Transmission and postexposure management of bloodborne virus infections in the health care setting: Where are we now?

Review

Synthèse

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Abstract

THERE HAS BEEN CONSIDERABLE DEBATE ABOUT THE NEED for mandatory serologic testing of individuals who are the source of bloodborne pathogen exposures in health care and other occupational settings. The transmission of hepatitis B (HBV), hepatitis C (HCV) and HIV between patients and health care workers (HCWs) is related to the frequency of exposures capable of allowing transmission, the prevalence of disease in the source populations, the risk of transmission given exposure to an infected source and the effectiveness of postexposure management. Transmission of HBV from patients to HCWs has been substantially reduced by vaccination and universal precautions. The transmission of HCV and HIV to HCWs does occur, although postexposure prophylaxis (PEP) is available to reduce the risk of HIV transmission. Transmission of bloodborne pathogens from infected HCWs to patients has also been documented. Policy-making concerning the mandatory postexposure testing of patients who may be the source of infection must weigh the relative infrequency of patients' refusals to be tested and the consequences for PEP recommendations with the ethical and legal considerations of bypassing informed consent and mandating testing. Mandatory postexposure testing of HCWs who are the source of infection will have a limited impact on reducing transmission because of the lack of recognition and reporting of exposures. Comprehensive approaches have been recommended to reduce the risk of transmission of bloodborne virus infections.

There has been considerable debate about the need for mandatory serologic testing of individuals who are the source of bloodborne pathogen (BBP) exposures in health care and other occupational settings.[1,2] The scientific, ethical and legal aspects of such a policy need to be considered for informed decision-making.[3,4] The transmission of BBPs between patients and health care workers (HCWs) is related to the frequency of exposures capable of allowing transmission, the prevalence of disease in the source populations, the risk of transmission given exposure to an infected source and the effectiveness of postexposure management.[5] Preventive efforts can reduce the risk of exposures, but not eliminate them, and comprehensive guidelines to this end have been published.[6] This paper will focus upon the available pertinent scientific information concerning the transmission and postexposure management of hepatitis B (HBV), hepatitis C (HCV) and HIV in the health care setting. Although they are important, issues related to transmission in other settings[7,8] (e.g., in which emergency responders, such as the police or ambulance attendants, are concerned) will not be specifically addressed.

The literature was reviewed, following searches of the MEDLINE and AIDSLINE databases, using the following key words: "bloodborne pathogens," "disease transmission, professional-to-patient," "disease transmission, patient-to-professional," "HIV," "hepatitis B" and "hepatitis C." References in articles were also retrieved. Web sites of key organizations were also searched, including those of the US Centers for Disease Control and Prevention (CDC); the Laboratory Centre for Disease Control (LCDC), Health Canada; and the UK Public Health Laboratory Service. Key informants were identified, based on initial contact with the LCDC and the Canadian Infectious Diseases Society, and contacted at hospitals located in different regions of the country, as were individuals involved in current research in this area.

Frequency of exposures

Needle-stick and other percutaneous and mucocutaneous exposures are frequent, and underreporting is common. The EPINet hospital-based surveillance system in the United States has estimated that there were approximately 590 164 percutaneous and 196 721 mucocutaneous exposures to blood or risky biologic substances in 1996, with 39% of incidents not having been reported.[9] The estimates of the CDC are 30% higher.[10]

National estimates of exposures in Canada are not currently available, although a national surveillance system is being developed (Sharon Onno, Health Canada, Ottawa, Ont.: personal communication, 2001). Initial investigations in Montreal in 1991/92 found that the overall exposure rate for all job titles was 12.1 per 100 full-time equivalent positions (FTEs) per year in hospitals[11] and 11.7 per 100 FTEs per year in CLSCs (centres locaux de services communautaires).[12] Hospital nurses were the most exposed group averaging 18.1 exposures per 100 FTEs per year, with operating room nurses experiencing the highest rates (39.7 exposures/100 FTEs per year). The researchers estimated that half of all exposures were not reported, with physicians tending not to report their exposures. As of 1997/98, hospital rates of exposure to BBPs decreased to 7.5 exposures per 100 FTEs per year.[13]

Surveys of hospital-based nurses in British Columbia, Alberta and Ontario were conducted in 1998/99. Nurses who worked in the operating room/recovery room were the most likely ever to have been stuck with a needle or sharp (70%–78%) and had the highest average number of injuries during their career (3.1–3.6) (Dr. Heather Clarke, Health and Nursing, Policy, Research and Evaluation Consulting, Vancouver, BC: personal communication, 2000. Dr. Phyllis Giovannetti, University of Alberta, Edmonton, Alta.: personal communication, 2000. Dr. Judith Shamian, WHO Centre for International Nursing Research, Toronto, Ont.: personal communication, 2000).

