# No transmission of blood-borne viruses among hospital staff despite frequent blood exposure

Hassan Ali Eskandarani, Michala Kehrer & Peer Brehm Christensen


## ABSTRACT

**INTRODUCTION:** Exposure to blood and body fluids (BBF) is a major concern for healthcare workers (HCWs) and implies a risk of infection with blood-borne pathogens. However, in Denmark, no exposure incidence studies among HCWs have been reported for the past ten years. The aims of this study were to provide an updated evaluation of the annual frequency of registered exposures during the 2003-2012 period, the prevalence and incidence of transmission of HIV, HBV and HCV among HCWs, the prevalence of HIV, HBV and HCV among source patients, the follow-up by HBV vaccination and blood sampling in exposed HCWs and, finally, reporting habits.

**MATERIAL AND METHODS:** All registered first-time cases of BBF exposure at Odense University Hospital during the 2003-2012 period were included. The exposed HCW and source patient were linked to a laboratory database to obtain the test results for HIV, HBV, HCV and the anti-HBs level at baseline and after exposure. For 2012, a detailed analysis of BBF exposure was performed.

**RESULTS:** A total of 2,274 first-time BBF exposures were analysed. We observed a 35% increase in the reported incidence of exposures in the period. The prevalence and incidence of HIV, HBV and HCV among HCWs was zero. The prevalence of anti-HIV among source patients was 0.9%, HBsAg 1.2% and anti-HCV/HCV-RNA 3.8%. In 2003-2012, 31.3% of the tested HCWs had an anti-HBs ≥ 10 IU/l at baseline and this increased to 76.1% after vaccination. In 2012, 95% of the HCWs had blood samples at the time of exposure, 35% had a three-month blood test and 17% had a six-month test.

**CONCLUSION:** Despite a high rate of exposure to BBF among HCWs, the risk of infection was low.

**FUNDING:** No external funding received.

**TRIAL REGISTRATION:** not relevant.


Healthcare workers (HCWs) are often exposed to blood-borne pathogens. In Denmark, no case of occupational HIV infection has yet been documented. During the past ten years, the average reported incidence of occupational HBV infection in HCWs has been 0.4/100,000 person years [1], whereas the corresponding incidence for HCV infection was 0.6/100,000 person years [2]. The latest study on the prevalence of HBV, HCV and HIV among Danish hospital staff found that the overall prevalence was 1.6% for anti-HBc, 0.14% for anti-HCV and 0% for anti-HIV [3].

The risk of transmission with HBV by a single needle-stick injury has been reported to reach 31% if the source person was HBeAg-positive and 6% if HBeAg-negative [4]. The risk of transmission with HCV from an infected source patient is 1.8% (0-¬7%) and the risk of transmission with HIV is 0.3% (0.2-0.5%) [4]. In 1995, the seroprevalence of chronic HBV infection and chronic HCV infection was 0.9% and 1.5% among Danish in-hospital patients, respectively [5]. The prevalence of HIV-positive in-hospital patients was found to be 1.3% [6]. The corresponding prevalence of chronic HBV, chronic HCV and HIV in the Danish population has recently been estimated to 0.2% [7], 0.4% [8] and 0.1% [9], respectively.

The aims of this study were to provide the annual frequency of registered exposures during the 2003-2012 period and the incidence of transmission of HIV, HBV and HCV among HCWs; and, furthermore, to provide the prevalence of HIV, HBV and HCV among source patients. Additionally, we aimed to evaluate follow-up with blood samples in exposed HCWs, HBV vaccination status and reporting habits in 2012.

## MATERIAL AND METHODS

We conducted an observational study of all HCWs reporting BBF exposure during the 2003-2012 period at Odense University Hospital (OUH), Denmark. BBF exposure was defined as any percutaneous or mucocutaneous exposure to blood or other body fluids.

