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Estimation of the global burden of disease attributable to contaminated sharps injuries among health-care workers

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Background
We estimated the global burden of hepatitis B (HBV), hepatitis C (HCV) and human immunodeficiency virus (HIV) infection due to percutaneous injuries among health care workers (HCWs).

Methods
We modelled the incidence of infections attributable to percutaneous injuries in 14 geographical regions on the basis of the probability of injury, the prevalence of infection, the susceptibility of the worker and the percutaneous transmission potential. The model also provided the attributable fractions of infection in HCWs.

Results
Overall, 16,000 HCV, 66,000 HBV and 1,000 HIV infections may have occurred in the year 2000 worldwide among HCWs due to their occupational exposure to percutaneous injuries. The fraction of infections with HCV, HBV and HIV in HCWs attributable to occupational exposure to percutaneous injuries fraction reaches 39%, 37% and 4.4% respectively.

Conclusions
Occupational exposures to percutaneous injuries are substantial source of infections with bloodborne pathogens among health-care workers. These infections are highly preventable and should be eliminated.

Keywords
Needlestick injuries; percutaneous injuries; sharps injuries; occupational disease; health care workers, HIV, HBV, HCV

INTRODUCTION

Health-care workers (HCWs) are at risk of many infections at their workplace through airborne, bloodborne, faecal-oral transmission and direct contact. Exposures to bloodborne pathogens have received increased attention since the HIV pandemic. The transmission of bloodborne pathogens may occur through percutaneous and mucocutaneous (i.e. contact with intact or non-intact skin, and contact with mucous membranes) routes, and sometimes, through exposure to other body fluids (Sepkowitz 1996).

Strategies are available to prevent infections due to sharps injuries including education of HCWs on the risks and precautions, reduction of invasive procedures, use of safer devices and procedures and management of exposures. In the industrialized world, occupational surveillance assess and monitor the health hazards related to bloodborne pathogens and prevention measures reduce the risk of transmission (e.g. Canadian Center for Occupational Health and Safety - CCOHS 2000, NIOSH 2002).

In contrast, in developing countries, exposure and health impacts are rarely monitored and much remains to be done to protect HCWs from such risks that cause infections, illness, disability and death, that may in turn impact on the quality of health care. To better target prevention efforts, information on the burden caused by occupational transmissions would be useful. This paper therefore assesses the burden of occupational infections with HCV, HBV and HIV attributable to sharps injuries among HCWs. This study focuses on injuries caused by contaminated sharps, which include needles, lancets, scalpels and broken glass. These are the exposures associated with the highest risk of transmission and they account for the largest proportion of exposures (EPINet 1998; NaSH 1999; CCOHS 2000; Puro *et al*. 2001; Romea *et al*. 1995). Hepatitis B virus (HBV), hepatitis C virus (HCV) and human immunodeficiency virus (HIV) are the three pathogens most commonly transmitted to health care workers in the occupational setting (Sepkowitz, 1996). This study was conducted in the framework of the World Health Organization's Global Burden of Disease project (WHO 2002).

MATERIALS AND METHODS

The methodology used in this study is described in greater detail elsewhere (Prüss-Üstün et al. 2003).

Risk factor definition

The studied risk consists in a percutaneous exposure of a HCW with at least one sharp object contaminated with HBV, HCV or HIV during the past year in their work environment. It was assumed that the contamination of the sharp object occurred through previous contact with blood or body fluids of another person.

Studied population groups

The number of infections was calculated for men and women, four age groups (20-29, 30-44, 45-59 and 60-69) and 14 regions. These regions correspond to geographical regions divided according to child and adult mortality levels (Nelson et al. 2004). Infections were assessed for sharps injuries occurring in the year 2000.

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Exposed population and proportion of susceptibles

To estimate the size of the population of health-care workers we used the following sources: (1) the WHO Statistical Information System WHOSIS (WHO, 2001a), (2) the International Labour Organization (ILO) database (ILO, 1994) and (3) the ILO Yearbook of Labour Statistics (ILO, 2000). As these sources contained limited information on either the categories of HCW or gender distribution, or had reduced geographical coverage, we used a combination of them to establish a global estimate.

