# Bandolier ***Extra***

**Evidence-based health care** **July 2003**

## NEEDLESTICK INJURIES

This ***Bandolier*** **Extra** looks at the evidence around needlestick injuries, principally in healthcare workers, how often these injuries occur, their consequences, their costs, and how to prevent them. It is not an area overburdened with large amounts of evidence in the form of randomised trials, or systematic reviews, though there are some.

Needlestick injuries is one of those hidden problems, much like latex allergy used to be. It happens, but mostly we forget it and get on with life. Increasingly the evidence is that we shouldn't do that. There is a risk of transfer of bloodborne pathogens, and, in some cases, we should have antiviral prophylaxis. At the very least there may be protection for the individual under employment legislation.

We start with some definitions, and take a quick look at the substantial recognition that needlestick injuries have attracted in the USA in recent years before moving to look at the evidence.

### Definitions

For the purposes of this document we will try to use the following definitions consistently.

- Needlestick injury means the parl¡teral introduction into the body of a health care worker, during the performance of his or her duties, of blood or other potentially infectious material by a hollow-bore needle or sharp instrument, including, but not limited to, needles, lancets, scalpels, and contaminated broken glass.

- Sharps means hollow-bore needles or sharp instruments, including but not limited to, needles, lancets and scalpels.

### Introduction

More than eight million health care workers in the United States work in hospitals and other health care settings and between 600,000 and 800,000 needlestick and other percutaneous injuries occur in them every year. About half of these injuries go unreported, though it could be more. Most reported injuries involve nursing staff, and the preponderance of injuries occurring in nursing staff is a common feature of studies around the world.

Some of these injuries expose workers to blood borne pathogens, such as hepatitis B (HBV), hepatitis C (HCV), and human immunodeficiency virus (HIV) that can cause infection in the person injured. These injuries result in at least 1,000 new cases of health care workers diagnosed with HIV, hepatitis C, or hepatitis B every year in the USA. Infections with each of these pathogens are potentially life threatening and preventable. The emotional impact of a needlestick injury can be severe and long lasting, even when a serious infection is not transmitted. Not knowing the infection status of the source patient can accentuate the health care worker's stress. Some places or institutions might have very high rates of infection in source patients, but even low rates can give rise to significant lifetime chance of infection.

Technology exists that can protect health care workers from needlestick injuries but less than 15% of the hospitals in the United States use safer needle devices because of the cost in purchasing these devices. Figures for other countries are not known, but uptake of safer devices is almost certainly lower outside the US, where there has been specific legislation. More than 80% of needlestick injuries can be prevented through the use of safer devices and effective safety programmes.

In May 1999, the Health Care Worker Needlestick Prevention Act was introduced in the US Senate and House. On October 26, 2000, the needlestick prevention legislation was passed in the US Congress. The Senate voted to pass H.R. 5178 / S. 3067, the Needlestick Safety and Prevention Act.

The United States Department of Labor Occupational Safety and Health Administration (OSHA) has added needlestick prevention to its agenda in an attempt to reduce the number of injuries that health care workers get from needles. The legislation provides for the following:

1 an exposure control plan where employers develop a written plan to identify and select needleless systems or sharps systems with safety features;
2 a sharps injury log where employers would be required to keep a log containing detailed information about sharps injuries; and
3 training of health care workers on the use of needleless technologies and systems.

A downloadable PowerPoint presentation can be found at the following Internet site: www.osha.gov/needlesticks/2001RevisedBBPStandardOutreach1.ppt.

## Important sources of information

Because of the huge interest and importance new legislation has given the issue of needlestick injuries in the USA, there has been a parallel growth in sources of substantive information on the Internet.

### EPINet

http://hsc.virginia.edu/medcntr/centers/epinet/home.html

The Exposure Prevention Information Network (EPINet) was developed in 1991 by Janine Jagger and colleagues to provide standardised methods for recording and tracking percutaneous injuries and blood and body fluid contacts. The EPINet system consists of a needlestick and sharp object injury report, a blood and body fluid exposure report, and software programmed in Access for entering and analyzing the data from the forms. A post-exposure follow-up form is also available.

Since its introduction in 1992, more than 1,500 hospitals in the USA have acquired EPINet for use; it has also been adopted in other countries, including Canada, Italy, Spain, Japan and U.K.

The Internet site gives visitors all the information they could want about how to get into EPINet, and the background on US government, and State, legislation. It also has downloadable reports.

### Centres for Disease Control

http://www.cdc.gov/ncidod/hip/Needle/needle.htm

Masses of stuff here, though (in July 2003) nothing posted much later than 1999. Importantly it has a direct link to the General Accounting Office report (of which, see more later).

### American Nurses Association

http://www.nursingworld.org/needlestick/nshome.htm

Good matreial for nurses, including fact sheets, information on bloodborne pathogens, and the ANA's safe needles saves lives programme. Some good linked resources too.

### Medicines and Healthcare Products Regulatory Agency

http://www.medical-devices.gov.uk/mda/mdawebsitev2.nsf/webvwSearchResults/12924D0AC85F56EB00256AF7004F3DBD?OPEN

Last modified in November 2001, this page on what was the MDA website includes a British approach.

## Needlestick injuries in healthcare workers

The most recent report from EPINet [1] gives the results for percutaneous injuries among 58 participating hospitals, which recorded 1,929 injuries in 2001. The average percutaneous injury rate for teaching hospitals was 26 injuries for every 100 occupied beds, and for non-teaching hospitals it was 18 per 100 occupied beds. This shows a reduction in rate from the previous numbers for 1999 (Figure 1) of about 35% and 45% respectively.

There were probably several factors for this decline, especially since the introduction of OSHA regulations in late 1999. This stated explicitly that the use of safety devices was required. But there has also been better education, and a greater awareness of the problem and need for reporting needlestick injuries. Better education and awareness, though, might have been expected to have reduced under-reporting and tended to inflate, rather than reduce the number of needlestick injuries reported.

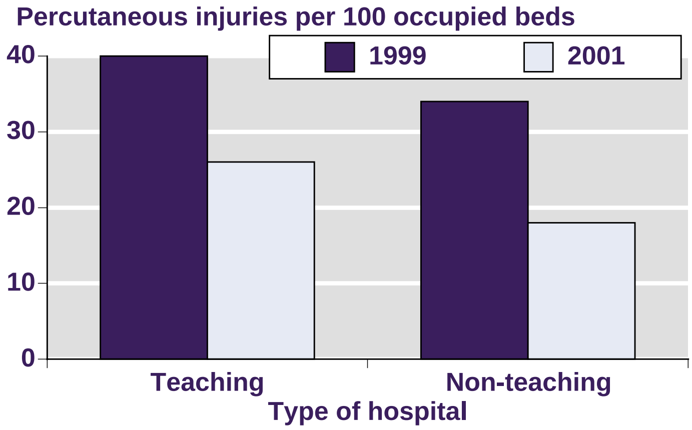
The information [1] available on these injuries was detailed. It showed that a significant minority of injuries (44%) occurred in nurses. Use of sharps for injections or drawing blood samples amounted to over a third of accidents, with disposable syringes and other steel needles contributing the largest single component (between 40 and 50% of all accidents).

Table 1 gives details of some of the studies on injuries to healthcare workers reported since 1990. It is probably not comprehensive, because these studies are often hard to find, and some will be published in journals that are not electronically indexed. They use different samples, of different size, with different methods and were performed at different times in different situations.

Each of the studies in Table 1 is abstracted on the ***Bandolier*** Internet site section for needlestick injuries, and more will be added there when information becomes available.

Because of the differences between studies, it is not possible to quantitatively synthesise their results, but a coherent picture emerges despite this.