### Population

OUH is a tertiary referral centre for 1.2 million inhabitants. OUH had 7,600 employees with 892 beds and 78,590 admissions in 2012. Since 2003, a systematic registration and follow-up of persons with occupational BBF exposures has been performed at the outpatient clinic, Department of Infectious Diseases. If the source patient was infected with hepatitis B or if the patient's status was unknown, follow-up vaccination of the HCW was performed by the needle-stick injury unit; otherwise, vaccination was performed elsewhere. If the source patient tested positive for any of the viruses, the exposed HCW would be followed in the outpatient clinic;

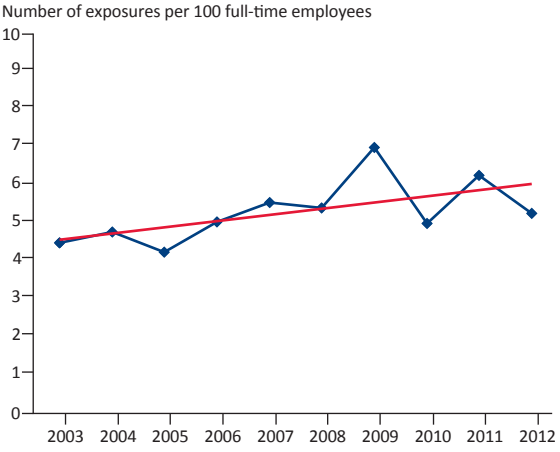
ORIGINAL ARTICLE

Department of Infectious Diseases, Odense University Hospital, Denmark

Dan Med J 2014;61(9):A4907

FIGURE 1

Incidence of blood and body fluids exposures at Odense University Hospital from 2003 to 2012.




The line shows the linear regression y = 0.162x + 4.412, $R^2$ = 0.36023

and in addition to blood sampling on the day of exposure (HBsAg, anti-HBs, anti-HCV, anti-HIV 1+2), the HCW was recommended follow-up with blood tests three and six months after the exposure. If the source patient tested negative, the HCW was referred for follow-up vaccination by a general practitioner or the department of employment.

**Case identification**

We identified all registered cases of occupational BBF exposure during the 2003-2012 period. We excluded cases not employed at the OUH and cases without percutaneous or mucocutaneous exposure.

**Data sources**

We extracted the civil registration number of the exposed HCW and the source patient for all recorded BBF exposures for each calendar year in the 2003-2012 period. The incidence was calculated as the total number of BBF exposures per 100 full-time employees (FTE) per year.

For further analysis, we used only the first exposure of all persons. For 2012, we also extracted information on the date of exposure, the profession and the department of the HCW and the type of exposure sustained.

All test results for HIV, HBV and HCV for the persons involved were extracted from the Department of Clinical Immunology at the OUH, which since 1992 has recorded all test results in the region.

In addition, we extracted reports of occupational injuries involving BBF exposure from the Department of Safety and Work Environment, OUH, for the period in which this register has been operational (as from 2006). From the overlap between the two registers, we calculated the number of exposures not found in any register by capture-recapture analysis.

If the record did not state the date of BBF exposure, the first anti-HBs sample in the year of reported exposure was considered as the vaccination status at the time of exposure; and, correspondingly, the last anti-HBs sample within one year (except for 2012) was used as the vaccination status after the exposure.

Contagious patients were defined as patients positive for anti-HIV, HBsAg or HCV-RNA. For anti-HCV-positive patients who were not tested for HCV-RNA, we assumed 62% to be HCV-RNA-positives, as previously reported [8].

The expected number of infected HCWs was calculated as 0.3% of those exposed to anti-HIV-positive patients, 2% of HCWs exposed to HBsAg-positive patients, 31% of exposed to HBeAg-positive patients, 1.8% of those exposed to HCV-RNA-positive patients and 1.1% [8] of those exposed to patients of unknown RNA status [4, 8].

**Data management**

All case form data were entered in Epidata Entry (version 3.1) and validated by proofreading.

Data were analysed using Stata 12 (Stata Corporation, Texas, USA). Nonparametric statistical tests were used throughout. A two-sided p value of 0.05 was considered significant.

The trial was approved by the Danish Data Protection Agency (2008-58-0035).

