Estimation of the risk of bloodborne pathogens to health care workers after a needlestick injury in Taiwan

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Objectives: To estimate the number of health care workers (HCWs) in Taiwan at risk annually for contracting hepatitis B virus (HBV), hepatitis C virus (HCV), and HIV after a needlestick and sharps injury (NSI) with a used hollow-bore needle.

Methods: All patients hospitalized in 1 tertiary hospital between September 1997 and June 1998 had routine pathological work-ups. On the first day of the months of September 1997, December 1997, March 1998, and June 1998, 1805 samples of deidentified residual sera randomly sampled from 18,474 inpatients older than 6 years were serologically tested for antigens to HBV (HBsAg and HBeAg) and antibodies to HCV (anti-HCV) and HIV (anti-HIV) with enzyme-linked immunosorbent assay reagents. The frequency of NSIs with contaminated devices in HCWs from 16 public teaching hospitals between July 1996 and June 1997 and the serologic results were used to extrapolate the estimated annual rate of seroconversion in HCWs after an NSI.

Results: Of the 1805 samples tested, 16.7% were seropositive for HBsAg (of which 1.7% were positive for HBeAg), 12.7% were positive for anti-HCV, and 0.8% were positive for anti-HIV. Of the 7550 NSIs reported by 8645 HCWs, 66.7% involved a contaminated hollow-bore needle. From these data, 308 to 924 HCWs were estimated to be at risk for contracting HBV; 334 to 836 were at risk for contracting HCV; and, at the most, 2 were at risk for contracting HIV. The estimated annual number of contaminated NSIs sustained by 4 categories of HCWs ranged from 0.3 to 0.7, resulting in 543 nurses, 113 technicians, 80 physicians, and 66 supporting staff to be at risk annually of acquiring HBV infection. The numbers of HCWs estimated to be at risk of acquiring HCV were 596 nurses, 90 physicians, 84 technicians, and 30 supporting staff. The risk of acquiring HIV was low, with 1 nurse and possibly 1 other staff potentially exposed annually.

Conclusions: Our estimates of the risk for seroconversion after an NSI have demonstrated that an occult risk can be formulated into a quantifiable risk. The number of susceptible HCWs at risk for seroconversion is as many as 1762 annually. With the number of nurses employed and the frequency with which they use sharps and sustain an NSI, 64.7% of all possible seroconversions will be in the nursing staff. This is a salient reminder of the importance of the introduction of early training in safe-needle–handling techniques before nurses enter their internship in countries where safety equipment, safety instructions, and staff vaccination programs are absent. (Am J Infect Control 2002;30:15-20.)

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Needlestick and sharps injuries (NSIs) in Taiwanese health care workers (HCWs) are hyperendemic, with an annual rate of 87.3%.[1] The medical management of an NSI is determined by evaluating the staff's risk of seroconversion on the basis of the available knowledge of the source-patient, type of item or device, and the severity of injury.[2] The seroprevalence of the hepatitis B virus (HBV) in Asian communities was recently estimated at between 15% and 21%,[3-4] and the seroprevalence of the hepatitis C virus (HCV) in the general community was estimated at 2.5%.[5] As a result, the risk for seroconver-

sion in an HCW from a device contaminated with a bloodborne disease is high. Since the number of HIV-positive persons in the community has been reported to be 1491,[6] the risk of seroconversion for staff is low but will increase as the number of patients with positive HIV antibody with high viral loads become hospitalized.

It is known that an NSI with a hollow-bore needle represents the greatest risk for seroconversion to injured staff.[7-9] The prevalence of the 3 common bloodborne diseases–HBV, HCV, and HIV–in hospitalized patients is speculatively high, and it is accepted that the prevalence is higher than in the general community.[10] As found in other Asian countries, the risk for seroconversion in a Taiwanese HCW with a contaminated hollow-bore needle is also speculated to be high. This study describes the estimation of this risk by delineating extrapolations of 2 prevalence surveys performed by the authors. The first survey measured the prevalence of HCWs who incurred an NSI involving contaminated hollow-bore needles and the vaccination status in staff from 16 public tertiary teaching hospitals.[11] The second survey established the seroprevalence of bloodborne pathogens in hospitalized patients at 1 tertiary referral hospital in Taiwan.