### Figure 1: EPINet percutaneous injury rates



## Table 1: Studies of needlestick injuries in healthcare workers

| Reference and country | Setting | Study | Results |
|---|---|---|---|
| Memish et al, 2002<br>Saudi Arabia | 600 bed tertiary hospital with 2,800 employees | Prospective study using EPINet from 1997-2000 | 364 reported injuries over 4 years, with average 33/1,000<br>Commonest were accidents to nurses, phlebotomists, respiratory therapists and paramedics<br>One HCV seroconversion |
| Newsom & Kiwanuka, 2002<br>Uganda | 280 healthcare workers in Ugandan teaching hospital in one month | Voluntary anonymous questionnaire asking about recall on needlestick injuries in past year | Response rate 64%<br>55% had needlestick injury<br>Average of two injuries per worker per year<br>Calculated cumulative rates of HBV and HIV seroconversion |
| Shiao et al, 2002<br>Taiwan | 16 randomly selected hospitals, with 10,500 workers | Questionnaire about needlestick injuries in previous 12 months | Response rate 83%<br>87% had needlestick injury<br>Hollow bore needle in 64%<br>Calculated seroconversion rates for various classes of workers in Taiwanese health service |
| Abu-Gad & Al-Turki, 2001<br>Saudi Arabia | 11 of 38 hospitals of eastern province with a reporting system | Retrospective record analysis | 282 injuries<br>Most occurred in nurses, and most related to use of syringes, and most occurred in those with fewer than five years experience |
| Karstaedt & Pantanowitz, 2001<br>South Africa | 102 interns in Johannesburg and Soweto | Anonymous questionnaire recalling all percutaneous injuries | At least one percutaneous injury in 83% of interns, 43% from HIV positive source. Rate was 0.45 per person during intern year and 0.24 during three student years.<br>Most injuries (69%) involved a hollow bore needle |
| Puro et al, 2001<br>Italy | 18 acute care hospitals over five years, 16,000 beds and 35,000 employees | Prospective study of occupational risk of infection | 11,000 percutaneous exposures, 65% caused by hollow bore needles<br>Five year rates varied by location and job, from 1% to 14% |
| Alzahrani et al, 2000<br>UK | 10 hospitals in Manchester between 1992 and 1999 | Retrospective examination of all needlestick incidents | 2,646 incidents over 7 years<br>HBV in 0.8% source patients |
| Moens et al, 2000<br>Belgium | Prevalence of HCV in Belgian hospital workers | 5,064 workers gave samples during annual occupational medical examination, of 15,600 employed | 33% of workers received at least one needlestick injury |
| Varma & Mehta, 2000<br>India | 100 third year medical students in 1996 and 1997 | Questionnaire survey | 106 responses from 200 (53%)<br>Most injuries when drawing blood<br>Rate was 1.5 injuries per student per month |
| Cassina et al, 1999<br>Switzerland | Percutaneous injuries in an operating room | 1000 consecutive procedures over four months | 73 injuries per 1000 procedures<br>calculated lifetime HIV transmission was 1 in 333 |
| Goob et al, 1999<br>USA | US Army medical centre | Hazard analysis of bloodborne disease transmission | Annual incidence of exposure was 94/1,000 healthcare workers, with 84% from sharps. House officers most at risk. |
| Ippolito et al, 1999<br>Italy | 41 hospitals, 63,000 employees in modified EPINet programme | Recording occupational exposure over 5 years to 1998 | 19,860 exposures, 75% percutaneous. Highest rates in surgeons and nurses<br>10,122 hollow bore needlestick injuries<br>1 in 100 seroconversion for HCV and 1 in 500 for HIV |
| Lee et al, 1999<br>USA | 3,239 participants of examination for emergency medicine residents | Recording occupational exposure over training | Response rate 90%<br>56% had one or more injuries<br>Hollow-bore needles accounted for 31% injuries |
| Shen et al, 1999<br>UK | 137 fourth year medical students trained in universal precautions | Questionnaire about sharps and needlestick injuries in third and part of fourth year | Response rate 77%<br>33% had one or more injuries<br>Surgery accounted for 70% of injuries<br>Hollow-bore needles accounted for 34% injuries |
| Wise & McCormick, 1999<br>UK | 75 anaesthetists in two anaesthetic departments | Postal survey | Response rate 69%<br>50% had at least one needlestick injury from hollow bore needle |
| Knight & Bodsworth, 1998<br>Australia | Registered nurses in a Sydney teaching hospital | Questionnaire about knowledge of precautions and risk | Response rate 48%<br>76% suffered occupational exposure in previous 6 months<br>Percutaneous exposure 65 per 100 nurse years |
| Gumodoka et al, 1997<br>Tanzania | 27 wards, labour rooms, operating theatres | 10% of 3,500 employees interviewed about knowledge of HIV transmission | Response rate 93%<br>10% had skin prick during previous week, and overall rate was 5 per year<br>Five year risk of HIV transmission was 1 in 30 to 1 in 77, depending on occupation |
| Resnic & Noerdlinger 1995<br>USA | Medical students and house staff in 1200 bed New York hospital with high rates of HIV | Anonymous questionnaire to 650 house staff, with 13 questions relating to occupational exposure | Response rate 60%<br>32% had exposure over previous 6 months, with 1 in 20 involving HIV positive source |
| Smedley et al, 1995<br>UK | 15 occupational health departments in Wessex and Oxford regions | Prospective data collection | 1,102 incidents<br>Rates for various staff ranged from 9 to 44 per 1,000 per year |
| Chia et al, 1994<br>Singapore | House officers undergoing training at a major hospital | Self-administered recall questionnaire | Response rate was 79%<br>1.2 needlestick injuries per month per house officer |
| Stotka et al, 1991<br>USA | General medical wards of two Virginia acute care hospitals | Prospective survey of occupational exposure over 8-9 months | In doctors there were 644 exposures, with 0.57 needlesticks per doctor per year<br>In nurses there were 235 exposures, with 0.83 needlesticks per nurse per year |
| McCormick et al, 1991<br>USA | Medical school staff | Prospective epidemiological survey | Annual incidence of sharps injuries 187/1,000 workers, with highest rates in cleaners and nurses, with two thirds of injuries in nurses |
| McGeer et al, 1990<br>Canada | All house staff (88) in a hospital | Anonymous questionnaire recalling all percutaneous injuries | Response rate 100%<br>0.7 injuries per person per year<br>Hollow-bore needles accounted for 98% injuries |

- Needlestick injuries can be common. Nurses almost always have higher rates of injury than other workers, with high rates also occurring in junior doctors.
- Needlestick injuries are often under-reported, and when levels of reporting have been examined, it is common for only a small proportion to be reported.
- Knowledge about needlestick injuries and possible infection from bloodborne pathogens is often low, and risks under-estimated.

Some examples might be useful.

## Italian experience

For instance, in Italy a multicentre prospective study of the risk of transference of HIV and other bloodborne pathogens to healthcare workers following occupational exposure has been ongoing since 1986 [13]. Hospitals are enrolled on a voluntary basis. Participating hospitals must actively encourage reporting of exposures, and must have an employee health team.

In 1994 a modified EPINet programme was adopted to record all occupational exposures in greater detail. There are now 41 hospitals taking part, 14 of them teaching hospitals. They have together about 36,000 beds, and employ 62,500 workers.

From January 1994 to June 1998 (5.5 years) there were 19,860 occupational exposures, 75% percutaneous and 25% mucocutaneous. Known infected sources were involved in 28% of all exposures: HCV 63%, HBV 13%, HIV 11%, and two or more of these together in 13%.

Employee groups involved are shown in Table 2. One in ten exposures involved personnel in training.

Two-thirds of the percutaneous exposures involved needle devices, and other sharps items 30%. There were 10,122 hollow bore needlesticks, and the particular devices involved here are shown in Table 2. Most injuries occurred during or after use, but before disposal of the device.

Rates per 100,000 devices for each year between 1991 and 1997 were fairly constant. IV catheters (12-21 per 100,000 devices) and winged steel needles (9-14 per 100,000 devices) were associated with higher rates of injury than disposable syringes or vacuum tube phlebotomy sets, each at about 4 per 100,000 devices.

**Table 3: Proportion of needlesticks from 10,122 hollow bore needles**

| Device | Percent of injuries |
|---|---|
| Disposable syringes | 44 |
| Winged steel needles | 29 |
| Vacuum tube phlebotomy sets | 5 |
| IV catheters | 10 |
| Other devices | 12 |

### Seroconversion for Hepatitis B

There were 1,155 exposures to HBsAg positive sources, and 158 of 926 (1994-1998) involved susceptible healthcare workers, 117 of whom received active and passive immunoprophylaxis after exposure. There were no seroconversions.

### Seroconversion for Hepatitis C

The results for hepatitis C are shown in Table 4. For blood-filled hollow bore needles the seroconversion rate was 0.85% (95% confidence interval 0.4 to 1.5%).

### Seroconversion for HIV

The results for HIV are shown in Table 4. For blood-filled hollow bore needles the seroconversion rate was 0.21% (95% confidence interval 0.03 to 0.5%). One worker seroconverted after conjunctival exposure to blood.

There was data on 789 workers given post-exposure prophylaxis with zidovudine monotherapy. More than half reported adverse events, mainly gastrointestinal, and 18% discontinued therapy because of adverse events after a mean of seven days.