*Trial registration*: not relevant.

## RESULTS

During the 2003-2012 period, we recorded 2,767 BBF exposures at the OUH. We excluded 48 due to unfulfilled inclusion criteria or missing/incorrect data. Furthermore, a total of 445 repetitive exposures were excluded. Thus, 2,274 first-time BBF exposures were eligible for analysis. A source patient was identified in 86% of cases (n = 1,956). Data were not available for 8.6% (168) of the source patients and 71 patients acted as a source patient in multiple exposures, leading to 1,717 source patients being tested (91.4% of the BBF exposures with an identified source).

A significant increase in the number of BBF exposures during the 2003-2012 period was observed; the lowest occurrence was in 2005 (218 cases) and the highest occurrence in 2009 (358 cases) with a median of 264.5, corresponding to an incidence of 5.2/100 FTE (**Figure 1**).

The annual incidence declined significantly with the age of the person exposed (10.3/100 FTE, 4.1/100 FTE

and 2.4/100 FTE for < 30, 30–49 and ≥ 50 years of age, p < 0.001). Laboratory technicians had the highest reported incidence of BBF exposure (**Table 1**). In 2012, 90% (173/192) of cases were percutaneous exposures, whereas 10% (19/192) were mucocutaneous exposures.

In 2012, 94.9% (188/198) of HCWs had blood samples drawn at the time of exposure, 34.8% (69/198) had a three-month follow-up test, and 16.7% (33/198) had a six month follow-up test. The proportion of exposed persons who had two or more tests performed within a year of exposure was 52-63% in the ten-year period, with no significant change over time.

### Hepatitis B vaccination

During the 2003-2012 period, the mean proportion protected against HBV among HCWs was 31.3% at the time of exposure (anti-HBs > 10IE/l). After vaccination, this increased to 76.1% with no significant change over time. In 2012, 37% of the exposed recalled a previous HBV vaccination at the time of exposure, 15% were not vaccinated and 48% did not know. Among the HCWs with unknown vaccination who had a baseline test, 19% were seroprotected against HBV. In 2012, 82% of HCWs reporting an exposure to BBF received the first dose of HBV vaccination, 11% the second, 7% the third and 3% the fourth dose.

### Serology of HIV and hepatitis

The prevalence of anti-HIV among the source patients tested was 0.9% (16/1,717), for HBsAg it was 1.2% (20/1,717) and for anti-HCV/HCV-RNA it was 3.8% (65/1,717) (**Table 2**).

There were no anti-HIV or anti-HCV-positive HCWs. There were three anti-HBc-positive HCWs, but all three were IgM and HBsAg-negative at the time of exposure. The corresponding prevalence was 0% for HIV and HCV (95% confidence interval (CI) 0-0.16%) and 0.13% (0.03-0.39%) for anti-HBc among the 2,274 HCWs tested at exposure. This zero incidence of infections among HCWs was significantly lower than the expected number infected with HIV: 0.05 (95% CI 0.03-0.08), HBV: 4.3 (2.6-6.7), HCV: 2.0 (1.6-2.6), and total 6.4 (4.3-9.3) (p < 0.001).

### Reporting coverage

During the 2006-2012 period, the Department of Safety and Work Environment received 1,511 reports of work-related injury due to BBF exposures among 1,375 individuals. There was no yearly increase in the prevalent cases during the period. In the same period, 814/1,626 (50%) of the registered cases of BBF exposures in the Department of Infectious Diseases were not reported to the Department of Safety and Work Environment. Correspondingly, 563/1,375 (41%) of the reported work-related cases of BBF exposures were not registered at the Department of Infectious Diseases. A capture-recapture estimate indicated a hidden population of 564 (20.5%) BBF exposures not present in any of the registers.