About 75% of US residents in emergency medicine[14] and Canadian residents in family medicine and internal medicine[15] experience needle-stick injuries during training, with most exposures not being reported. In a study in Toronto of medical students, interns and residents, surgical residents had the highest rates of injury, experiencing an average of 5.4 needle-stick injuries per year with less than 5% of injuries being reported.[16]

Surgeons have high rates of exposure to BBPs that are similar to those of OR nurses and surgical residents. A survey of orthopedic surgeons found that 39.2% had had a percutaneous blood contact in the preceding month.[17] A survey of surgeons from the United States and the University of Toronto found that respondents averaged 11 needle-stick injuries over a 3-year period.[18] Most respondents (70%) rarely or never reported needle-stick injuries.

A CDC review of 9 prospective studies conducted since 1990 reported that a surgical team member sustained at least one percutaneous injury during 1.3%–15.4% of procedures.[19] Possible patient exposures to a sharp object that had previously injured the surgeon occurred in 1.7%–2.5% of operations and 0.1% of deliveries. Table 1 shows the percentage of procedures with injuries and recontact by surgical specialty from a study based in 4 US university teaching hospitals.[20] Recontact was defined as contact of a sharp object that has penetrated an HCW's skin with a patient's open wound or injury of an HCW by a bone fragment or surgical wire fixed in the patient's body. Data from a survey of surgeons at a teaching hospital in London, England, are shown in Table 2.[21] Cardiac and gynecologic surgeries involved the highest frequency of injuries.

Prevalence of disease

Within the general population, the prevalence of potentially infectious individuals varies depending on the virus involved:[6] HBV (< 0.5%), HCV (1%) and HIV (0.15%). Their prevalence in population subgroups can be substantially higher. The rate of HCV infection among injection drug users (IDUs) in Montreal and Vancouver has been reported as being 70% and 85% respectively.[22] Although the majority (67%) of prevalent HIV cases are still among men who have sex with men (MSM) or MSM who are IDUs,[23] almost half of all new infections are among IDUs.[24] HIV

Table 1: Percentage of procedures with injuries and recontact* by surgical specialty in 4 US teaching hospitals

Procedure	Cardiac	Gynecologic	General	Orthopedic	Trauma
Procedures with injury, % (range)	9 (All 9)	10 (3–21)	8 (2–17)	4 (0–8)	5 (3–5)
Procedures with recontact, %	3	4	1	0.3	3

*Recontacts were defined as "(1) recontact of a sharp object with a patient's open wound after penetration of the health care worker's skin or (2) injury of a worker by a bone fragment or surgical wire fixed in the patient's body."[20]
Adapted, with permission, from Tokars et al,[20] *JAMA* 1992;267:2899-904.

prevalence among IDUs has been estimated as being 19.5%, 9% and 23% in Montreal, Toronto and Vancouver respectively.[25]

Limited information is available about the prevalence of BBPs in HCWs, and data are based on nonrepresentative samples. Some 13%–17% of surgeons had evidence of previous or current HBV infection, and 0.8%–0.9% have been found to be anti-HCV-positive.[26] The prevalence of HIV infection among surgeons has been documented to be low (0%–0.1%).[17,27]

BBP transmission

Patient to HCW

Endemic and epidemic transmission of HBV to HCWs was the norm in the past.[28] In many cases, specific exposures could not be retrospectively identified.[29] The introduction of the HBV vaccine and universal precautions contributed to a 95% decrease in the occupational transmission of HBV to US HCWs from 1983 to 1995.[30] Only a minority of people with acute HCV have symptoms, so that transmission will often go unrecognized without serology testing.[31]

As of 1997, there were 94 documented and 170 possible cases of HIV transmission to HCWs.[32] Table 3 shows the distribution of documented and possible HIV infections by occupation. Nurses were the most frequently infected HCWs. Most infections followed a single percutaneous injury (87.2%) and, where the stage of infection was known, 77% of sources had AIDS. One source patient was in the "window" period, that is, the patient was antibody-negative. One Canadian case was reported in 1996 involving a shallow puncture wound in a patient with advanced AIDS.[33] Using estimates of rates of occupational exposure, disease transmission and patient prevalence, the number of US HCWs who probably became infected in 1996 has been calculated as follows: HBV 400, HCV 75–1573 and HIV 400.[9]

HCW to patient

Transmission of BBPs from infected HCWs to patients is possible by recontact when instruments or gloves that are possibly contaminated with an HCW's blood enter an open wound. Patients would not normally be aware of such an exposure unless notified by the HCW.

From 1972 to 1994, there were 42 HBV-infected HCWs, primarily surgeons or dentists, with documented transmission of disease to over 375 patients.[19] This includes a Canadian HBeAg-positive orthopedic surgeon who infected 4 patients despite having received counselling about technique and routinely wearing double gloves during surgery.[19,34] Since 1994, the frequency of dental transmission of BBPs has fallen significantly, although additional clusters of HBV transmission have occurred[35] involving HBeAg-positive[36] and HBeAg-negative surgeons.[37] Transmissions have occurred despite there having been no recognizable breaches in infection-control practices.[38] An outbreak of 75 cases of HBV in the Toronto area was linked to an HBeAg-positive EEG technician using reusable subdermal EEG electrodes.[39]

The surgical specialties involved in transmission have tended to be those with the highest rates of percutaneous injuries and recontact.[19] These recognized cases probably provide an underestimate of the extent of transmission, because only about half of acute HBV cases are symptomatic; isolated, sporadic cases may be more difficult to link with an HCW; and completeness of surveillance may vary among jurisdictions. Virtually all investigations were conducted when the index event was recognition of transmission to a patient.