There was data on 103 workers given post-exposure prophylaxis with two reverse transcriptor inhibitors and 112 with these plus a protease inhibitor. Adverse events were again

**Table 2: Occupational exposure to hospital employees in Italian hospitals over 5.5 years**

| | | Exposure per 100 full time equivalents | | |
|---|---|---|---|---|
| Occupation | FTE positions | Percutaneous | Mucocutaneous | Total |
| Surgeon | 6534 | 10.1 | 1.9 | 12.0 |
| Nurse | 43897 | 8.4 | 2.6 | 11.0 |
| Midwife | 1002 | 6.6 | 4.7 | 11.3 |
| Housekeeper | 14603 | 4.0 | 0.9 | 4.9 |
| Physician | 12491 | 2.8 | 1.1 | 3.9 |
| Laboratory worker | 6855 | 2.7 | 1.4 | 4.1 |

**Table 4: Seroconversion rates for HCV and HIV**

| Exposure type | Number Infected/exposed | Rate (%, 95% CI) |
|---|---|---|
| **Seroconversion for HCV** | | |
| Percutaneous | 12/3076 | 0.4 (0.2 - 0.7) |
| By hollow bore needle | 12/1955 | 0.6 (0.3 - 1.1) |
| - blood filled | 11/1301 | 0.9 (0.4 - 1.5) |
| - no blood | 1/631 | 0.2 (0.0 - 0.9) |
| By other sharp object or solid needle | 0/987 | 0 |
| Mucocutaneous contamination | 2/225 | 0.4 (0.0 - 1.3) |
| Non-skin contamination | 0/473 | 0 |
| **Seroconversion for HIV** | | |
| Percutaneous | 3/2125 | 0.14 (0.03 - 0.4) |
| By hollow bore needle | 2/1434 | 0.14 (0.02 - 0.5) |
| - blood filled | 2/962 | 0.21 (0.03 - 0.8) |
| - no blood | 0/344 | 0 |
| By other sharp object or solid needle | 1/470 | 0.21 (0.06 - 1.2) |
| Mucocutaneous contamination | 2/468 | 0.43 (0.05 - 1.5) |
| Non-skin contamination | 0/573 | 0 |

common, and 5% and 12% stopped treatment because of adverse events after a mean of 11 and 10 days respectively.

There is a wealth of detailed information in this study, examining nearly 20,000 occupational exposures. While most exposures resulted from disposable syringes, this was because of the number being used. Winged steel needles and IV catheter sets had the highest rates of injury.

One in 100 workers with percutaneous exposure to HCV infected blood will be infected, as will one in 500 exposed to HIV infected blood (and with postexposure prophylaxis). These are high rates.

## Lifetime risk of occupational viral infection

A French study [25] looked at the individual cumulative risk (ICR) of occupational viral contamination run by surgeons in France. It used the following equation:

**ICR = 1 - [1-(seroprevalence of virus x seroconversion rate)] raised to the power of number of skin injuries per year x number of years of practice**

In performing its calculations, it used the following figures for a surgeon in an average French hospital.

- Seroprevalence of hepatitis C and HIV have been estimated as 1.2% and 0.16%.
- Seroconversion rate has been estimated as 3% for hepatitis C and 0.5% for HIV.
- Incidence of skin injury is about 0.8 punctures per 100 hours of operating time.
- Mean surgical activity is 750 hours of operating time each year (average of about 3 hours a working day), over a 35 year career.

With a working lifetime estimate of 210 skin punctures, the individual cumulative risks were calculated to be 6.9% for hepatitis C and 0.15% for HIV. For hepatitis C that is a 1 in 14 chance, and for HIV it is a 1 in 660 chance. The figure for HIV is similar to estimates for US surgeons.

It is the figures for hepatitis C that are worrying. Some populations, like drug addicts and prisoners, have high prevalence rates. This dramatically increases the chance of a surgeon being infected. Then the risk becomes so high that within a short time it moves from if to when.

Surgeons have a higher risk of injury than most healthcare professions. But other circumstances also confer higher risk. Where there is high risk of high levels of viral infection in the population served, for instance, or where there are more injuries over time, the equation generates higher levels of individual risk.

## Individual cumulative risk

**Individual cumulative risk = 1 - [1-(seroprevalence of virus x seroconversion rate)] raised to the power of number of skin injuries per year x number of years of practice**

## Example 1: Uganda [3]

A voluntary, anonymous questionnaire was circulated to 280 healthcare workers in a Ugandan teaching hospital in November 1999. It explored recall of needlestick injuries in the previous year, the circumstances, and the action taken. It also examined local prevalence of HIV and HBV infection in patients, and calculated the risk of infection from a single needlestick.

Most (61%) respondents took blood without wearing gloves.The most common action was to squeeze the puncture site and then wash it with bleach.

Blood from 435 anonymous patients was tested, and the seroprevalence of HIV was 26% and HBV was 3%. The risk of infection following a single needlestick injury, using literature data for transmission, was:

For HIV:

- For a single needlestick 0.08% (1 in 1,250, ranging from 1 in 400 to 1 in 2,000 in different departments).
- The cumulative risk for a doctor by the end of two years as a student and a one year internship was calculated as 0.6% (1 in 1,600).

For HBV:

- For a single needlestick 0.14% (1 in 700, but up to 1 in 200 to 1 in 45 in some departments).
- The cumulative risk for a doctor by the end of two years as a student and a one year internship was calculated as 1% (1 in 100).

One student reported developing acute hepatitis B infection, but no-one disclosed their HIV status.

## Example 2: Taiwan [4]

This study set out to estimate the annual risk for contracting hepatitis B, hepatitis C and HIV after a needlestick injury with a used narrow bore needle. It did this using several methods.

The incidence of needlestick injuries in workers in 16 randomly-selected hospitals of the 132 in Taiwan, stratified by size. There were 10,500 healthcare workers, and 83% completed a questionnaire about needlestick injuries and the type of device in the previous 12 months.

HBV, HCV and HIV antibody prevalence in patients using residual sera of 1805 collected on four days in separate quarters of the year. This was a 10% sample of the patients admitted on each of the four days. Half the diagnoses were for cancer, circulatory problems, poisoning and injury, and diseases of the respiratory system. This was somewhat different than for the whole hospital population. Seroconversion rates were taken from the literature.

### Needlestick

Needlestick injuries occurred in 7,750 workers (87%) during the previous 12 months. Of these, 64% involved a hollow bore needle, and in 3% the cases were unknown. A figure of 67% hollow bore needles was used as the basis for calculations on susceptibility to pathogen transfer.

For each class of worker, figures from the questionnaire were used to calculate the number of contamination exposures a year, which ranged from 0.7 per year for nurses to 0.3 per year for support personnel.

Not all workers were protected against HBV, and 28% had neither natural protection nor had been vaccinated.

### Patient prevalence

Antibodies to HBV were present in sera of 17% of patients, HCV in 13% and HIV in 0.8%.

### Risk of seroconversion

The literature rates of seroconversion were taken as 10-30% for HBV, 1-10% for HCV and 0.1-0.3% for HIV.

### Annual number of seroconversions in Taiwan

This was estimated for the entire Taiwanese healthcare system by taking the annual exposure rates for individual risks and multiplying by the seroconversion rate and the total number of employees in that category. The results are shown in Table 5.

The lesson is that while individual risk is low, the risk for the healthcare worker population is significant. If each of the needlestick injuries was reported, it would place a high burden on occupational health departments for counselling, prophylaxis and testing. In 110,000 workers about 1,000 each year have occupational infection through injury from a hollow bore needle means individual as well as collective tragedy.

**Table 5: Seroconversions for needlestick injuries in Taiwan**

| Category | Total employed | Annual number of seroconversions: HBV | HCV | HIV |
|---|---|---|---|---|
| All workers | 110,000 | 300-900 | 330-840 | <1-2 |
| Nurses | 66,900 | 180-540 | 230-600 | <1-1 |
| Physicians | 17,710 | 30-80 | 40-90 | <1 |
| Technicians | 16,390 | 40-110 | 30-80 | <1 |
| Support staff | 7,810 | 20-25 | 10-30 | <1 |

## Occupational exposure a risk factor

That occupational exposure is an important factor in some of the transmissable viral diseases was emphasised by a n epidemiological study of the source of HCV infection in the USA [26].

Consecutive chronically infected HCV patients eligible for a clinical trial were recruited, with HBV and HIV as specific exclusions, as was advanced liver disease. A detailed questionnaire about risk factors was completed during an interview with a single investigator.

There were 148 patients (88 men, 60 women) aged 18 to 72 years (mean 45 years). Only 5% had no known risk factor, and the most commonly found known risk factors were injected drug use, sharing razors and toothbrushes, body piercing, being a recipient of blood products, sexual exposure and occupational exposure to blood in 48% to 32% of cases. Tattooing was associated with 17% of cases.

Exposure to risk factors differed greatly between men and women, with 92% of women having body piercing (Figure 2). Most cases had more than one risk factor. Of the 23 persons with a single risk factor 3 underwent body piercing, and one had a needlestick exposure.

## The viruses

### Hepatitis B

HBV has probably infected something like 2 billion people in the world, roughly a quarter to a third of the world's population, and about 300 million people are carriers of the virus. The carrier rate is low in most western countries (less than 1% in the UK and USA, for example), but in Africa and some parts of Asia the carrier rate can be well above 10%, and was 17% in Taiwan, for instance [4].