It was assumed that the age distribution of HCWs at risk was similar to the age distribution of the general population between the age of 20 and 64 years old (UN, 1998).

The model for estimating incidence of infection due to sharps injuries (I_n)

The model developed to estimate the incidence of HCV, HBV and HIV infections attributable to sharps injuries among HCWs was based on an estimation of the probability of infection using an equation frequently used in modelling incidence of communicable diseases. The probability of at least one infection corresponded to x events with probability p leading to at least one "success" (infection) as follows (Snedecor & Cochran, 1989):

$$P_{(\text{at least one infection})} = 1 - (1 - p)^x$$

In our model, p represents the probability of all events that need to occur jointly for an injury with a contaminated sharp object to result in an infection. This probability is based on the multiplication of a series of probabilities of independent events:

$$p = p_v * p_t * p_s$$

in which p_v is the prevalence of active infection in the population (that determines the probability of contamination with blood borne pathogens for the object causing the injury), p_t the probability of infection following percutaneous exposure with a sharps used on an infected source patient and p_s the proportion of the population that is susceptible to infection. This probability being based upon mass action assumptions (i.e. the assumption that the risk of infection increases proportionally to the number of infectious individuals in the population), the incidence of infection caused by sharps injuries was expressed as[1]:

$$I_n = 1 - (1 - p_s * p_t * p_v)^n$$

where n is the average number of percutaneous injuries suffered by HCWs.

The proportion of susceptibles (p_s) among the HCWs was calculated using catalytic modelling based upon the incidence of the disease among susceptible HCWs

$$P_{s\,(a)} = P_{s(a-1)} * (1 - I_s)^A$$

where a is the age category, A is the total number of years in the age category considered, and I_s the incidence of disease among susceptible HCWs.

The calculation of HCWs susceptible to HBV took into account the proportion of HCWs immunized against the disease in each region, as reported from available studies.

The number of infections (N_I) due to sharps injuries was calculated by multiplying the number of HCWs at risk (N_{HCW}) by the incidence of infection caused by sharps injuries (I_n).

$$N_I = I_n * N_{HCWs}$$

The attributable fraction of infections due to percutaneous injuries was calculated as the proportion of infections due to sharps over the total number of infections in HCWs.

Sources of information for input parameters

Frequency of sharps injuries (n). To estimate the number of percutaneous exposures among HCWs (n) an electronic literature search was conducted in MEDLINE and the WHO Regional library databases. Searches used a combination of the MeSH terms "viral infection", "hepatitis", "hepatitis B virus", "hepatitis infection", "hepatitis C", "AIDS virus", "HIV", with "needlestick injury", "percutaneous exposure", "occupational exposure", "sharps", "occupational disease", "health care worker", "health care personnel", "employee health" and "accident prevention". The search was limited to articles that (1) studied primarily human subjects, (2) were published between 1985 and 2001 and (3) included a full text or an abstract in English, French, Spanish, Portuguese, Italian or German. The reference list of identified articles and reviews were also checked to identify other relevant articles.

After combining search results and eliminating duplicates, the search yielded more than 700 references. Articles that were retrieved for review reported (1) observational studies addressing occupational exposure of HCWs to sharps injuries, (2) retrospective or prospective analysis of occupational exposures (3) analysis of occupational surveillance data and (4) literature reviews. In addition, we reviewed reports of injections safety surveys performed with WHO standardized "Rapid assessment tool" and "Tool for the assessment of injection safety" (WHO, 2001b; WHO, 2000a)).

*Probability of infection following a percutaneous exposure.*The probability of infection following exposure to a sharps used on infected patients (p_t) has been studied in health-care settings. It was assumed to be 0.018 for HCV (CDC, 1997) and 0.003 for HIV (Cardo *et al.*, 1997). For HBV, p_t was assumed to be 0.18 as an average between the estimated 0.06 and 0.3 for source patients hepatitis B e-antigen (HBeAg)-negative and for source patients HBeAg-positive, respectively (Seeff *et al.* 1978).

[1] This equation can be applied to a population group provided that the probability, p, remains relatively low, which was the case for all groups considered in this analysis.