**TABLE 1**

First-time exposures to blood and body fluids reported in 2012 according to profession and specialty

| Variable | n[a] | Percentage (95 % CI) | Total no. of HCWs within each group | Incidence/100 FTE per year (95% CI) | p value |
|---|---|---|---|---|---|
| *Profession* | | | | | |
| Nurses | 91 | 46.7 (39.5-53.9) | 2,020.6 | 4.5 (3.6-5.5) | Baseline |
| Doctors | 32 | 16.4 (11.5-22.4) | 849.5 | 3.8 (2.6-5.3) | 0.42 |
| Nurse assistant | 17 | 8.7 (5.2-13.6) | 529.9 | 3.2 (1.9-5.1) | 0.23 |
| Students[b] | 19 | 9.7 (6.0-14.8) | 320.7 | 5.9 (3.6-9.1) | 0.32 |
| Laboratory technicians | 7 | 3.6 (1.5-7.3) | 65.1 | 10.8 (4.4-20.9) | 0.04 |
| Midwives | 6 | 3.1 (1.1-6.6) | 59.7 | 10.1 (3.8-20.5) | 0.07 |
| Other | 23 | 11.8 (7.6-17.2) | 1,257.6 | 1.8 (1.2-2.7) | < 0.001 |
| *Total* | 195 | | | | |
| *Specialty* | | | | | |
| Internal medicine | 56 | 28.9 (22.1-35.1) | 1,338.1 | 4.2 (3.2-5.4) | Baseline |
| Surgery | 62 | 32.0 (24.9-38.3) | 1,304.9 | 4.8 (3.7-6.0) | 0.51 |
| Other[c] | 76 | 39.2 (31.6-45.5) | 1,458.3 | 4.5[d] (3.5-5.7) | 0.25 |
| *Total* | 194 | | | | |

a) Three cases with unknown profession and four cases with unknown department were excluded.
b) Medical students, nursing students and nurse assistant trainees.
c) Departments of psychiatry, cross-disciplinary departments and unclassified departments.
d) Ten exposures were omitted from the calculation due to missing information on department.
CI = Confidence interval; FTE = Full-time employees; HCW = Healthcare workers

**TABLE 2**

Serology among 1,717 source patients to blood and body fluids exposures from 2003 to 2012.

| Variable | Number | Percentage (95% CI) |
|---|---|---|
| Anti-HIV-positive | 16 | 0.9 (0.5-15.1) |
| HIV-RNA-positive | 8[a] | 0.5 (0.2-0.9) |
| HIV-RNA-negative | 5 | 0.3 (0.09-0.7) |
| Unknown HIV-RNA status | 3 | 0.2 (0.04-0.5) |
| Anti-HBc-positive | 164 | 9.6 (8.2-11.0) |
| HBsAg-positive | 20 | 1.2 (0.7-1.8) |
| HBV-DNA-positive | 10 | 0.6 (0.3-1.1) |
| HBV-DNA > $10^6$ IE/L | 1 | 0.06 (0.001-0.3) |
| HBeAg-positive | 14 | 0.8 (0.4-1.4) |
| Anti-HCV or HCV-RNA-positive | 65 | 3.8 (2.9-4.8) |
| HCV-RNA-positive | 48 | 2.8 (2.1-3.7) |
| HCV-RNA-negative | 14 | 0.8 (0.4-1.4) |
| Unknown RNA status | 3 | 0.2 (0.04-0.5) |
| Total no. of contagious source patients[b] | 85 | 5.0 (4.0-6.1) |
| Detectable virus in blood of patients[c] | 69 | 4.0 (3.1-5.1) |

a) One of the patients was involved in two exposures. The source patient was HIV-RNA-positive in both cases.
b) Calculated as [anti-HIV] + [HBsAg] + [HCV-RNA] + [62% of anti-HCV-positive with unknown HCV-RNA status]. One case had two infections.
c) Calculated as [HIV-RNA] + [HBsAg] + [HCV-RNA] + [62% of anti-HCV-positive with unknown HCV-RNA status] = 8 + 48 + 11 + 2 = 69.
CI = Confidence interval

## DISCUSSION

In this study among HCWs in a university hospital, the median BBF exposure incidence was 5.2/100 FTE per year, which increased by 35% over ten years. However, no transmission of blood-borne diseases was observed. The increase was higher than the 10% increase in employees during the study period and most likely due to increased reporting as has been previously observed [10].