Spread of HBV is often by intravenous routes through infected blood or blood products, or contaminated needles used by drug abusers, or by tattooists or acupuncturists, or in body piercing. Another major route is close personal contact, with virus present in semen and saliva. Perhaps the most important transmission route worldwide is vertical transmission from mother to baby. Seroconversion after a needlestick with contaminated blood is estimated at 10-30%.

While most infected persons recover completely, fulminant hepatitis can occur in up to 1%, and some patients go on to develop chronic hepatitis or liver cancer. Some become carriers, which may preclude them from carrying on working in their chosen career if they are healthcare professionals.

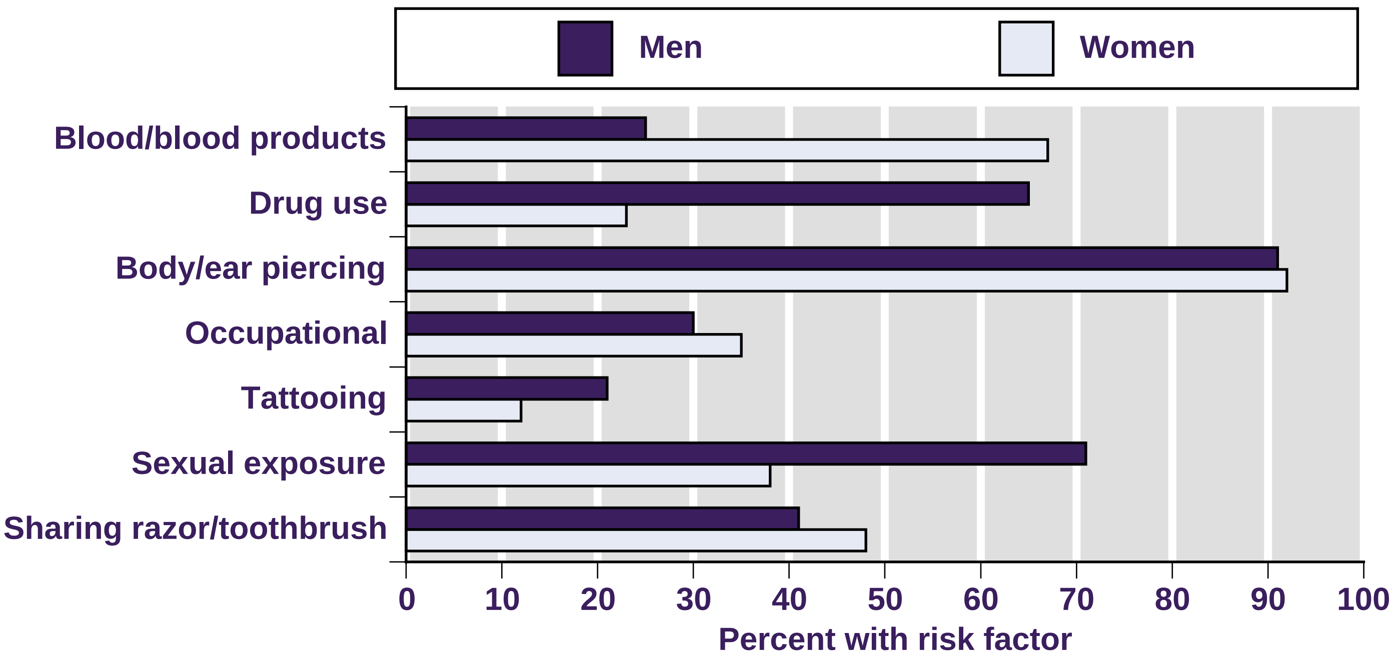
Vaccination against HBV should nortmally be given to all healthcare personnel in the UK, including members of emergency and rescue teams, people with haemophilia, and some other higher risk conditions or professions. In the event of a needlestick injury vaccination and immunoglobulin should be used, though local guidelines may vary.

### Hepatitis C

HCV was only identified in 1988, and has since been found to be responsible for the majority of post-transfusion hepatitis. In healthy blood donors the rate of infection is about 0.02% in northern Europe, but 6% in Africa and as high as 19% in Egypt and parts of Africa. Incidence is high in intravenous drug users and people with haemophilia because transmission is through blood or blood products, and with vertical transmission from mother to child. Seroconversion after a needlestick with contaminated blood is estimated at 1-10%.

Infection is mostly asymptomatic, with 1 in 109 infected people having an influenza-like illness with jaundice. Most patients are detected when they present many years later with chronic liver disease, with occures in about half of infected patients, with cirrhosis and liver cancer being common.

**Figure 2: Risk factors associated with hHCV infection in men and women in the USA**



Determining the actual prevalence of HCV infection and liver disease depends upon good epidemiology. For instance, a survey of 4,820 employees of a telephone company in Italy [27]found that about 2% tested positive and were viraemic, and this degree of prevalence is not insignificant.

In case of needlestick injury, antiviral agents may be given, but there is no good evidence that they prevent infection. HCV infection in a healthacre worker may result in loss of emplyoment because of the risk of transmission of HCV to unifected patients. These risks are not negligible, and have been estimated at 50% liklihood of one patient being infected in 5,000 procedures carried out by an HCV infected surgeon over 10 years [28].

## HIV and AIDS

There are about 35 million known cases in the world, but it is commonly recognised that this is likely to be a gross underestimate. Many cases are in Africa, where prevalence can be very high, 26% in the example from Uganda [3]. Other areas with high prevalence include parts of Asia, and parts of western countries where needle-sharing or sexual practices increase the risk. Vertical transmission from mother to baby is high, unless specific treatments are instituted. Seroconversion after a needlestick with contaminated blood is estimated at 0.1-0.3%.

Most HIV seroconversions are clinically silent, though some might be associated with short self-limiting illness. After a symptom free period which is often many years in otherwise healthy individuals, symptomatic HIV infection is associated with increasing viral load and failure of the immune system. Problems can be many.

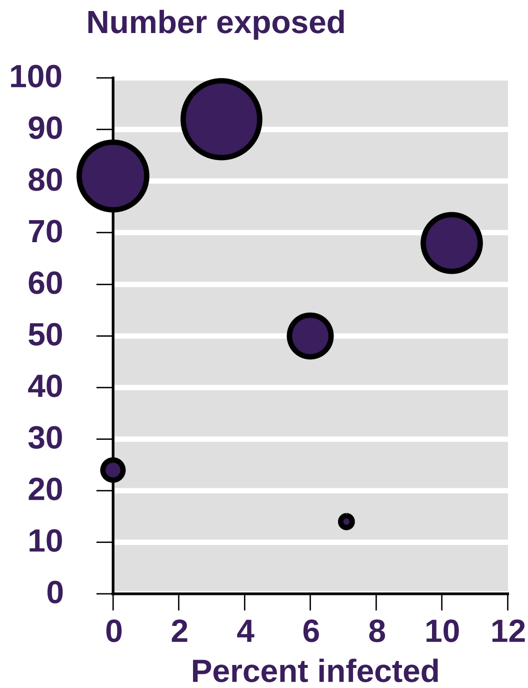
After needlestick exposure from known (or suspected) HIV-infected material, antiviral agents are now commonly used and probably this does reduce infection. Treatment with two or even three antiviral agents is likely, though practice is different in different establishments.

## Studies on needlestick infection prevention

### HCV

An interesting case presentation of needlestick transmission of hepatitis C with a review of some aspects of transmission and treatment [29] is worth a read. It includes data on transmission rates from a review of hepatitis C transmission studies.

**Figure 3: HCV transmission studies**




The authors found five studies documenting the transmission of hepatitis C to healthcare workers. Two were from Japan, and one each from the United States, Spain and Kuwait. An additional study was in Taiwan. In all there were 329 exposed persons, and the overall transmission rate was 4.3%. The variability in studies, with transmission rates between 0% and 10%, is shown in Figure 3.

### HIV

A case-control study examined case patients who were healthcare workers with a documented occupational, percutaneous exposure to HIV-infected blood by a needlestick or cut with a sharp object [30]. HIV conversion had to be temporally related to the injury, and with no concurrent exposure. Control subjects were workers with documented occupational, percutaneous exposure to HIV-infected blood who were seronegative at least six months after exposure.

There were 33 case patients and 679 controls from the USA, France, UK and Italy. Thirty of the 33 injuries were needlesticks with hollow bore needles. A similar proportion (91%) of injuries to controls were needlesticks, again mostly with hollow bore needles.