METHODS

Calculation of risk for seroconversion

The potential yearly seroconversion rate to HBV, HCV, and HIV was calculated with extrapolations from the following:

1. The prevalence of NSIs with contaminated hollow-bore needles per year in Taiwanese HCWs, adjusted for the percentage of susceptible HCWs for HBV identified from our survey. Since HCV and HIV antibody status was not reported by HCWs in our survey, all HCWs were considered to be at risk for HCV and HIV.
2. The probabilities of seroconversion after an NSI exposure to HBV, HCV, and HIV, reported in the literature: 10% to 30% for HBV, 4% to 10% for HCV, and 0.1% to 0.3% for HIV.
3. The seroprevalence of HBV, HCV, and HIV in 1805 hospitalized patients.

Prevalence of contaminated percutaneous NSI exposures

Sixteen hospitals were randomly selected from 132 hospitals from northern, southern, western, the middle, and the East Coast areas of Taiwan in 1996. Hospitals were selected within 4 strata on the basis of the number of HCWs employed: 1 to 199, 200 to 499, 500 to 999, and more than 1000. Of the 10,469 eligible HCWs, 8645 (82.6%; 95% CI, 81.9%–83.3%) from 16 hospitals completed the questionnaire, pretested for reliability r = 0.90). Participants reported the type of item or device involved in their most recent NSI in the past 12 months, the usage status of the device or item, the job category of the HCW involved in the NSI, and the HCW's vaccination status for HBV.

The total contamination exposures per HCW per year was estimated from the frequency of the proportion of NSIs that involved a used hollow-bore needle for each HCW category. Only those NSIs that involved a hollow-bore needle were included in the estimation of risk for seroconversion because of the large amount of contaminated blood and/or body fluids they transfer.[12] Of the 7550 NSIs reported, 64.7% involved a hollow-bore needle. Of these, 64.4% (3146) occurred during patient care, whereas the usage in 3.5% (171) of cases was unknown. The number of all used hollow-bore needles (3147) and 64.4% of the hollow-bore needles with unknown usage (3.5% × 64.4%) were assumed to have been used and were included in the calculation. The measured and assumed number of NSIs with a used hollow-bore needle was 66.7%.

Susceptibility of HCWs to HBV, HCV, and HIV

A total of 27.8% of HCWs reported that they were not protected against HBV through either natural infection or vaccination. The percentage of HCWs susceptible to HBV was stratified by job category to estimate the risk for seroconversion. Infection with HCV or HIV was not recorded in the survey, and since there is no vaccine available for either infection or other data sources of the rate of HCV and HIV in HCWs, all were considered to be susceptible.

Seroprevalence of HBV, HCV, and HIV in hospitalized patients

Four cross-sectional surveys of inpatients were performed to estimate the seroprevalence of HBV, HCV, and HIV. To improve seasonal representation, the 4 surveys were taken during the 4 seasons between July 1, 1997, to June 30, 1998. During this period, the first day of each of the 4 seasons was selected for sample collection to represent seasonal patient mix: September and December 1997, March 1998, and June 1998. This selection criterion was made on the basis of a preliminary analysis of hospital data from the previous year and a prior knowledge of the seasonal disease patterns in Taiwan.