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Prevalence and incidence of infections. The country-specific estimates of the prevalence of HCV, HBV and HIV infection (p_v) were obtained from the WHO programmes on immunization against hepatitis B (WHO 1996) and hepatitis C prevention (WHO 2001) and the United Nations Programme on HIV/AIDS (UNAIDS 2000, 2001). For HCV and HBV, the annual incidence and age-specific susceptibility was estimated by catalytic modelling. HIV incidence estimates were obtained from UNAIDS.

Prevalence of infection in in-patients as compared to the general population. Based on a review of studies from the literature, we estimated the median ratio of prevalence of infection in patients to the general population. As a conservative approach, we used the prevalence in the general population for HCV and HBV. For HIV, we used a patient prevalence of twice the value of the general population. The median ratio was considered in the uncertainty analysis for the upper estimate. A detailed analysis of the data that lead to these decisions was published elsewhere (Prüss-Üstün et al. 2003)

Post exposure prophylaxis

For the regions Amr A, Eur A and Wpr A the incidence of HBV and HIV infections caused by a sharps injury took into account the effect of post exposure prophylaxis (PEP). In the absence of accurate coverage estimates, we considered that PEP was offered following each incident. The efficacy of the PEP regimen was estimated to be 90% for HBV (CDC 2001, Beasley 1983; Stevens 1985) and 81% for HIV (Cardo 1997).

Uncertainty analysis

We considered the main sources of quantifiable uncertainty to be: (1) the annual incidence of sharps injuries (2) the hepatitis B immunization coverage and (3) the prevalence of the disease among the hospital populations as compared to the general population.

We estimated the upper and lower bounds of the annual number of sharps injuries as ±65% around the regional average, being the mean average deviation. For A regions, the lower and upper bounds of the HBV immunization rate were estimated by proportionally applying the confidence interval of the main study performed in Amr A (Mahoney *et al.* 1997). For the other regions the lower bound was arbitrarily fixed at 5% and the upper bound was taken as 30% above the reported figure. The values for the median ratio of hospital patient prevalence to the general population prevalence (i.e. 3.4 for HCV, 1.9 for HBV and 5.9 for HIV) were introduced to estimate the upper uncertainty boundary. Lower and upper uncertainty boundaries of the estimated number of infections caused by sharps were obtained by introducing into the model lower and upper estimates of the annual incidence of sharps injuries, the HBV immunization rates, and by introducing the hospital patient prevalence for the estimate of the upper bound.

Estimation of the number of deaths

HCV, HBV and HIV infections attributable to sharps injuries are converted into resulting deaths using theoretical cohorts followed for (1) background mortality and (2) deaths from acute hepatitis, hepatocellular hepatitis, end-stage liver disease and AIDS (Hauri et al. 2003). To estimate mortality from HCV infections, 63% of persons infected before the age 40 years were assumed to progress to chronic infection, with a cumulated incidence rate of cirrhosis of 5% at 20 years and a yearly mortality rate associated with chronic liver disease of 3.7% after the onset of cirrhosis. In persons infected after the age of 40 years, the assumed rate of progression to chronic infection was 80%, the cumulated incidence rate of cirrhosis of 20% at 20 years and the yearly mortality rate remained the same as in the younger age group. To estimate the mortality rate due to HBV, we assumed a rate of progression to chronic infection of six percent in persons infected at adult age and an annual sero-conversion rate of 1% following chronic infection. Further details and references on the natural history parameters, including the rate of progression to chronic infection, mortality rates associated with chronic liver infection and risk of fulminant hepatitis are outlined in Hauri et al. 2003.

RESULTS

Overall, the number of HCWs was estimated at 35,702,000 worldwide (Table I). Over 44% of these workers were from the three A regions, whose combined population only represents the 15% of the total world population. The proportion of HCWs among the general population ranged from 0.1% in Sear D to 2.5% in Amr A. The proportions were generally higher in A countries and especially low in D countries.