**Figure 4: Odds ratio for risk factor for HIV seroonversion**

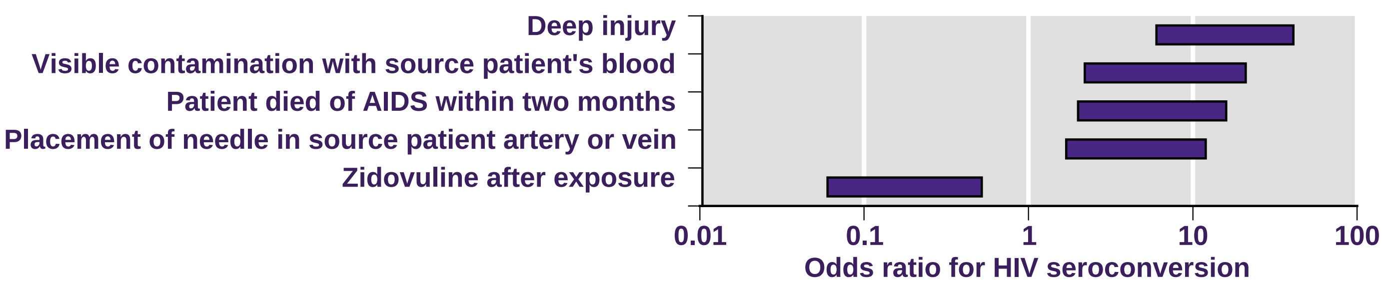


**Table 6: Percent of patients with risk factors**

| Risk factor | Percent of cases | Percent of controls |
|---|---|---|
| Large gauge hollow bore needle | 15 | 1 |
| Deep injury | 52 | 7 |
| Visible blood | 84 | 35 |
| Needle in artery or vein | 73 | 31 |
| Emergency procedure | 12 | 2 |
| Use of gloves | 78 | 78 |
| AIDS in source patient | 82 | 70 |
| Terminal illness in source patient | 48 | 16 |
| Postexposure use of zidovudine | 27 | 36 |

Using logistic-regression analysis, the 95% confidence intervals for odds ratio for the odds of seroconversion after exposure in workers with the risk factor compared with those without it are shown in Figure 4. Seroconversion was more likely to accompany deep injury (OR = 15), visible blood on the device (OR = 6), procedure involving needle in artery or vein (OR = 4), death of source patient with AIDS within two months (OR = 6). Patients who seroconverted were less likely to have used zidovudine after exposure (OR = 0.2). The percentages of case and control patients with risk factors is shown in Table 6.

## Who gets antiviral prophylaxis?

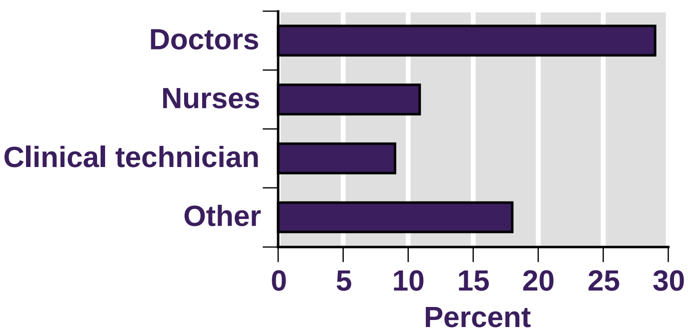
To respond to guidance about bloodborne HIV infection, a protocol was drafted with input from all stakeholders for provision of a 24-hour immediate evaluation of blood borne pathogen exposure [31]. Instruction sheets were developed, education sessions held, and special laboratory requests implemented to ensure confidentiality of results and to streamline follow ups. Initial prescriptions were made available for a 96-hour supply of antiretroviral medication while results from laboratories were awaited.

Extensive efforts were made to track each potential blood borne pathogen exposure, and to collect data. Job titles were classified into 12 occupational categories.

### Injuries

Over 18 months there were 639 potential exposures. Of these 284 (44%) occurred in nurses, 138 (22%) in doctors, 148 (22%) in clinical technicians and the remainder in housekeeping and other staff.

**Figure 5: Acceptance of post exposure prophylaxis by job category**




Most of the exposures (62%) involved hollow bore needles.

The HIV status was known to be positive in 7%, negative in 63% and was unknown in 30%. HIV positive tests were found in 0.15% of exposed workers.

Hepatitis C was positive in 4.8% of source patients, and 1% of exposed workers.

### Prophylaxis

Post-exposure prophylaxis for HIV was taken by 82 individuals (13%). Two thirds of these took the medications for less than 96 hours. Ten completed the full four week course. Reasons for discontinuation included confirmation that the source patient tested negative for HIV (65%), gastrointestinal adverse effects (13%), headache (4%) and personal decision after counselling in 18%.

Prophylaxis was accepted more in men than women, and more in doctors than nurses or clinical technicians, and when the source patient was known to have tested positive for HIV. Twenty nine workers did not accept prophylaxis even when the source patients tested positive for HIV.

Post-exposure prophylaxis by main worker category is shown in Figure 5. Prophylaxis was much more accepted by doctors and other grades than by nurses and clinical technicians. For exposure involving hepatitis C positive source patients, 26% accepted post exposure prophylaxis.

## Intermediate thoughts

This is perhaps a suitable place to take a moment to sum up what we know so far about needlestick injuries in the form of a few bullet points:

- ♦ Needlestick injuries are common.
- ♦ Needlestick injuries affect some people more than others: nurses are the largest single group, and have high rates of injury.
- ♦ Over a lifetime, the risk for an individual is finite and measurable. In some high risk specialties the risk is appreciable.
- ♦ The risk to institutions is also high.
- ♦ The risk is one of transmission of bloodborne viruses, HBV, HCV and HIV being the most important.
- ♦ The risk is dependent on the prevalence of the viruses in the population.
- ♦ The risk is dependent on the transmission rate - higher with HBV and HCV than HIV.
- ♦ Hollow bore needles with appreciable amounts of blood (and virus) carry the most risk.
- ♦ Prophylaxis and vaccination may help in some cases.

The next part of this essay turns to those things that can help reduce needlestick injuries.

# Preventing needlestick injuries

What strategies can be employed to reduce needlestick injuries? The ones we have come down to education of healthcare professionals in the risks and how to avoid them, to better provision of waste management, and to safer devices relating to hollow bore needles. The first place to look is for a systematic review, and there is one [32].

## Systematic review

A Cochrane search strategy was used looking at four electronic databases for randomised trials with the following inclusion criteria:

- Intervention to reduce needlestick injuries was evaluated in a defined population.
- Randomised study with appropriate comparison group.
- Outcomes were objectively measured with interpretable data.

Eleven studies were found. Four examined use of double gloves, three blunt suture needles, two evaluated safety devices, like needleless IV systems, and two surgical techniques.

### Double gloves

Three studies had a significant reduction, but one had a nonsignificant increase in glove perforations, while reducing hand contamination for surgeons.

### Blunt suture needles

Three studies with 1,054 individuals showed that blunt suture needles reduced needlesticks from an average of 18% to 6%, with a relative risk of 0.34 (0.23 to 0.49). The number needed to treat to prevent one needlestick with blunt rather than standard suture needles was 8 (6 to 12).

### Other interventions

The use of needleless IV systems in two studies produced lower rates of needlestick injuries.

Randomised studies may well not be the only way to examine the effect of safety devices or techniques on needlestick injuries. There are several reasons why this may be so, including the possible imposition of conditions that are not like normal, limiting applicability, and because the rates of needlestick are sufficiently low to warrant very large numbers. The studies in this review all chose high risk situations, and demonstrated that safety devices could reduce needlestick injuries.

For these and other reasons, ***Bandolier*** has chosen some more recent studies examining interventions to reduce needlestick injuries.

# Education and training

## Universal precautions

At the Clinical Centre at the National Institutes of Health in Bethesda an intensive training programme began in late 1987, with initial training efforts continuing for about a year, involving the use of universal precautions when handling body fluids [33]. New employees also go through the training programme.

The programme uses video and interactive sessions, stressing the need to report all injuries, and the availability of chemoprophylaxis. A computerised database of occupational injuries, including percutaneous and needlestick injuries involving blood or body fluids has been maintained since 1984.

In the years after the intervention, the number of needlestick injuries fell in absolute terms (from a peak of 170 in 1988 to 110 in 1991), despite a growth in workload and personnel (Figure 6). Most needlesticks occurred in nurses, and it was in nurses that the largest fall in absolute numbers of needlestick injuries was seen, from about 60 to 11 per year. Other falls were seen in housekeeping staff and phlebotomists. Although much lower, these fell almost to zero. Injuries to physicians and laboratory technicians were not much affected.