Presumably, the true incidence of BBF exposures was much higher, as under-reporting of BBF exposures has been found in several studies [11-13]. Among 6,005 Danish hospital doctors, only 1.7% of all BBF exposures were reported [12]. In 1998, a study at our hospital established an incidence of 69/100 person years [3]. Of these, only 4% had been reported the incidence corresponding to a reported incidence of 2.8/100 person years.

Laboratory technicians reported BBF exposures more frequently than other occupational groups, which is in agreement with previous Danish studies [6, 14].

Adherence to the initial blood tests was high in 2012, but only 17% of exposed HCWs had blood samples taken six months after BBF exposure compared with 27% in a previous Danish study [15]. Neglect and low perceived risk of infection were the two most frequent causes registered for non-adherence to follow-up blood sampling [15]. As only 35% of HCWs had a three-month follow-up test and 17% had a six-month test in 2012, the majority of potential viral transmissions would not have been detected. However, up to a third of the adults infected with HBV or HCV would have developed jaundice within six months. This was not observed which supports that the transmission rate must have been very low. Notably, we were unable to detect an increase in follow-up tests during the ten-year observation period. The low testing rate may reflect that 95% of the source patients were not infected, which decreases the motivation of the HCWs to perform follow-up tests.

Only 31% of HCWs had protecting levels of antibodies to HBV prior to the BBF exposure, but this figure increased to 76% after vaccination. Adherence to HBV vaccination was 81% for the first dose, but declined hereafter; and only 7% reported to have received the third dose. This was probably due to under-reporting as 95% of follow-up vaccinations of HCWs exposed to non-infectious source patients were not performed at our department.

That 5% of the source patients were contagious could be an overestimation, as high-risk patients would be more likely to be tested [15].

The anti-HCV prevalence among our hospital source patients (3.8%) was significantly higher than the 1.5% reported in a 1995 Danish hospital study [5]. In 1995, all patients were tested independently of any BBF exposure, but as only 9% of source patients were not tested, this is unlikely to account for the difference observed. Our source patients had a nine-fold increased HIV prevalence compared with the general Danish population [9]. Correspondingly, the prevalence of HBV was five-fold higher [7] and the prevalence of HCV ten-fold higher [8]. The most likely explanation is that an increased immigration from countries with a high prevalence of blood-borne viral infections has taken place over the past decades.

No HCW was infected with HIV, HBV or HCV during the study period. This could reflect a protective effect of post-exposure HBV vaccination or an overestimation of infected patients as mentioned above. However, we cannot exclude that subclinical infections may have taken place at the hospital during our observation period as the estimated reporting rate was very low. But we would have expected to see some clinical cases if transmission had taken place. Also, the very low (and decreasing) prevalence of infection found at baseline among more than 2,000 exposed HCWs suggests a low risk for HCWs.

The prevalence was 0% for HIV and HCV and 0.13% for anti-HBc during the 2003-2012 period. In 1998, the prevalence among HCWs at our hospital was 0% (anti-HIV), 0.14% (anti-HCV) and 1.6% (anti-HBc), which indicates a decrease in anti-HBc during the past decades [3]. This corresponded to a ten-fold decrease in chronic HBV infection among native Danish pregnant women (from 0.1% to 0.01% over the past 30 years) [16].

Only 54% of registered exposures to BBF were reported as work-related injuries, but it is likely that the vast majority of exposures were not reported at all. We suggest that reporting of BBF exposure should be facilitated in order to improve coverage.

In conclusion, despite frequent exposure to BBF among HCWs, the risk of infection was low. Over ten years, no transmission of HIV, HBV or HCV was detected among HCWs reporting BBF exposure. However, the possibility of transmission could not be ruled out due to significant underreporting and non-adherence to follow-up blood testing. This suggests that improved surveillance of BBF exposure is needed.