Documentation of transmission of HCV from infected surgeons to patients has begun to be reported. In the United Kingdom, an infected cardiothoracic surgeon[40] and a gynecologist[41] and, in Spain, an HCV-infected cardiovascular surgeon[42] have been implicated in the transmission of HCV to patients. Transmission of HCV from a patient with chronic infection to an anesthesiology assistant who subsequently infected 5 patients has been described recently.[43]

Table 2: Frequency of sharps injuries and their reporting by surgeons at a teaching hospital in London, England, by specialty

Frequency	Cardio-thoracic	OB/Gyn	General*	Others†‡
Sharps injury, %				
> 1/ mo	60	63	54	19
< 1/mo but > 1/ yr	40	31	23	35
< 1/ yr	0	6	23	47
Always reports sharps injury, %	0	6	14	28

Note: Ob/Gyn = obstetrics and gynecology.
*Data exclude one "no answer" from general surgery.
†Others include orthopedics, ophthalmology, plastic surgery, ear nose and throat, and urology.
‡Column exceeds 100% due to rounding.
Source: Adapted, with permission, from Smith et al,[21] *Ann R Coll Surg* 1996;78:447-9.

Table 3: Number of documented and possible occupational HIV infections worldwide by occupation, 1997

Occupation	No. (and %) of HIV infections in HCWs worldwide: Documented	Possible	Total
Nurse	49 (52.1)	45 (26.5)	94 (35.7)
Lab worker	20 (21.2)	23 (13.5)	43 (16.2)
Physician, nonsurgical	9 (9.6)	17 (10.0)	26 (9.8)
Physician, surgical	1 (1.1)	14 (8.2)	15 (5.7)
Other	15 (16.0)	71 (41.8)	86 (32.6)
Total	94 (100)	170 (100)	264 (100)

Note: HCW = health care worker.
Source: Adapted, with permission, from Ippolito et al,[32] *Clin Infect Dis* 1999;28:365-83.

Six patients became infected with HIV while receiving care from a US dentist with HIV.[44] There had been no other evidence of HIV transmission from infected HCWs[45] until transmission from an orthopedic surgeon with AIDS to a patient in France was reported in 1999.[46] A possible transmission was also reported from France in 2000 involving an infected ward nurse.[47]

Risk of transmission

The average risks of seroconversion after a significant exposure to BBPs without benefit of prophylaxis (HIV) or vaccine (HBV) have been estimated and are shown in Table 4.[28,48] Exposures involving higher volumes of blood or source blood with higher viral titres would be expected to involve higher risks of transmission.

Using these risks of transmission and the rates of percutaneous injuries, estimates have been made regarding the risk of infected HCWs transmitting BBPs to patients. The probability of transmission to at least one patient during 3500 procedures (CDC estimate of number of procedures during a surgeon's career) is 0.81%–8.1% for HIV and 57%–100% for an HBeAg carrier.[49] The HBV rates do not consider clusters of transmission from some infected HCWs that have been observed to have transmission rates that are higher than 10% in some instances. HCV rates were not calculated in the study, although they would be expected to be intermediate between the HIV and HBV estimates.

Current management recommendations

A Canadian integrated protocol to manage HCWs exposed to BBPs was published in 1997.[50] The protocol identifies the necessary counselling, informed consent and testing of both the source of exposure and the HCW for HBV, HCV and HIV. The protocol is explicit that "testing the source without consent is unethical." Baseline serology for the HCW will show the individual to be previously uninfected by any of the viruses and the existence of protective immunity for HBV. Subsequent testing to determine if a susceptible HCW becomes infected is recommended at 6 weeks (HIV only), 3 months and 6 months.

Counselling is intended to reduce the risk to others in case transmission has occurred. Depending upon the BBP involved, exposed HCWs may need to practise safer sex and avoid pregnancy for 6 months, notify sexual partners of their potential exposure and stop breast-feeding.

Table 4: Average risk of seroconversion following a percutaneous exposure to an infected source

Virus	Risk of seroconversion
Hepatitis B* (HbsAg-positive)	HbeAg-negative: 5% HbeAg-positive: 19%–30%
Hepatitis C†	1.8%
HIV*	0.31%

*Data from Lanphear,[28] *Epidemiol Rev* 1994;16:437-50.
†Data from CDC,[48] *MMWR Morb Mortal Wkly Rep* 1998;47(RR-19):1-39.