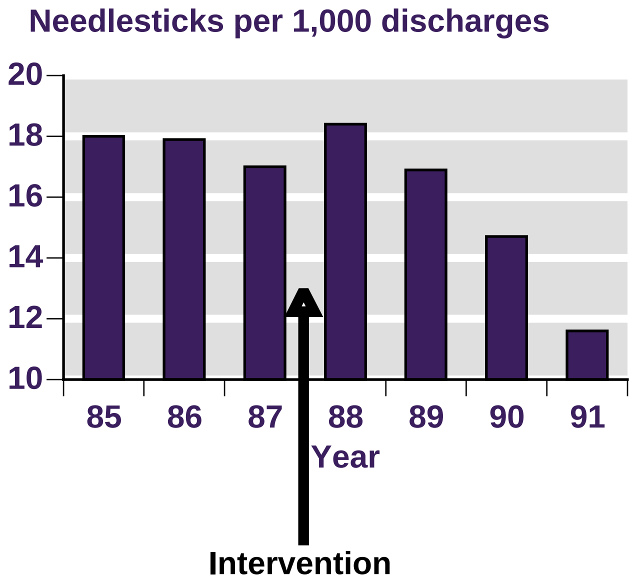
Most injuries occurred during manipulation of intravenous catheters, or recapping needles or disassembling syringes.

## Improving sharps disposal

This study [34] used the plan-do-study-act (PDSA) approach to reducing sharps injuries by introducing improved sharps containers at a hospital in Tennessee.

- The planning stage involved available sharps containers, choosing one on various grounds, presenting it to

**Figure 6: Effect of training about universal precautions on needlestick injury rate**



management, trialling in key area, and then adjusted decisions based on experience and information.

- The doing stage involved introduction of the chosen "letter-box" containers throughout the centre, with problem solving to ensure swift and effective change.
- The study stage involved evaluation, including complaints or suggestions from staff using a special telephone number. This highlighted a number of problems.
- These were acted upon with the container manufacturer to redesign the boxes to eliminate the problems.

This was followed by a second cycle to measure injury rates and staff satisfaction.

In the period before the introduction of the new disposal system the injury rate from disposal of needles was 24 a year. In the period after their introduction it was 14 a year, despite an increase of over 10% in the workforce.

The increased acquisition cost of the new boxes was $10,000 a year. Estimated savings from reduced testing and prophylaxis against hepatitis and HIV infection was $72,000 a year, making a saving of $62,000 a year. Cost of employee days lost from work were not included in the cost calculation.

## Training student nurses

Two of three classes of student nurses who had completed three years of academic work and three months of clinical practice were randomised to receive standard education or an educational intervention [35]. The standard intervention was brief instruction on vaccination against hepatitis B. The educational intervention included a 60 minute lecture and 20 minute video with teaching aids and printing material covering a wide range of issues. It emphasised the prevention of needlestick injuries.

A self-administered questionnaire on universal precautions and professional behaviour was used at the start, and after four months. It measured knowledge and behaviour. Adherence to universal precautions was documented using an observational checklist looking at handwashing, wearing gloves and handling needles. Details of needlestick injuries were collected using forms available in the clinical areas where students worked.

There were 56 student nurses in the education group and 50 in the control. Their average age was 19 years (range 16 to 21 years). Most had been or were being vaccinated against hepatitis B, while 21% were not vaccinated. The response rate for return of questionnaires was 86%.

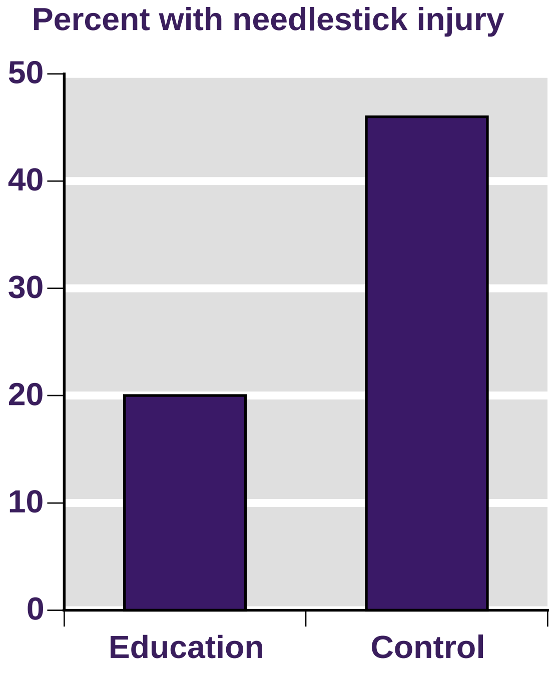
### Questionnaire

Knowledge and behaviour scores were quite high at baseline in both groups. At four months the results were significantly higher in the education group.

### Needlestick

Direct observations were carried out on a subset of 38 student nurses for 30 minutes four months after the intervention. While not statistically significant, the pattern was one of improved and safer behaviour in those nurses given the intervention. There were 50 needlestick injuries over four months, a rate of 1.4 per student nurse per year. Three-quarters involved hollow bore needles. There were significantly fewer needlestick injuries among nurses who received the educational intervention (Figure 7).

**Figure 7: Percent with needlestick injuries over four months**




## Comprehensive programme

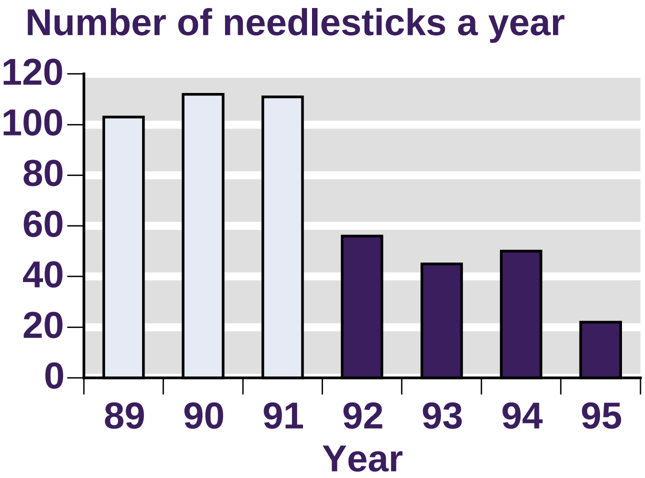
This study [36] was of a pre-post design in a 350-bed acute hospital in the USA, with 1,500 healthcare workers, excluding doctors. In 1991 a needlestick prevention committee was formed. It was multidisciplinary and instituted the following actions in 1991:

- Education and awareness programme (lectures, videotapes, handouts)
- Needlestick and bloodborne infection education through handouts, buttons, posters
- Needlestick hotline installed
- Recapping and resheathing discouraged
- Help to be used for uncooperative patients
- Environmental services began to use heavy gloves
- Proper disposal reinforced
- New arrangements for sharps disposal to avoid overfilled boxes

In 1991/2 safe needle devices were evaluated and implementation begun.

There was intensive education on prevention, coupled with an active awareness programme whenever a new device was introduced to assist staff with changes. Compliance was monitored and corrective action taken in the case of noncompliance. Progressive disciplinary action was taken in the case of continued noncompliance.

**Figure 8: Needlestick injuries before and after a prevention programme (light before, dark after programme began)**




An infection control coordinator and employee health nurse reviewed all needlestick injury reports from 1989 to 1995.

In the three years before the programme the number of needlestick injuries reported was 103-112 per year. In the fourth year after the start of the programme it was 22 (Figure 8). Dramatic falls were seen in some scenarios, like recapping needles, or from overfilled sharps boxes.

## Multifocused intervention

A 450 bed acute care hospital in Washington, DC, was the site of this study [37]. A task force charged with developing a comprehensive programme to reduce needlestick injuries produced recommendations that were implemented during the calender year of 1992.

The intervention consisted of the introduction of needless systems for intravenous therapy and a new sharps disposal system. The disposal system consisted of new, wide-mouthed containers, together with a new system of changing the containers on a regular basis, and before they were full. In addition there was:

- an intensive educational effort with mandatory annual training in general infection control and sharps injury prevention.
- employee health programmes were enhanced and expanded.
- the injury reporting process was improved and employee issues addressed.

The safety programme became an important management tool, and the use of safety procedures and compliance with them were built into employee and manager performance evaluations.

Sharps injury data were collected from 1990 to 1998, a period when reporting was mandatory, with incentives to encourage reporting. A questionnaire was used to elicit information about the cause and nature of the injury. Information reported was on all personnel other than doctors.