Table 1. Frequency of percutaneous exposure to HCWs estimated with NSI survey

Job category	No. NSI per HCW	% NSI (95% CI)	No. of NSI per HCW per year [A]	% Used hollow bore needles [B]	Total No. contamination exposures per HCW per year [A] × [B] = [C]
Total HCWs in Taiwan	7550/8645	87.3 (86.6-88.0)	1.3	66.7	0.6
Nurses	4908/5269	93.2 (92.5–93.9)	1.6	62.6	0.7
Physicians	1011/1291	78.3 (76.1–80.5)	0.9	74.0	0.4
Technicians	417/684	61.0 (57.3–64.7)	0.9	74.9	0.4
Supporting personnel	1204/1390	86.6 (84.8–88.4)	0.8	88.6	0.3

All inpatients have a work-up of their pathological condition performed routinely. Sera were tested on all admissions on the first days of September and December 1997 and March and June 1998. Residual serum samples are routinely kept for 7 days at -70°C until discarded. All pediatric patients younger than 6 years were excluded from the study since pediatric serum samples were insufficient for testing. When patients had more than 1 serum sample available, the most recent sample was tested. All inpatients during the study test-days had their admission diagnosis, age, sex, and postcode linked to their sera by medical record number. A unique study number was then assigned, and sera were delinked from the medical record number. Admission diagnoses according to the ICD-9-CM (1996) for eligible patients were obtained from the hospital information department. The third-generation (1996) enzyme-linked immunosorbent assay reagents were used to test for HBsAg, anti-HCV, and anti-HIV. All samples seropositive for HBsAg were tested for HBeAg.

Generalizability of the serum sample chosen

The distribution of the discharge diagnoses, with the ICD-9-CM, was used to determine the generalizability of our study group, 1805 hospitalized patients tested, to our reference population, the 18,474 patients hospitalized on the first day of each of the 4 test days, between June 2, 1997, and June 1, 1998. Differences between ICD-9-CM classification of the reference and study groups during the 4 test-days were compared. Differences in distribution of 8 levels of urbanization, 4 age categories, and sex for the study group with a bloodborne disease were examined.

RESULTS

Prevalence of NSIs with a contaminated hollow-bore needle per HCW per year

Nearly 9 in every 10 (87.3%; 95% CI, 86.6%-88.0%) Taiwanese HCWs surveyed sustained an NSI during a 12-month period; 64.7% (95% CI, 63.6%-65.8%) of these involved a hollow-bore needle (Table 1). Of these injuries, 66.7% (95% CI, 65.3%-68.0%) of the devices were estimated to have been used on a patient. The total number of contamination exposures per HCW per year was 0.6 in the 8645 HCWs surveyed (see Table 1).

The frequency of the yearly incidence of percutaneous exposure with a used hollow-bore needle differed per HCW category, with 0.7 exposures per nurse, 0.4 per physician, 0.4 per technician, and 0.3 per supporting personnel (see Table 1).

Seroprevalence of HBV, HCV, and HIV in inpatients

Residual sera from 1805 patients were tested, and hepatitis (HBsAg) was the most prevalent bloodborne disease (16.7%; 95% CI, 15.0%-18.4%); 1.7% (95% CI, 1.1%-2.3%) of patients also had positive results for HBeAg. Antibodies to hepatitis C were identified in 12.7% (95% CI, 11.2%-14.2%) of patients, and 0.8% (95% CI, 0.4%-1.2%) had positive results for anti-HIV (Table 2).

Susceptibility of HCWs to HBV, HCV, and HIV

The level of susceptibility to HBV reported by HCWs was 27.8% (95% CI, 26.9%-28.7%), which was determined on the basis of staff neither receiving a vaccination nor having natural protection from infection and staff who were unsure of their HBV vaccination or serological status (see Table 2). Supporting staff reported the highest level of susceptibility to HBV (55.3%), followed by technical staff (33.8%), nurses (23.2%), and physicians (23.1%). All HCWs were assumed to be susceptible to HCV and HIV (see Table 2).