The protocol for postexposure prophylaxis for HBV is well established[51] and is determined by previous immunization status and documented immunity at any time. The use of the HBV vaccine with or without hepatitis B immune globulin (HBIG) is considered for those who may not be protected. No effective postexposure prophylaxis is available for HCV, and neither interferon nor immune globulin are recommended.[52]

Guidelines for postexposure prophylaxis (PEP) for exposure to HIV[50,53] are primarily based upon a retrospective case–control study showing an 81% (95% CI 43%–94%) reduction in HIV transmission among HCWs who used zidovudine (ZDV).[54] The failure of PEP may be due to exposure to ZDV-resistant strains of HIV; high viral titre or large exposure inoculums, or both; delayed initiation or short duration of PEP, or both; as well as possible host-specific and virus-specific factors.[53] Current PEP protocols include ZDV and at least one other drug taken for a period of 4 weeks. Most HCWs (50%–75%) who take PEP experience one or more complaints, and a large proportion discontinue the drug because of symptoms.[53–57] Although side effects usually disappear on discontinuation of PEP, some serious side effects have been reported including nephrolithiasis, hepatitis and pancytopenia. There have been recent reports of severe adverse reactions including the need for liver transplant following the use of nevirapine in HCW PEP.[58,59] HCWs and others being offered PEP following possible or documented exposure to HIV must be fully aware of the potentially serious risks of some antiretroviral drugs and balance these against the relatively low risk of becoming infected with HIV. PEP is usually discontinued if subsequent source testing is negative. The use of point-of-care HIV testing will facilitate early decision-making.[60]

Refusal to be tested

Concern has been expressed about the potential barrier to achieving informed consent for HIV testing and the subsequent impact on postexposure management. Many of the published studies predate knowledge of effective prophylaxis, whereas others may be limited by the overall effectiveness of the occupational health program. Studies from Virginia (1988),[61] Calgary (1989–1993)[62] and Maryland (1999)[63] reported refusal rates from 0.5% to 6%, with high proportions of patients lost to follow-up. Recent data from St. Paul's Hospital in Vancouver included 2 instances of refusal by patients to be tested in an estimated 1700 accidental exposures (0.1%) over a 10-year period.[1] Infectious disease practitioners or occupational health practitioners in other parts of the country confirmed the infrequency of refusal to be tested by patients who may be the source of infection following reported exposures, with the estimated frequency ranging from 0.2% to 0.5% (Dr. Mark Joffe, Capital Health Region Hospitals, Edmonton, Alta.: personal communication, 2000. Ms. Carol Small, Sunnybrook Campus, Sunnybrook & Women's College Health Sciences Centre, Toronto, Ont.: personal communication, 2000. Dr. Mark Miller, Sir Mortimer B. Davis Jewish General Hospital, Montreal, Que.: personal communication, 2000. Ms. Bonnie Walker, Queen Elizabeth Health Sciences Centre, Halifax, NS: personal communication, 2000).

At least 2 US states require patients who are the source of an occupational exposure to be tested for HIV. Virginia has had this law since 1989[64] and Florida since 1998.[65] Some additional states (e.g., California) allow testing of blood that had been collected for other purposes.[63] No information about these states' experiences since the implementation of these laws was found in the literature.

No information was encountered in the literature regarding the refusal of HCWs to be tested if they were the source of an exposure to a patient. However, it is unlikely that the patient would know that there had been an exposure unless the HCW acknowledged the fact.

Psychological consequences

The consequences of occupational exposure to BBPs are not limited solely to infections. The anxiety experienced by HCWs is related to the perception of risk from the incident and the predicted reaction of others (colleagues, family, friends) who have to be told.[66] HCWs will frequently experience intrusive thoughts, problems concentrating, sleep difficulties, anger and a decrease in sexual desire,[67] which can act as a catalyst to exacerbate any pre-existing unresolved emotional issues.[68] Whereas the hepatitis viruses are more easily transmissible, the fear of HIV infection is at the core of the stress and anxiety experienced by many HCWs.[69]

Economic evaluation of postexposure prophylaxis

A cost-effectiveness analysis of an HIV PEP program in a New York City hospital calculated that if the serologic status of the sources was unknown and 35% were HIV-positive, ZDV would prevent 53 of 66 possible HIV seroconversions in 100 000 exposures at a cost of US$2 million per case of HIV prevented.[70] If the source was known to be HIV-positive, the cost per case prevented would range from US$400 000 to US$560 000.[70,71] For comparison purposes, offering maternal HIV screening with ZDV chemoprophylaxis, which is endorsed by the Canadian Medical Association (CMA),[72] has been estimated to cost US$198 000 per newborn case prevented for a population at average risk.[73]

Summary

In 1999, the CMA's General Council approved a resolution to require patients to sign a waiver that would allow appropriate testing of the patient's serologic status for HIV and hepatitis if an HCW received a potential exposure to a BBP.[1] A comparable resolution involving exposures from HCWs to patients was referred to the CMA Board of Directors for further study. Over the following year, it was determined that a waiver approach was not feasible or appropriate, and a differently worded resolution enabling mandatory testing of source patients or HCWs following a BBP exposure was presented to the 2000 CMA General Council (Dr. Isra Levy, CMA, Ottawa, Ont.: personal communication, 2001) and defeated.[2]