Table I: Estimates of the number of health care workers at risk in the 14 WHO regions

Region[1]	Total population (x1000)	Number of health care workers	Proportion of health care workers in total population
Afr D	292,130	611,000	0.21%
Afr E	337548	1,011,000	0.30%
Amr A	311,000	7,696,000	2.47%
Amr B	428,680	1,518,000	0.35%
Amr D	71,200	176,000	0.25%
Emr B	133,400	739,000	0.55%
Emr D	325,340	782,000	0.24%
Eur A	409,897	5,773,000	1.41%
Eur B	216,930	2,255,000	1.04%
Eur C	249,400	4,222,000	1.69%
Sear B	293,300	488,000	0.17%
Sear D	1,238,890	1,395,000	0.11%
Wpr A	152,000	2,351,000	1.55%
Wpr B	1,524,050	6,685,000	0.44%
Total	5,983,765	35,702,000	0.60%

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Regional estimates for the coverage of hepatitis B immunization among HCWs ranged between 18% and 77%, with higher rates in "A" countries. The reported incidence of sharps injuries ranged from 0.18 per year and HCW (Amr A) to four per year and HCW (Emr D, Table II). Estimates for the two African sub-regions (Afr D and Afr E) and for the two European regions (Eur B and Eur C) were pooled because of assumed similarities in care practices and the lack of major differences in socio-economic conditions. As no quantitative data were available for the region Amr D the estimates were extrapolated from Amr B. Overall the number of HCWs annually exposed to a sharps injuries contaminated with HCV, HBV and HIV was estimated to reach 926,000, 2.1 million, and 327,000, respectively (Table III).

Table II: Regional estimates of the annual incidence of sharps injuries and data sources used

	Afr D*	Afr E*	Amr A	Amr B	Amr D	Emr B	Emr D	Eur A	Eur B#	Eur C#	Sear B	Sear D	Wpr A	Wpr B
Mean number of sharps injuries /HCWs/year	2.10	2.10	0.18	2.53	2.53	1.06	4.68	0.64	0.93	0.93	2.08	2.27	0.74	1.30
Countries for which sharps injuries surveys or review of surveillance systems were used	Nigeria[3]	South Africa[4]	USA[6]	Brazil[7] Chile[8] Jamaica[9]	Extrapolated from AMR B	Saudi Arabia[10]	Egypt[11] Pakistan[1,2]	Denmark[13] France[14] Greece[15] Spain[16,17] Switzerland[18] UK[19]	NA	NA	Thailand[2,1]	NA	Australia[2,3] New Zealand[24]	China[25]
Countries for which rapid assessment surveys were used	NA	Tanzania[5]	NA	NA	NA	NA	NA	NA	Uzbekistan[20]	NA	NA	India[22]	NA	Mongolia[26]
Countries for which tool C surveys[1,2] were used	Burkina Faso Chad Gambia Niger	Ethiopia	NA	NA	NA	Syria	Egypt Morocco	NA	Kyrgystan	Moldova	NA	NA	NA	NA

*,# Pooled together for analysis for the two regions
NA: Not available

1 WHO, 2001b
2 Fitzner J, 2001
3 Adegboye AA et al., 1994
4 Karstaedt AS et al., 2001
5 Gumodoka B et al., 1997
6 Jagger J, 2002
7 Costa JM et al., 1997
8 Wolff M et al., 1992
9 Figueroa JP et al., 1994
10 al-Turki KA et al., 2000
11 Talaat M, 2001
12 Mujeeb SA et al., 1998
13 Nelsing S et al., 1993
14 Abiteboul D et al., 1992
15 Pournaras ST et al., 1999
16 Failde I et al., 1998
17 Benitez RE et al., 1999
18 Luthi JC et al., 1998
19 Williams S et al., 1993
20 Kammerlander et al., 2001
21 Danchaivijitr S et al., 1995
22 Vishnu-Priva et al., 2001
23 McCall L, 1999
24 Lum D et al., 1997
25 Guo YL et al., 1999
26 Logez S, 2001

Table III: Number of HCWs exposed to at least one percutaneous injury with a sharp object contaminated with HCV, HBV and HIV