Estimated risk for seroconversion in Taiwanese HCWs after sustaining a percutaneous exposure from a contaminated device

The yearly risk of seroconversion in Taiwanese HCWs to each bloodborne virus (see Table 2) was

Table 2. Yearly incidence of percutaneous exposure of HCWs to bloodborne pathogens estimated from NSI survey and patient seroprevalence survey

Job category [A]	Total no. contamination exposures per year [C]	Rate of exposure to HVB per HCW per year [D] = [C] × Total contamination exposures to HBV (16.7%) × HCW susceptible to HBV (%)	Rate of exposure to HCV per HCW per year [E] = [C] × Total contamination to HCV exposures (12.7%) × HCW susceptible to HCV (100%)	Rate of Exposure to HIV per HCW per year [F] = [C] × Total contaminated Exposures to HIV (0.8%) × HCW susceptible to HIV (100%)
Total HCWs in Taiwan	0.6	0.6 × (16.7) × (27.8) = 0.028	0.6 × (12.7) × (100) = 0.076	0.6 × (0.8) × (100) = 0.005
Nurses	0.7	0.7 × (16.7) × (23.2) = 0.027	0.7 × (12.7) × (100) = 0.089	0.7 × (0.8) × (100) = 0.006
Physicians	0.4	0.4 × (16.7) × (23.1) = 0.015	0.4 × (12.7) × (100) = 0.051	0.4 × (0.8) × (100) = 0.003
Technicians	0.4	0.4 × (16.7) × (33.8) = 0.023	0.4 × (12.7) × (100) = 0.051	0.4 × (0.8) × (100) = 0.003
Supporting personnel	0.3	0.3 × (16.7) × (55.3) = 0.028	0.3 × (12.7) × (100) = 0.038	0.3 × (0.8) × (100) = 0.002

estimated from the total number of contamination exposures per year and the seroprevalence of inpatients for 3 bloodborne pathogens (see Table 2) identified from 4 seasonal survey-days. The annual rate of HBV exposure per HCW was between 0.015 and 0.028 per injury; for HCV, the rate of exposure was between 0.38 to 0.089 per injury, and for HIV, the rate of exposure was between 0.002 to 0.006 per injury (see Table 2).

There were about 110,000 HCWs employed in Taiwan, of whom 60.9% (66,990) were nurses, 16.1% (17,710) physicians, 14.9% (16,390) technicians, and 7.1% (7810) supporting personnel (Table 3). Seroconversion-rate calculations excluded 1% of HCWs who did not specify their job category. Extrapolations of the 27.8% of 8645 HCWs surveyed and classified as susceptible to HBV resulted in 3080 susceptible HCWs in Taiwan being exposed to HBV per year (see Table 3). The frequency of seroconversion in these susceptible HCWs after an NSI was estimated at between 308 to 924 per year (see Table 3). Nurses had the highest number of staff at risk for seroconversion to all bloodborne viruses, whereas the frequency of seroconversion in the other HCW groups was dependent on the type of bloodborne virus (see Table 3). The annual estimated number of seroconversions to HBV was more common in nurses, 181 to 543, followed by technicians, 38 to 113, physicians, 27 to 80, and supporting personnel, 22 to 66 (see Table 3).

There were 8360 susceptible HCWs in Taiwan estimated to be exposed annually to HCV after an NSI (see Table 2), and between 234 to 596 nurses were estimated to undergo seroconversion to HCV annually. The estimated frequency of susceptible physicians acquiring HCV was between 36 to 90; for technicians, the rate was between 33 to 84, and the rate for supporting staff was between 12 to 30 (see Table 3). At the most, 1 nurse annually was estimated to be at risk for an HIV seroconversion illness after an NSI, whereas the rate for all other HCWs was less than 1 per year.

Generalizability of the seroprevalence of HBV, HCV, and HIV in hospitalized patients

Between June 2, 1997, and June 1, 1998, 18,474 patients were admitted, of whom 12% (2209) were selected for testing. Of the patients tested, 9.8% (1805) were found to have sufficient aliquots for HBV, HCV, and HIV tests. The age of the 1805 patients ranged from 7 to 99 years, with a mean age of 54.7 years (SD, 19.3 years), and just more than half (54.7%) of all patients tested were male. The age of tested patients did not differ ($P = .18$, respectively) between the 4 sera collecting-days but the distribution of sex differed ($P = .04$) over the 4 test-days.