Because HBV can be prevented with immunization and postexposure treatment for HCV exposure is not available, the primary purpose of source testing is to establish HIV serologic status. HIV PEP reduces the risk of transmission and must be started within hours of exposure. A negative result is not totally reassuring because of the potential for a window period of infection without the presence of antibodies, however, a patient's refusal to be tested will impair fully informed decision-making concerning PEP, increase HCW anxiety and possibly result in unnecessary PEP side effects. Policy-making in this area must weigh the relative infrequency of such refusals and the consequences for PEP recommendations with the ethical and legal considerations of bypassing informed consent and mandating testing.

Addressing the issue of infected HCWs has also been troublesome. The 1998 Canadian "consensus" conference recommended that HBV immunization with confirmation of immunity be mandatory for HCWs who perform or will perform exposure-prone procedures. Those found to be HBV carriers were to be referred to an expert panel who would assess the risk of transmission.[5] The CMA and the Canadian Dental Association submitted dissenting opinions, and the mandatory immunization and serology recommendations have yet to be implemented. Provincial colleges are at various stages of setting up expert panels to address the practice issues of infected physicians.[74]

In the United States, the CDC recommended in 1991 that HIV-positive and HBeAg-positive HCWs should be reviewed by an expert panel and should inform patients of their serologic status before engaging in exposure-prone procedures.[75] It has been argued recently that this approach should be replaced with a less aggressive strategy,[76] although the accompanying editorial argues that providing greater protection of the interests of the infected HCW occurs at an unknown expense to patients' health.[77] In the United Kingdom, the initial restriction on performing invasive procedures by HCWs who are HBeAg-positive has been expanded to include those who are HBeAg-negative but with high viral loads following clusters of HBV transmission from HBeAg-negative surgeons.[78]

The differences in policies, approaches and recommendations that address the issue of infected HCWs occur despite the same information being available to all decision-makers. Needle-stick injuries in some health care settings provide the potential for bilateral transmission. For most patient infections, the injury or recontact is either not recognized or not reported in time to initiate prophylactic treatment, and patients have no independent source of information regarding exposure other than notification by the HCW. Considering the lack of recognition and reporting of potential exposures, it is unlikely that a policy of mandatory postexposure HCW testing would contribute in any substantive way to the reduction of HCW-to-patient transmission of BBPs. Previous recommendations to reduce transmission have included the proper implementation of infection control and engineering techniques, universal HCW immunization with HBV vaccine, improved reporting of exposures, making HCWs responsible for being aware of their serologic status, a reporting and review mechanism for infected HCWs and a support system including retraining, if required, for infected HCWs.[5] Although improved information and surveillance systems could provide better data to inform decision-making, they will not eliminate the difficulties of reconciling patient and HCW perspectives at the interface of scientific, legal and ethical considerations.