Region	Estimated numbers of health-care workers exposed annually (Lower and upper estimates)		
	HCV	HBV	HIV
Afr D	33,000 (12,000-53,000)	131,000 (50,000-201,000)	33,000 (5,900-144,000)
Afr E	57,000 (20,000-92,000)	223,000 (84,000-340,000)	194,000 (37,000-652,000)
Amr A	22,000 (14,000-31,000)	7,100 (4,300-10,000)	8,000 (2,500-33,000)
Amr B	57,000 (20,000-93,000)	61,000 (22,000-99,000)	23,000 (4,100-109,000)
Amr D	10,000 (3,700-17,000)	8,700 (3,100-14,000)	4,500 (800-21,000)
Emr B	18,000 (6,300-29,000)	43,000 (15,000-70,000)	170 (30-840)
Emr D	178,000 (68,000-272,000)	143,000 (53,000-222,000)	2,200 (380-11,000)
Eur A	16,000 (5,700-27,000)	43,000 (15,000-71,000)	9,400 (1,700-46,000)
Eur B	39,000 (14,000-64,000)	113,000 (40,000-183,000)	420 (70-2,000)
Eur C	94,000 (33,000-156,000)	148,000 (52,000-241,000)	12,500 (2,000-61,000)
Sear B	28,000 (10,000-46,000)	83,000 (31,000-130,000)	5,600 (1,000-27,000)
Sear D	57,000 (20,000-93,000)	109,000 (39,000-75,000)	23,000 (4,000-107,000)
Wpr A	47,000 (17,000-77,000)	34,000 (12,000-56,000)	670 (120-3,000)
Wpr B	269,000 (96,000-439,000)	953,000 (350,000-1,498,000)	10,400 (1,800-51,000)
Total	926,000 340,000-1,490,000	2,100,000 770,000-3,300,000	327,000 61,000-1,300,000

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The total number of infections attributable to sharps injuries was 16,000 (range: 6,000-86,000) for HCV, 66,000 (range: 2,400-240,000) for HBV and 1,000 for HIV (range: 200-5,000) (Table IV). These infections are estimated to result in 145 (53-766) early deaths from HCV between the years 2000 and 2030, 261 (86-923) deaths from HBV and about 736 (129-3,578) HCWs would die prematurely from HIV infections. Globally, occupational HBV and HCV infections were estimated to account for about 37% and 39% of all HBV and HCV infection among HCWs (Table V). Most regions are relatively close to the global average, with the exception of Amr A, Eur A and Wpr A where HCWs experience fewer sharps injuries. The overall fraction of HIV infection acquired through a sharp injury among HCWs was 4.4%.

Table IV: Number of infections attributable to sharps injuries among HCWs (average value for ages 20-65)

Region	Number of infections attributable to sharps injuries among health-care workers* (Lower and upper estimates)		
	HCV [infections]	HBV [infections]	HIV [infections]
Afr D	580 (200-3,100)	3,600 (1,300-10,900)	100 (20-510)
Afr E	1,000 (350-5,400)	6,200 (2,200-18,800)	620 (110-3000)
Amr A	390 (240-1,800)	40 (20-120)	5 (1-20)
Amr B	1,000 (360-5,500)	6,000 (1,800-25,100)	70 (13-360)
Amr D	180 (60-980)	760 (230-3,200)	14 (3-70)
Emr B	310 (110-1,700)	2,300 (680-9,600)	1 (0-3)
Emr D	3,200 (1,200-14,900)	6,800 (2,200-25,000)	7 (1-30)
Eur A	290 (100-1,600)	210 (60-730)	6 (1-30)
Eur B	690 (240-3,800)	6,400 (2,100-23,000)	1 (0-7)
Eur C	1,700 (590-9,100)	8,200 (2,600-29,800)	40 (7-200)
Sear B	500 (180-2,700)	1,500 (480-6,100)	20 (3-90)
Sear D	1,000 (360-5,500)	7,300 (2,600-22,000)	70 (13-350)
Wpr A	830 (290-4,500)	110 (30-400)	0 (0-2)
Wpr B	4,700 (1,700-25,400)	16,000 (5,100-63,500)	30 (6-160)
Total (rounded)	**16,400** (5,900-86,000)	**65,600** (2,400-240,000)	**1,000** (200-5,000)

Table V: Fraction of HCV, HBV and HIV infections in HCWs attributable to injuries with contaminated sharps (Average value for ages 20-65)

