Nosocomial hepatitis B virus infections in cardiac transplant recipients transmitted during transvenous endomyocardial biopsy. J Hosp Infect **1994**; 26:81–92.
51. Khan AJ, Cotter SM, Schulz B, et al. Nosocomial transmission of hepatitis B virus infection among residents with diabetes in a skilled nursing facility. Infect Control Hosp Epidemiol **2002**; 23:313–8.
52. Oren I, Hershow RC, Ben Porath E, et al. A common-source outbreak of fulminant hepatitis B in a hospital. Ann Intern Med **1989**; 110:691–8.
53. Schvarcz R, Johansson B, Nystrom B, Sonnerborg A. Nosocomial transmission of hepatitis C virus. Infection **1997**; 25:74–7.
54. Widell A, Christensson B, Wiebe T, et al. Epidemiologic and molecular investigation of outbreaks of hepatitis C virus infection on a pediatric oncology service. Ann Intern Med **1999**; 130:130–4.
55. Krause G, Trepka MJ, Whisenhunt RS, et al. Nosocomial transmission of hepatitis C virus associated with the use of multidose saline vials. Infect Control Hosp Epidemiol **2003**; 24:122–7.
56. Quale JM, Landman D, Wallace B, Atwood E, Ditore V, Fruchter G. Deja vu: nosocomial hepatitis B virus transmission and fingerstick monitoring. Am J Med **1998**; 105:296–301.
57. Kent GP, Brondum J, Keenlyside RA, LaFazia LM, Scott HD. A large outbreak of acupuncture-associated hepatitis B. Am J Epidemiol **1988**; 127:591–8.
58. Stryker WS, Gunn RA, Francis DP. Outbreak of hepatitis B associated with acupuncture. J Fam Pract **1986**; 22:155–8.
59. Canter J, Mackey K, Good LS, et al. An outbreak of hepatitis B associated with jet injections in a weight reduction clinic. Arch Intern Med **1990**; 150:1923–7.
60. Hlady WG, Hopkins RS, Ogilby TE, Allen ST. Patient-to-patient transmission of hepatitis B in a dermatology practice. Am J Public Health **1993**; 83:1689–93.
61. Tallis GF, Ryan GM, Lambert SB, et al. Evidence of patient-to-patient transmission of hepatitis C virus through contaminated intravenous anaesthetic ampoules. J Viral Hepat **2003**; 10:234–9.
62. Larghi A, Zuin M, Crosignani A, et al. Outcome of an outbreak of acute hepatitis C among healthy volunteers participating in pharmacokinetics studies. Hepatology **2002**; 36:993–1000.
63. Oldach D. Multidose jeopardy: HCV transmission risk and management of acute HCV in hospital settings. Hepatology **2002**; 36:1020–1.
64. Jarvis WR. Infection control and changing health-care delivery systems. Emerg Infect Dis **2001**; 7:170–3.
65. Garner JS. Guideline for isolation precautions in hospitals. The Hospital Infection Control Practices Advisory Committee. Infect Control Hosp Epidemiol **1996**; 17:53–80.
66. Boyce JM, Pittet D. Guideline for hand hygiene in health-care settings: recommendations of the Healthcare Infection Control Practices Advisory Committee and the HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force. Society for Healthcare Epidemiology of America/Association for Professionals in Infection Control/Infectious Diseases Society of America. Healthcare Infection Control Practices Advisory Committee, HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force. MMWR Recomm Rep **2002**; 51:1–45, quiz.
67. O'Grady NP, Alexander M, Dellinger EP, et al. Guidelines for the prevention of intravascular catheter–related infections. MMWR Recomm Rep **2002**; 51:1–29.
68. Sehulster L, Chinn RY. Guidelines for environmental infection control in health-care facilities. recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee (HICPAC). CDC, HICPAC. MMWR Recomm Rep **2003**; 52:1–42.
69. Hutin Y, Hauri A, Chiarello L, et al. Best infection control practices for intradermal, subcutaneous, and intramuscular needle injections. Bull World Health Organ **2003**; 81:491–500.
70. Survey reveals that some providers reuse needles. RN **2003**; 66:14.
71. American Association of Nurse Anesthetists. Reuse of needles and syringes by healthcare providers puts patients at risk. 13 November **2002**. Available at: http://www.aana.com/press/2002/111302.asp. Accessed on 10 May 2004.