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References

1. Tyndall MW, Schechter MT. HIV testing of patients: let's waive the waiver. *CMAJ* 2000;162(2):210-1. Available: www.cma.ca/cmaj/vol-162/issue-2/0210.htm
2. Hoey J. CMA rescinds controversial policy. *CMAJ* 2000;163(5):594. Available: www.cma.ca/cmaj/vol-163/issue-5/0594b.htm
3. *Mandatory testing*. Information sheet number 12. Montreal: Canadian HIV/AIDS Legal Network; 2000.
4. Elliot R, Jurgens R. *Rapid HIV screening at the point of care: legal and ethical questions*. Montreal: Canadian HIV/AIDS Legal Network; 2000.
5. Laboratory Centre for Disease Control. Proceedings of the consensus conference on infected health care workers: risk for transmission of bloodborne pathogens. *Can Commun Dis Rep* 1998;24(Suppl 4).
6. Laboratory Centre for Disease Control. Preventing the transmission of bloodborne pathogens in health care and public service settings. *Can Commun Dis Rep* 1997;23(Suppl 3).
7. Lorentz J, Hill L, Samimi B. Occupational needlestick exposures in a metropolitan police force. *Am J Prev Med* 2000;18:146-50.
8. Bill C-244: an act to provide for the taking of samples of blood for the benefit of persons administering and enforcing the law and good Samaritans and to amend the Criminal Code. Ottawa: The House of Commons; 1999. Available: www.parl.gc.ca/36/2/parlbus/chambus/house/bills/private/C-244/C-244_1/362020bE.html (accessed 2001 July 23).
9. International Health Care Worker Safety Center, University of Virginia. Annual number of occupational percutaneous injuries and mucocutaneous exposures to blood or potentially infective biological substances. Charlottesville (Va): The Center; 1998 June. Available: www.med.virginia.edu/medcntr/centers/epinet/estimates.html (accessed 2001 June 26).
10. Panlilio AL, Cardo DM, Campbell S, Srivastava PU, Williams I, Jagger J, et al. Estimate of the annual number of percutaneous injuries in US health-care workers [abstract]. 4th Decennial International Conference on Nosocomial and Healthcare-Associated Infections; 2000 Mar 5-9; Atlanta (Ga). Available: www.cdc.gov/ncidod/hip/NASH/4thabstracts.htm (accessed 2001 July 23).
11. Robillard P, Roy E. Blood and body fluid exposures among health care workers in acute care hospitals. In: Hagberg, Hofmann, Stobel, Westlander, editors. *International Commission on Occupational Health: occupational health for health care workers*. 2nd International Congress. 1st update. Stockholm (Sweden). Landsberg (Germany): Ecomed; 1995. p. 158-65.
12. Roy E, Robillard P, Charlebois AM. Blood and body fluid exposures among health care workers in non hospital settings. In: Hagberg, Hofmann, Stobel, Westlander, editors. *International Commission on Occupational Health: occupational health for health care workers*. 2nd International Congress. 1st update. Stockholm (Sweden). Landsberg (Germany): Ecomed; 1995. p. 166-70.
13. Robillard P, Roy E, Larouche L. Trends in blood and body fluid (BBF) exposures in acute care hospitals (ACHs) [abstract]. National HIV Prevention Conference; 1999 Aug 29-Sept 1; Atlanta (Ga).
14. Lee CH, Carter WA, Chiang WK, Williams CM, Asimos AW, Goldfrank LR. Occupational exposures to blood among emergency medicine residents. *Acad Emerg Med* 1999;6:1036-43.
15. Shapiro MF, Hayward RA, Guillemot D, Jayle D. Residents' experiences in, and attitudes toward, the care of persons with AIDS in Canada, France, and the United States. *JAMA* 1992;268:510-5.
16. McGeer A, Simor AE, Low DE. Epidemiology of needlestick injuries in house officers. *J Infect Dis* 1990;162:961-4.
17. Tokars JI, Chamberland ME, Schable C, Culver DH, Jones M, McKibben PS, et al. A survey of occupational blood contact and HIV infection among orthopedic surgeons. *JAMA* 1992;268:489-95.