Region	Fraction of infections attributable to sharps injuries among health-care workers (Lower and upper estimates)		
	HCV	HBV	HIV
Afr D	45% (22%-82%)	46% (23%-73%)	4.5% (0.8%-19%)
Afr E	45% (22%-82%)	47% (24%-73%)	5.0% (0.9%-20%)
Amr A	8% (5%-29%)	1% (1%-3%)	0.5% (0.2%-2%)
Amr B	55% (30%-87%)	83% (63%-94%)	11% (2.0%-37%)
Amr D	52% (28%-86%)	65% (39%-85%)	7% (1.3%-27%)
Emr B	35% (16%-75%)	35% (16%-63%)	0.6% (0.1%-3%)
Emr D	66% (40%-91%)	64% (39%-85%)	6.2% (1.1%-24)
Eur A	25% (11%-65%)	8% (3%-22%)	1.4% (0.3%-7%)
Eur B	34% (15%-74%)	32% (14%-59%)	7.0% (1.3%-27%)
Eur C	38% (17%-77%)	24% (10%-50%)	1.2% (0.2%-6%)
Sear B	51% (26%-85%)	40% (19%-68%)	9.8% (1.9%-35%)
Sear D	52% (27%-86%)	42% (20%-70%)	7.9% (1.5%-29%)
Wpr A	27% (11%-67%)	5% (2%-14%)	3.1% (0.6%-14%)
Wpr B	41% (20%-80%)	36% (16%-63%)	3.7% (0.7%-16%)
Total	39% (19%-78%)	37% (18%-65%)	4.4% (0.8%-18.5%)

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DISCUSSION

Despite substantial progress in industrialized countries, health care worker protection is still very incomplete in most developing and transitional countries. We estimated that more than three million HCWs experience the stressful event of a percutaneous injury with a contaminated sharp object each year. These exposures result in about 16,000 infections of HCV, 66,000 of HBV and about 1,000 of HIV that lead to about 1,100 deaths and significant disability. Half of these deaths would occur in Sub-Saharan Africa. These adverse consequences weaken the health-care system by impacting on its workforce at a moment where shortages of HCWs are reported (WHO 2000b). In addition to the burden caused in this professional group, occupational exposure to sharps may lead to additional problems, including the discrimination of HIV infected patients by fear of becoming infected. However, exposures to sharps and their consequences are highly preventable through simple interventions, such as HBV vaccination for HCWs, education of HCWs and providing sharps containers (Anonymous 1994; CDC 2002; Wilburn 2004).

Sharps injuries are a major source of HCV infection among HCWs, accounting for almost 40% of HCV infections in that group, having caused 16,000 infections worldwide in the year 2000 and estimated to result in 145 deaths. In Emr D where HCV is highly endemic (WHO 2000c) and sharps waste collection practices are unsafe, two thirds of new infections among HCWs are caused by sharps injuries. Occupational infections with HCV occur during adulthood, an age at which the risk of progression from infection to severe long-term liver damage, including cirrhosis and hepatocarcinoma, is highest (Freeman et al. 2001). HCV prevalence has reached alarming levels over recent decades in a number of countries of the Emr and Afr region (WHO 2000b; Franck et al. 2001; Khan et al. 2000). Thus, the long-term consequences of HCV infection could emerge as a major cause of disability and death among senior HCWs in these regions.

HBV infections among HCWs are also to some extent driven by occupational exposures to contaminated sharps, with an attributable fraction of 37% within this occupational group. However, as the global incidence of HBV infection is higher than that of HCV, contaminated sharps were estimated to cause more HBV infections with 66,000 cases annually, associated with 261 deaths. HCWs infected with HBV through occupational exposures during adulthood may have a more favourable prognosis than those infected with HCV, however, unlike HCV, HBV can be efficiently prevented and at low cost through immunization (Mahoney et al., 1997). Furthermore, PEP of HBV infection in the case of occupational exposures has been adopted in many industrialized countries (Beasley 1983; Stevens, 1985, CDC, 2001), and efforts should be made to vaccinate HCWs as early as possible in their career. In addition, whenever is feasible to manage and follow-up the exposure, PEP measures should also be used, at least using the vaccine in countries where Hepatitis B Immune Globulin cannot be afforded. The modelled estimates are consistent with surveillance data available for certain countries of "A" regions. For example, in the USA, 800 HBV infections associated with occupational exposures were reported in 1995. These infections are on a sharp decline (CDC, 2001). Our model reports 400 infections (70-1,100) (without application of PEP for comparability) for the year 2000 in the whole region Amr A (including USA, Canada and Cuba), and 40 (20-120) when PEP is taken into account in the model (Table IV).