The top 4 (51.3%) diagnoses made on discharge for the reference group (all patients during the 4 test-days) included neoplasm (20.4%); disease of the circulatory system (11.2%); complications of pregnancy, childbirth, and the puerperium (10.7%); and disease of the nervous system and sense organs (9.0%). The top 4 diagnoses for the study group included only the first 2 diagnoses in the reference group: neoplasm (23.9%) and disease of the circulatory system (13.9%). Injury and poisoning (10%) and disease of the respiratory system (9.1%) were the next most common diagnoses in the study group. In the reference group, the distribution of 3 of the 4 top diagnoses were the same but differed ($P < .001$) in order for 3 of the 4 test seasons. These included neoplasm; disease of the circulatory system; and complications of pregnancy, childbirth, and the puerperium. The distribution of diagnoses in the study group was also significantly ($P < .001$) dif-

Table 3. Number of HCWs in Taiwan at risk for seroconversion to HBV, HCV, and HIV, as estimated from Table 2 and the literature

Job category	HBV (10%-30%) [A]*	HCV (4%-10%) [A]*	HIV (0.1%-0.3%) [A]*
Total HCWs in Taiwan			
No. Taiwanese HCWs × rate of exposure to specific BBV in total HCWs† = No. susceptible HCW	110,000 × 0.028 = 3080	110,000 × 0.076 = 8360	110,000 × 0.005 = 550
No. susceptible HCW × [A] = No. HCW at risk for seroconversion	3080 × [A] = 308-924	8360 × [A] = 334-836	550 × [A] = <1-2
Nurses (201 - 536)			
No. Taiwanese nurses × rate of exposure to specific BBV in nurses† = No. susceptible nurses	66,990 × 0.027 = 1809	66,990 × 0.089 = 5962	66,990 × 0.006 = 402
No. susceptible nurses × [A] = No. nurses at risk for seroconversion	1809 × [A] = 181-543	5962 × [A] = 234-596	402 × [A] = <1-1
Physicians			
No. Taiwanese physicians × rate of exposure to specific BBV in physicians† = No. susceptible physicians	17,710 × 0.015 = 266	17,710 × 0.051 = 903	17,710 × 0.003 = 53
No. susceptible physicians × [A] = No. physicians at risk for seroconversion	266 × [A] = 27-80	903 × [A] = 36-90	53 × [A] = <1
Technicians			
No. Taiwanese technicians × rate of exposure to specific BBV in technicians† = No. susceptible technicians	16,390 × 0.023 = 377	16,390 × 0.051 = 836	16,390 × 0.003 = 49
No. susceptible technicians × [A] = No. technicians at risk for serioconversion	377 × [A] = 38-113	836 × [A] = 33-84	49 × [A] = <1
Supporting personnel			
No. Taiwanese supporting personnel × rate of exposure to specific BBV in supporting personnel† = No. susceptible supporting personnel	7810 × 0.028 = 219	7810 × 0.038 = 297	7810 × 0.002 = 16
No. susceptible supporting personnel × [A] = No. supporting personnel at risk for seroconversion	219 × [A] = 22-26	297 × [A] = 12-30	16 × [A] = <1

*Rates of seroconversion after NSI with hollow-bore needle identified from literature.
†Rate of exposure to specific BBV per year (see Table 2, columns [D], [E], and [F]).

ferent between the 4 test-seasons. Whereas the diagnosis of neoplasm consistently ranked first for each test season, respiratory disorders were more prevalent in the fall and digestive problems were more prevalent in the summer.

Seroprevalence testing in the inpatient study group found that significantly (P = .04) more male than female patients were positive for HIV and HBV infections. Inpatients with HBV infection were significantly (HBsAg, P = .008) older, and HBeAg was identified more frequently (P = .0007) in patients aged 21 to 60 years than in younger and older patients. There was no significant (P = .51) difference in sex among patients with positive test results for HBeAg. Hepatitis C virus was found in male and female patients with similar frequency (P = .13) but with increasing frequency with age. Patients infected with HBV, HCV, or HIV were not significantly different in their level of urbanization (HBsAg, P = .25; HBeAg, P = .96; anti-HCV, P = .44; and anti-HIV, P = .30).