18. Patterson JMM, Novak CB, Mackinnon SE, Patterson GA. Surgeons' concern and practices of protection against bloodborne pathogens. *Ann Surg* 1998;228:266-72.
19. Bell DM, Shapiro CN, Ciesielski CA, Chamberland ME. Preventing bloodborne pathogen transmission from health-care workers to patients: the CDC perspective. *Surg Clin North Am* 1995;75:1189-203.
20. Tokars JI, Bell DM, Culver DH, Marcus R, Mendelson MH, Sloan EP, et al. Percutaneous injuries during surgical procedures. *JAMA* 1992;267:2899-904.
21. Smith ER, Banatvaia JE, Tilzey AJ. Hepatitis B vaccine uptake among surgeons at a London teaching hospital: How well are we doing? *Ann R Coll Surg Engl* 1996;78:447-9.
22. Laboratory Centre for Disease Control. Hepatitis C prevention and control: a public health consensus. Ottawa, October 14–16, 1998. *Can Commun Dis Rep* 1999;25(Suppl):1-25.
23. Laboratory Centre for Disease Control. National HIV prevalence and incidence estimates for 1999: no evidence of a decline in overall incidence. Ottawa: Health Canada; 2001 May. Available: www.hc-sc.gc.ca/hpb/1cdc/bah/epi/estima_e.html (accessed 2001 July 23).
24. Laboratory Centre for Disease Control. Positive HIV test reports in Canada. Ottawa: Health Canada; updated 2000 May 16. Available: www.hc-sc.gc.ca/hpb/lcdc/bah/epi/poshiv_e.html (accessed 2001 July 23).
25. Laboratory Centre for Disease Control. HIV/AIDS among injection drug users in Canada. Ottawa: Health Canada; updated 2001 May 16. Available: www.hc-sc.gc.ca/hpb/lcdc/bah/epi/idus_e.html (accessed 2001 July 23).
26. Cardo DM, Bell DM. Bloodborne pathogen transmission in health care workers: risks and prevention strategies. *Infect Dis Clin North Am* 1997;11:331-46.
27. Short LJ, Bell DM. Risk of occupational infection with blood-borne pathogens in operating and delivery room settings. *Am J Infect Control* 1993;21:343-50.
28. Lanphear BP. Trends and patterns in the transmission of bloodborne pathogens to health care workers. *Epidemiol Rev* 1994;16:437-50.
29. Lanphear BP. Transmission and control of bloodborne viral hepatitis in health care workers. *Occup Med* 1997;12:717-30.
30. 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;157:2601-3.
31. Gully PR, Tepper ML. Hepatitis C. *CMAJ* 1997;156(10):1427. Available: www.cma.ca/cmaj/vol-156/issue-10/1427.htm
32. Ippolito G, Puro V, Heptonstall J, Jagger J, De Carli G, Petrosillo N. Occupational human immunodeficiency virus infection in health care workers: worldwide cases through September 1997. *Clin Infect Dis* 1999;28(2):365-83.
33. Laboratory Centre for Disease Control. Protocols help protect against getting HIV — but you have to use them. *Can Commun Dis Rep* 1996;22:54-6.
34. Johnston BL, MacDonald S, Lee S, LeBlanc JC, Gross M, Schlech WF, et al. Nosocomial hepatitis B associated with orthopedic surgery — Nova Scotia. *Can Commun Dis Rep* 1992;18:89-90.
35. Sheldon T. Dutch consider obligatory testing of surgeons for hepatitis B. *BMJ* 1999;319:1219.
36. Mukerjee AK, Westmoreland D, Rees HG. Response to the discovery of two practicing surgeons infected with hepatitis B. *Commun Dis Rep CDR Rev* 1996;6(9):R126-8.
37. Incident Investigation Team. Transmission of hepatitis B to patients from four infected surgeons without hepatitis B e antigen. *N Engl J Med* 1997;336:178-84.
38. Harpaz R, Seidlein LV, Averhoff FM, Tormey MP, Sinha SD, Kotsopoulou K, et al. Transmission of hepatitis B virus to multiple patients from a surgeon without evidence of inadequate infection control. *N Engl J Med* 1996;334:549-54.
39. Hepatitis B Outbreak Investigation Team. An outbreak of hepatitis B associated with reusable subdermal electroencephalogram electrodes. *CMAJ*