The incidence of sharps injuries declined over the period, from 82/1,000 whole time equivalent employees in the preintervention period of 1990-1991, to 24 per 1,000 in the period 1997-1998 (Figure 9). This represents a 69% reduc-

**Figure 9: Rate of sharps injuries before ((pale fill) and after (dark fill) the introduction of a multifocused intervention**

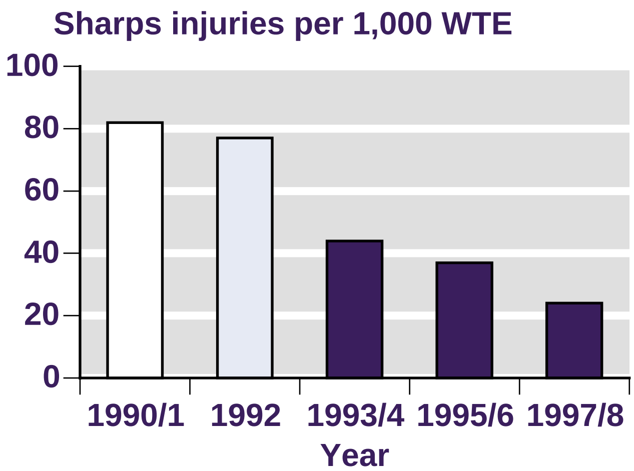
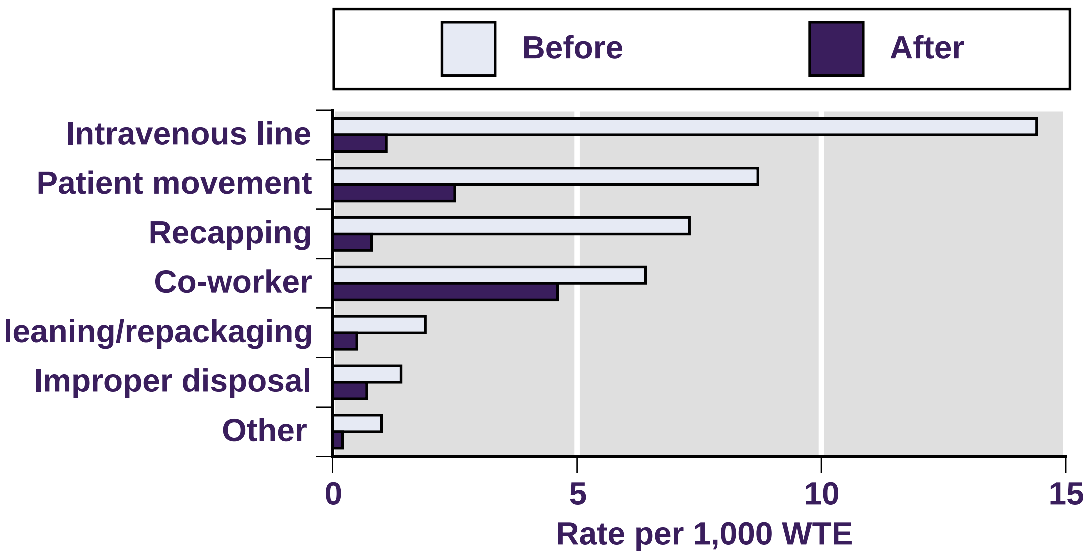



**Figure 10: Factors related to sharps injuries in the period before and the latest after the intervention**



tion in needlestick injuries over seven years. Throughout the period the most common type of sharp involved in injury was hollow bore needles, usually accounting for over two-thirds of cases.

There were dramatic changes in the factors related to needlestick injuries comparing the 1990-1991 preintervention period with the latest postintervention period of 1997-1998 (Figure 10). Only for injuries caused by co-workers was there no reduction in injury rates.

## Comment

This last is an interesting and important study. It was probably begun as an idea back in about 1990, well over a decade ago, and before the issue was raising as much attention as it does today.

The results were very good, with a very large reduction in sharps injuries. Other benefits were also seen, like an increase in appropriate glove use in exposed workers, from 50% in 1990 to 81% in 1998. Improved compliance with occupational and other safety standards were also documented.

All these studies emphasise that there are no quick fixes. Yes, some benefits can be immediate, but in the longer term, as more people become "sold" on the programme, and as it matures (with the annual retraining included in this one), benefits continue to accrue.

There are lessons here for healthcare workers (why is this programme not being adopted in my institution?), administrators (why an I not adopting this programme in my institution?) and politicians (why on earth are we not doing this in ALL our hospitals?). These are interesting questions.

### Devices

## Phlebotomy

Six university-affiliated hospitals in the USA took part in the study over the years 1993-1995 [38]. The comparison was safety devices with conventional devices. Devices to be tested were chosen by the hospitals:

- Resheathable winged steel needle (Safety-Lok, Becton Dickinson) - six hospitals
- Bluntable vacuum tube blood collection needle (Punctur-Guard, Bio-Plexus) - three hospitals
- Vacuum tube blood collection needle with hinged recapping sheath (Venipuncture Needle-Pro, Smith Industries) - four hospitals

Before introducing safety devices each hospital conducted a comprehensive training programme.

In a first phase (average 10 months) conventional phlebotomy devices were used, with enhanced surveillance for injuries. An anonymous survey was conducted in workers regularly engaged in phlebotomy to determine rates of under-reporting, and the average number of phlebotomies done each day, and each week.

In a second phase (average duration 12 months) conventional phlebotomy devices were replaced with safety devices throughout the hospital. The supplies of phlebotomy equipment were monitored, autoclaved hospital waste was examined to determine rates of use, and the enhanced surveillance continued. The anonymous survey was repeated 1-2 months before the end of the period.

Response to the survey was 75% in 3,120 workers in the two surveys. Overall, 54% of needlestick injuries were reported, with 563 needlestick injuries in the previous year: 18% of workers had at least one needlestick injury in the previous year. Phlebotomists reported 91% of injuries, nurses 68%, medical students 35% and residents 31%.

The introduction of safety devices reduced the number of percutaneous injuries associated with phlebotomy. There was a large number of phlebotomies with conventional and safety devices, and in each case the safety device delivered statistically significant reductions in percutaneous injuries, by 23% to 76%. Uptake of the safety devices was over half in all cases, but was as high as 98% with the Venipuncture Needle-Pro. This might reflect a low rate of reporting of technical difficulties or adverse patient effects with this device.

## Haemodialysis and guarded fistula needles

Five haemodialysis clinics in the northwestern USA participated in this study [39]. They all had preexisting systems for reporting needlestick injuries, had historical data, and used unguarded arteriovenous fistula needles. Retrospective data were collected for 15 months before introducing guarded arteriovenous fistula needles, from January 1999.

After their introduction, information was collected prospectively. Only one design of guarded arteriovenous fistula needles was used, and unguarded needles were prohibited.

During the retrospective period healthcare workers were trained in the clinic's needlestick injury and reporting policy. On the introduction of the guarded arteriovenous fistula needles full training was given, and the reporting policy reaffirmed.

Information on the number of devices used, and the number of needlestick injuries, is shown in Table 7. The number of needlestick injuries per 100,000 devices used fell from 8.6 to zero.

**Table 7: Needlestick injuries with unguarded and guarded arteriovenous fistula needles**

| Device | Number used | Needlestick injuries | Rate per 100,000 |
|---|---|---|---|
| Unguarded | 81,534 | 7 | 8.6 |
| Guarded | 54,044 | 0 | 0 |

## Intravenous cannula safety device

This study of an intravenous cannula safety device [40] randomised patients scheduled for elective surgery in whom an intravenous infusion was needed to a conventional intravenous cannula (Insyte) or a safety cannula (Insyte Auto Guard). Exclusions were patients with blood-borne infections, bleeding disorder, or pathology of hand or arm.

Outcomes were insertion attempts, ease of insertion (using a VAS), needlestick injury, or blood contamination on patient or tray.

Fifty patients in each group (average age about 50 years) were recruited. There was no difference in ease of inserting the devices, but the safety device was scored as being significantly easier to handle.

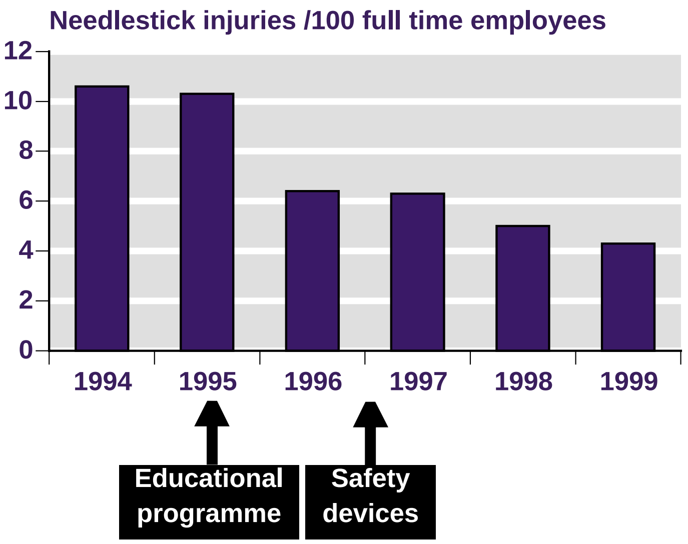
There were no needlestick injuries. Blood contamination for staff, patients or equipment was the same in both groups (7 and 5 out of 50), but tray contamination occurred in 39/50 with the conventional device and 0/50 with the safety device.