Neoplasm was the most common (37.2%; P = .0002) diagnosis in patients with HBV followed by diseases of the respiratory system (11.6%) and circulatory system (10.6%). In patients with HCV and HIV infection, no significant (P = .013 and P = .25, respectively) pattern in the frequency of diagnosis was identified.

DISCUSSION

Evidence of HBV infection was found in nearly 17 of every 100 (16.7%) patients tested, HCV was found in 13 of every 100 (12.7%) patients, and HIV was found in 8 of every 1000 patients (0.8%). Our rate for HBV is comparable with that reported (17%) in hospitalized patients a year earlier[13] and is not unlike that estimated for the community (15% to 21%).[3-4] However, the seroprevalence of HCV was 5.1 times higher in our hospitalized patients compared with that of the general population (2.5%).[5] Although the rate of seroconversion after exposure to HBV is 3 greater than that for HCV, the similar fre-

quency of HCV to HBV in patients and the susceptibility by 100% of HCWs means that the number of potential seroconversions after an NSI annually will be similar to that of HBV. We found a higher level of HIV, 8 in 1000, compared with the reported level a year earlier of approximately 0.068 in 1000 patients.[6] The disparity between the HIV rate identified in 1997 and ours in 1998 may be a result of our rate reflecting only hospitalized adult patients from 1 tertiary referral hospital in southern Taiwan. Our higher rates of HCV and HIV compared with those for the community reflect the increasing number of admissions due to clinical illness associated with a bloodborne pathogen. We believe that our seroprevalence and potential seroconversion rates reflect that of the wider hospital community, since there was a minimal difference in ranking of the major diseases between our study groups and the hospital reference group.

Infections with HBV, HCV, and HIV in our study group were not associated with socioeconomic status but were more frequently identified in older patients. The finding of a lower seroprevalence among younger patients, younger than 20 years, suggests that the introduction of universal vaccination of HBV in 1984 among newborns was successful.[3] Since our staff were not included in the 1984 vaccination program, a staff "catch-up" HBV vaccination program would protect between 308 to 924 HCWs potentially at risk of acquiring HBV infected annually from an NSI. Nurses were found to be the largest group at risk for HBV after an NSI because of (1) the number or nurses employed in Taiwan; (2) the high number of nurses who were estimated to be susceptible to HBV; and (3) the high number, 0.7, of estimated NSIs with contaminated devices per year. The rate of HCWs acquiring HCV was also high, between 334 to 836, annually. These rates may be slightly overestimated since, in the absence of available data, we assumed that all HCWs were susceptible to HCV.

The total number of HCWs estimated to be at risk for acquiring any of 3 bloodborne pathogens was between 643 and 1762, which reflected the 100-fold difference in the range, 0.3% to 30%, in the expected rate of seroconversion for the 3 viruses. An assumption used to estimate the number of seroconversions was that every NSI with a contaminated device constituted a significant exposure. However, the high levels of infection in the community and the medical management after an NSI with a contaminated device suggest that all exposures to contamination from an NSI that breaks the skin are considered to pose a risk for infection. With this limitation in mind, taking the lower estimated number, 643, of HCWs at risk for seroconversion means that annually a little fewer than 1 in every 100 HCWs in Taiwan may acquire a debilitating or life-threatening HBV or HCV infection. Our results highlight the potentially large number of HCWs, particularly nurses, who would benefit from early practical education programs before their internship that includes the use of gloves for activities involving hollow-bore needles and safe-handling techniques.

The methodology developed for our investigation can be duplicated in most health care settings to generate accurate seroprevalence measures of HBsAg, HBeAg, anti-HCV, and anti-HIV to establish annual rates of exposure. These rates can be used to encourage HCWs to report their NSI promptly so that they may take advantage of the benefits of postexposure medical management with hepatitis B immunoglobulin and the "catch-up" vaccination and be reminded of safe use and disposal of hollow-bore needles.

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