**CORRESPONDENCE:** *Peer Brehm Christensen*, Department of Infectious Diseases Q, Odense University Hospital, Sdr. Boulevard 29, 5000 Odense C, Denmark. E-mail: peer.christensen@dadlnet.dk

**ACCEPTED:** 3 July 2014

**CONFLICT OF INTEREST:** none. Disclosure forms provided by the authors are available with the full text of this article at www.danmedj.dk.

**LITERATURE**

1. Statens Serum Institut, Department of Infectious Disease Epidemiology. Hepatitis B, Duty to notify specified diseases [Hepatitis B, Individuelle anmeldelsespligtige sygdomme] http://www.ssi.dk/Smitteberedskab/Sygdomsovervaagning.aspx. (16 December 2013).
2. Statens Serum Institut, Department of Infectious Disease Epidemiology. Hepatitis C, Duty to notify specified diseases [Hepatitis C, Individuelle

anmeldelsespligtige sygdomme] http://www.ssi.dk/Smitteberedskab/Sygdomsovervaagning.aspx (16 December 2013).
3. Fisker N, Mygind LH, Krarup HP et al. Blood borne viral infections among Danish Health Care Workers – frequent blood exposure but low prevalence of infection. Eur J Epidemiol 2004;19:61-7.
4. Centers for Disease Control and Prevention. Updated U.S. Public Health Service Guidelines for the Management of Occupational Exposures to HBV, HCV, and HIV and Recommendations for Postexposure Prophylaxis. MMWR 2001;50(RR-11);1-42.
5. Nelsing S, Wantzin P, Skøt J et al. The seroprevalence of hepatitis B and C in hospitalized Danish patients. Scand J Infect Dis 1995;27:445-8.
6. Pedersen EB. Exposure to blood and body fluids among health care workers in a hospital. Ugeskr Læger 1996;158:1807-11.
7. Hansen N, Hay G, Cowan S et al. Hepatitis B prevalence in Denmark – an estimate based on nationwide registers and a national screening programme, as on 31 December 2007. Euro Surveill 2013;18:pii=20637.
8. Christensen PB, Hay G, Jepsen P et al. Hepatitis C prevalence in Denmark – an estimate based on multiple national registers. BMC infect Dis 2012 Aug 6;12:178.
9. Statens Serum Institut, Department of Infectious Disease Epidemiology. HIV 2012, Aids 2012, European HIV testing week. EPI-NEWS [Overvågning og forebyggelse af smitsomme sygdomme. Hiv 2012]. Andersen PH, Ed. 2013;44 http://www.ssi.dk/English/News/EPI-NEWS/2013.aspx (4 February 2014).
10. Frijstein G, Hortensius J, Zaaijer HL. Needlestick injuries and infectious patients in a major academic medical centre from 2003 to 2010. Neth J Med 2011;69:465-8.
11. Prüss-Üstün A, Rapiti E, Hutin Y. Estimation of the global burden of disease attributable to contaminated sharps injuries among health-care workers. Am J Ind Med 2005;48:482-90.
12. Nelsing S, Nielsen TL, Nielsen JO. Underreporting and initial follow-up of occupational blood exposure among Danish doctors. Ugeskr Læger 1997;159:6211-5.
13. Wicker S, Gottschalk R, Rabenau HF. Risk of needlestick injuries from an occupational medicine and virological viewpoint. Dtsch Arztebl 2007;104:A 3102-7.
14. Kaczan E, Gottlieb I, Jans H. [Occupational injuries with risk of transmission of blood-borne pathogens. A study of a 2-year material from the Holstebro Central Hospital]. Ugeskr Læger 1994;156:4360-4.
15. Graversen M, Bytzer P. Follow-up with blood samples following needlestick injury in hospital. A questionnaire survey. Ugeskr Læger 2004;166:592-5.
16. Harder KM, Cowan S, Eriksen MB et al. Universal screening for hepatitis B among pregnant women led to 96% vaccination coverage among newborns of HBsAg-positive mothers in Denmark. Vaccine 2011;29:9303-7.