Occupational acquisition of HIV represents a particularly serious consequence of sharps injuries given its high case fatality ratio. Most of the estimated 1,000 (200 - 5,000) HIV infections associated with sharps injuries annually would occur in sub-Saharan Africa according to our model. These occupational HIV infections are likely to be overlooked among HCWs who, like other adults in the general population, may also report sexual exposures. Our model estimated that worldwide, 4.4% (0.8%-18.5%) of HIV infections among HCWs may be attributable to occupational sharps injuries. In industrialized countries, post exposure prophylaxis has considerably reduced the risk of HIV infection among HCWs who experienced injuries with sharps used on an infected source patient. However, management of occupational exposures with post exposure prophylaxis is costly and requires a responsive health system. Such resources and systems are most likely to be present only in countries where primary prevention of exposure to sharps efficiently already reduces the incidence of sharps injuries. In US health-care workers, 56 documented and 136 possible cases of occupational transmission were reported between 1985 and 1999 (CDC, 1998), reducing in recent years to one confirmed and 2 possible cases (1997-2001, CDC 1998; CDC 2002). In comparison, for Amr A our model provides an estimate of 5 (1-20) cases for the year 2000. In Europe the surveillance system reports 96 confirmed cases since the disease appeared, and our model estimates 7 (1-30) work-related seroconversions in the year 2000. Also these results are compatible with the modelled results.

There are a number of limitations in this study that need to be accounted for. First, the number of HCWs at risk is likely to be underestimated, as our data sources did not report all the HCW categories that may be at risk, including laboratory technicians, nursing aids, traditional health professionals, acupuncturists, hospital cleaners, laundry workers, waste workers, nursing students, medical students and emergency response personnel. In the absence of data, we were unable to account for these groups. Second, the quantity and the quality of the data on the number of sharps injuries per year was limited. Available studies and surveys focused on hospital settings that may not be representative of other health care settings. Most of the studies reviewed were surveys estimated the incidence of sharps injuries retrospectively on the basis of self-reports. To address these problems, in addition to a best estimate obtained as described, lower and upper estimates were generated. Third, we limited our study to sharps injuries. Sharps injuries account for the largest proportion of occupational exposure to bloodborne pathogens and are associated with the highest risk of infection. However, the failure to include

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mucocutaneous and skin exposures may also have underestimated the number of infections. Fourth, the estimation of source prevalence of the three infections are based on general population prevalence, but HCWs are exposed to the patient population whose prevalence may differ significantly to that of the general population. To account for this limitation, upper and lower estimates of prevalence were introduced into the model to explore possible ranges of attributable infections. Additional parameters used in the model carry assumptions, such as the transmission potential (p_t) and the background rate of disease. Overall, because of these limitations, our estimates are therefore likely be conservative with upper and lower estimates outlining possible ranges the results may take by introducing different input parameters. In light of the scarcity of surveillance data, the results could not be validated in developing and transitional countries.

While secondary prevention of HCV and HIV infection associated with sharps injuries is expensive and requires a strong health system, simple measures are available to engage in effective primary prevention of sharps injuries. First, unnecessary injections should be avoided. Second, contaminated sharps waste should be collected immediately after use and without recapping in puncture- and liquid-proof sharps containers. Third, sharps waste should be managed in a safe, efficient and environment-friendly manner. In addition, to minimize the risk of exposures, countries should consider programmes to immunize HCWs at risk of sharps injuries against hepatitis B. Finally, in settings where they can be cost-effective, use of safety and needle-free devices may be considered. Successful implementation of these prevention measures will resolve in a progress for public health and HCW's health and safety.

DISCLAIMER

The views expressed in this article are those of the authors and do not necessarily reflect the position of the World Health Organization.

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