2000;162(8):1127-31. Available: www.cma.ca/cmaj/vol-162/issue-8/1127.htm
40. Public Health Laboratory Service. Hepatitis C virus transmission from health care worker to patient. *Commun Dis Rep CDR Wkly* 1995;26:121.
41. Public Health Laboratory Services. Transmission of hepatitis C virus from surgeon to patient prompts lookback. *Commun Dis Rep CDR Wkly* 1999;9 (44):387.
42. Esteban JI, Gomez J, Martell M, Cabot B, Quer J, Camps J, et al. Transmission of hepatitis C virus by a cardiac surgeon. *N Engl J Med* 1996:334(9):555-60.
43. Ross RS, Viazov S, Gross T, Hofmann F, Seipp HM, Roggendorf M. Brief report: transmission of hepatitis C virus from a patient to an anesthesiology assistant to five patients. *N Engl J Med* 2000;343:1851-4.
44. Ciesielski C, Marianos D, Chin-Yih O, Dumbaugh R, Witte J, Berkelman R, et al. Transmission of human immunodeficiency virus in a dental practice. *Ann Intern Med* 1992;116:798-805.
45. Robert LM, Chamberland ME, Cleveland JL, Marcus R, Gooch BF, Srivastava PU, et al. Investigation of patients of health care workers infected with HIV. The Centers for Disease Control and Prevention database. *Ann Intern Med* 1995;122(9):653-7.
46. Lot F, Seguier JC, Fegueux S, Astagneau P, Simon P, Aggoune M, et al. Probable transmission of HIV from an orthopedic surgeon to a patient in France. *Ann Intern Med* 1999,130:1-6.
47. Goujon CP, Schneider VM, Grofti J, Montigny J, Jeantils V, Astagneau P, et al. Phylogenetic analyses indicate an atypical nurse-to-patient transmission of human immunodeficiency virus type 1. *J Virol* 2000;74:2525-32.
48. Centers for Disease Control and Prevention. Recommendations for prevention and control of hepatitis C virus (HCV) infection and HCV-related chronic disease. *MMWR Morb Mortal Wkly Rep* 1998;47(RR-19):1-39.
49. Bell DM, Shapiro CN, Culver DH, Martone WJ, Curran JW, Hughes JM. Risk of hepatitis B and human immunodeficiency virus transmission to a patient from an infected surgeon due to percutaneous injury during an invasive procedure: estimates based on a model. *Infect Agents Dis* 1992;1:263-9.
50. Laboratory Centre for Disease Control. An integrated protocol to manage health care workers exposed to bloodborne pathogens. *Can Commun Dis Rep* 1997;23S2.
51. National Advisory Committee on Immunization. *Canadian immunization guide*. 5th ed. Ottawa: Canadian Medical Association; 1998.
52. Centers for Disease Control and Prevention. Recommendations for follow-up of health-care workers after occupational exposure to hepatitis C virus. *MMWR Morb Mortal Wkly Rep* 1997;46:603-6.
53. Centers for Disease Control and Prevention. Public Health Service guidelines for the management of health-care worker exposures to HIV and recommendations for postexposure prophylaxis. *MMWR Morb Mortal Wkly Rep* 1998; 47(RR-7):1-33.
54. Cardo DM, Culver DH, Ciesielski CA, Srivastava PU, Marcus R, Abiteboul D, et al. A case-control study of HIV seroconversion in health care workers after percutaneous exposure. *N Engl J Med* 1997;337:1485-90.
55. Sepkowitz KA, Rivera P, Louther J, Lim S, Pryor B. Postexposure prophylaxis for human immunodeficiency virus: frequency of initiation and completion of newly recommended regimen. *Infect Control Hosp Epidemiol* 1998;19: 506-8.
56. Public Health Laboratory Services. Surveillance of health care workers exposed to bloodborne viruses at work: July 1997 to June 1999. *Commun Dis Rep CDR Wkly* 1999;9:319.
57. Centers for Disease Control. The national surveillance system for hospital health care workers: summary report for data collected from June 1995 through July 1999. Atlanta (Ga): US Centers for Disease Control and Prevention; updated 2000 Jan 7. Available: www.cdc.gov/ncidod/hip/NASH /report.htm (accessed 2001 June 26).
58. Johnson S, Baraboutis JG. Adverse effects associated with use of nevirapine in HIV postexposure prophylaxis for 2 health care workers. *JAMA* 2000;284:2722-3.
59. Sha BE, Proia LA, Kessler HA. Adverse effects associated with use of nevirapine in HIV postexposure prophylaxis for 2 health care workers. *JAMA* 2000; 284:2723.
60. Laboratory Centre for Disease Control. Point-of-care HIV testing using simple/rapid HIV test kits: guidance for health-care professionals. *Can Commun Dis Rep* 2000;26:49-59.
61. Miller PJ, Farr BM. A study of the rate of postexposure human immunodeficiency virus testing in a hospital requiring written informed consent. *J Occup Med* 1989;31:524-7.
62. Hope KM, Henderson E, Ledgerwood D, Hume K, Louie TJ. Should infection control practitioners do follow-up of staff exposures to patient blood and body fluids. *Am J Infect Control* 1996;24:57-66.
63. Solomon L, Thompson C, Squiers L, Wulff K, Benjamin G. Occupational exposure and voluntary human immunodeficiency virus testing: a survey of Maryland hospitals. *Infect Control Hosp Epidemiol* 1999;20:430-2.
64. Sistrom MG, Coyner BJ, Gwaltney JM, Farr BM. Frequency of percutaneous injuries requiring postexposure prophylaxis for occupational exposure to human immunodeficiency virus. *Infect Control Hosp Epidemiol* 1998;19:504-6.
65. Florida State Department of Health. 1998 HIV/AIDS legislative overview. Available: www9.myflorida.com/aids/legal/legislative.html (accessed 2001 July 23).
66. Cockcroft A, Oakley K, Gooch C, Mastin S. Anxiety and perception of risk of HIV and hepatitis B infection among health-care workers reporting accidental exposures to blood and body fluids. *AIDS Care* 1994;6:205-14.
67. Armstrong K, Gorden R, Santorella G. Occupational exposures of health care workers (HCWs) to human immunodeficiency virus (HIV): stress reactions and counseling interventions. *Soc Work Health Care* 1995;21:61-80.
68. Husack PJ. HIV threat and health care workers: a view from the therapist's chair. *J Healthcare Safety Compliance Infect Control* 1999;3:327-35.
69. Tannebaum J, Anastasoff J. The role of psychosocial assessment and support in occupational exposure management. *AIDS Educ Prev* 1997;9:275-84.
70. Marin MG, Lieu JV, Yee A, Bonner E, Glied S. Cost-effectiveness of a post-exposure HIV chemoprophylaxis program for blood exposures in health care workers. *J Occup Environ Med* 1999;41:754-60.
71. Pinkerton SD, Holtgrave DR, Pinkerton HJ. Cost-effectiveness of chemoprophylaxis after occupational exposure to HIV. *Arch Intern Med* 1997;157: 1972-80.
72. CMA endorses HIV testing during pregnancy. *CMA News* 1997;7(6):5. Available: www.cma.ca/cmanews/vol-7/june5b-e.htm (accessed 2001 June 27).
73. Ecker JL. The cost-effectiveness of human immunodeficiency virus screening in pregnancy. *Am J Obstet Gynecol* 1996;17:716-21.
74. Physicians with infectious diseases: patchwork of policies will likely persist. *CMA News* 1999;9(8):5.
75. Centers for Disease Control. Recommendations for preventing transmission of human immunodeficiency virus and hepatitis B virus to patients during exposure-prone invasive procedures. *MMWR Morb Mortal Wkly Rep* 1991; 40(RR-8):1-9.
76. Gostin LO. A proposed national policy on health care workers living with HIV/AIDS and other blood-borne pathogens. *JAMA* 284;15:1965-70.
77. Fost N. Patient access to information on clinicians infected with blood-borne pathogens. *JAMA* 2000;284:1975-6.
78. National Health Service. Hepatitis B infected health care workers: guidance on implementation of health service circular 2000/020. London: The NHS; updated 2000 June 23. Available: www.doh.gov.uk/nhsexec/hepatitisb.htm (accessed 2001 June 26).

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