### Long-term controls

An 800-bed hospital serving a major metropolitan area in Texas was the study site [41]. In 1995 it implemented an extensive in-service educational programme to inform all hospital employees of the importance of needlestick safety and bloodborne pathogens. Over six months in 1997 it implemented hospital-wide use of safety syringes and needleless intravenous system in all departments, except in cases where the use of traditional needles was unavoidable.

Retrospectively injury reports to an occupational health clinic between 1994 and 1999 were examined. Results from physicians were excluded for legal reasons. Results were reported on the basis of needlestick injuries per 100 full time employees (all types and grades), and over the period the number of full time employees rose from 945 to 1508.

**Figure 11: Change in incidence of needlestick injuries over a six year period**




There were 550 injuries, and excluding physicians 533 remained for analysis. Of these, 474 (89%) were from needle-related devices, but the proportion from traditional or safety devices had not been recorded.

Over the six years incidence fell from over 10% to just 4% (Figure 11). The absolute number per year fell from about 100 in each of the first two years to 63 in 1999.

## Comment

This last ecological study does not clearly relate the fall in needlestick injury to any particular intervention. It might be seen as being important for educational interventions and for the introduction of safety devices, because both probably contributed, and other studies show that both types of intervention have an effect.

Following both together there was a fall in needlestick incidence, and that fall continued and was sustained. This happened despite a large increase in full time equivalents over the same period, while the absolute number of needlestick injuries fell. The overall message of these studies of implementing strategies to reduce needlestick injuries is that they worked.

What is needed for the future are more studies examining components of educational interventions and partcular types of device, and, most important, pulling this all together in programmes that can be instituted to reduce needlestick injuries, perhaps by half in a short time.

Workplace problems can exacerbate needlestick injury rates, as a report of a survey done in 1991 of nurses working on 40 inpatient units in 20 general hospitals in 11 cities in the USA shows [42]. A retrospective survey of 865 nurses asked about needlestick injuries and near misses in the previous month and year. Prospective information was also collected at the end of each shift over two one-month periods in 1990 and 1991, with data from 12,349 shifts by 962 regular and temporary nursing staff. Measures examined included:

- Exposure to contaminated sharps
- Staffing data
- Resource adequacy and nurse manager leadership
- Emotional exhaustion
- Risk factors

In the retrospective study 34 of 789 (4.3%) nurses reported a needlestick injury in the previous month. Of 962 nurses reporting on at least one shift in the prospective part 53 (5.5%) reported a needlestick or sharp injury involving blood contamination, and 228 (24%) reported a near miss.

Nurses working in hospital units with poor work climates and lower staffing levels were more likely to report the presence of risk factors. Nurses with less adequate resources, lower staffing and less nurse leadership with higher levels of emotional exhaustion were typically twice as likely to report the presence of risks. Needlestick injuries were nearly three times higher when these factors were present, compared to when they were absent.

# HEATH ECONOMICS OF NEEDLESTICK INJURIES

There is not a huge literature on this topic. There should be, because what we have suggests that reducing needlestick injuries could save money for healthcare systems, at the same time as improving safety for employees and patients. The best analysis we have is from the General Accounting Office of the USA (links on page 2).

It first reviews data from the CDC on needlestick injuries in the USA, and how safety devices and other interventions may affect this number.

## Baseline data

Data for the USA is captured from 45 EPINet hospitals. The estimate of percutaneous injuries and blood and body fluid exposures in one year (based on 1996 data) was calculated as follows:

- 30 injuries per 100 occupied hospital beds reported (from our national EPINet data for 1996)
- 600,000 occupied hospital beds in the USA
- 180,000 injuries in one year reported in hospitals (0.3 x 600,000)
- 39% of incidents not reported (according to surveys conducted in 6 EPINet hospitals in 1996-1997) = 295,082 injuries occurred in hospitals
- double this figure because 50% of health care workers work outside of hospital settings (total = 590,164 percutaneous injuries)
- according to EPINet data for 1996, an additional 1/3 of reported exposures involve skin/non-intact skin or mucous membrane contact with blood or at-risk biological substances which can also transmit HIV, HBV, HCV (total = 196,721 mucocutaneous exposures)

Thus the total annual percutaneous and mucocutaneous exposures to blood or at-risk biological substances in the USA in 1996 = 786,885.

In an updated report (Advances in Exposure Prevention, 2000 5: 19), the CDC increased the estimate of annual percutaneous injuries for healthcare workers in hospitals to 384,325.

### Occupational infections

Based on transmission rates of 0.2-0.4% for HIV, 6-30% for HBV and 0.4-1.8% for HCV, the calculations for occupational infection are:

- The CDC estimates that 400 new occupational HBV infections occurred in 1995 among US health care workers, down from 17,000 in 1983. (Arch Intern Med 1997;157:2601-2603)
- Assuming that between 1% and 2% of patients are HIV-positive (and therefore that 1% to 2% of needlesticks are HIV-contaminated) between 18 to 35 new occupational HIV infections would occur from percutaneous injuries each year. Infections resulting from blood exposures to non-intact skin or mucous membranes would add between 2 to 4 cases (based on a transmission rate of .09% for a mucous membrane exposure).
- Assuming that between 2% and 10% of patients are HCV-positive, between 59 to 1,180 new occupational HCV infections would occur each year. Infections resulting from blood exposures to non-intact skin or mucous membranes would add between 16 to 393 cases (assuming that the transmission rate was between 0.4% and 1.8% per exposure).

## Preventable needlesticks

The number of percutaneous injuries caused by needles each year in hospital workers in the USA is estimated at 384,000, with about 236,000 arising from hollow bore needles. Most injuries occur after the device has been used and therefore exposed to potentially contaminated blood.

About a quarter of the needlesticks occur during use of a needle in a patient, for instance on insertion or withdrawal, or with sudden patient movement. These are probably not preventable with safety devices.

## Safer technology

Hospitals using needles with safety features are reducing the number of needlestick and other types of percutaneous injury. Training and education help, as do safer working practices.

The weight of evidence for needlestick reductions with new devices is not exhaustive, but, for instance, a CDC study on use of safer devices for phlebotomy over about six million phlebotomies showed a substantial fall in needlestick rates. Safer devices, though, are not suitable for every occasion, and cost and resistance to change can limit their effectiveness.

## Reduction of needlestick injuries in hospitals

The General Accounting Office believe that about 29% of needlesticks in hospitals (69,000 injuries a year) can be prevented by safer devices, and that a further 109,000 by eliminating use of unnecessary needles, education and safer working practices (Table 8).

**Table 8: Annual preventable needlesticks in hospitals in the USA**

| | Number | Percent |
|---|---|---|
| Annual number of needlesticks | 236,000 | 100 |
| Not currently preventable | 59,000 | 25 |
| Preventable needlesticks | 177,000 | 75 |
| **Using safety devices** | **69,000** | **29** |
| **Eliminating unnecessary use** | **58,000** | **25** |
| **Using safer work practices** | **51,000** | **21** |

**Table 9: Annual use of needles in hospitals in the USA**

| Needle type | Number used each year | Number per hospital bed |
|---|---|---|
| Hypodermic needle/syringe | 367,000,000 | 367 |
| Vacuum blood collection tube | 217,000,000 | 217 |
| IV catheter | 111,000,000 | 111 |
| Winged-steel needle | 56,000,000 | 56 |

## Number of needles used

The GAO estimates for the number of needles and types used in hospitals in the USA every year is shown in Table 9. The estimates for the additional costs of purchasing this number of safety devices ranged from $70 million to $352 million per year.

## Reducing occupational infections in hospitals

Preventing needlestick injuries in turn prevents occupational exposure to bloodborne diseases, and consequent infection of hospital workers. Using information collected in the USA, the number of preventable HBV and HCV infections in a year in hospitals in the USA is 65 and 42 cases respectively (Table 10).

## Cost of treating workers injured by needlesticks

The costs of postexposure treatment vary widely, and depend on the situation. Estimates for postexposure treatment run from $500 to $3,000 per injury sustained. Using three levels of assumed cost of $500, $1,500 and $2,500, the GAO estimate for treating needlestick injuries in hospitals in the USA every year was between $37 million and $173 million per year.

This did not include longer term costs, which are potentially significant. The cost of treating a person with HIV has been estimated at about $25,000 a year. No account was taken for any legal costs for negligence, nor any compensation for lost employment or other damages.

These longer term costs could be substantial, and add significantly to the costs of immediate care.

**Table 10: Projected number of HBV and HCV infections from needlesticks avoided in one year**

| Mode of prevention | HBV | HCV |
|---|---|---|
| Using safety devices | 25 | 16 |
| Eliminating unnecessary use | 21 | 14 |
| Using safer work practices | 19 | 12 |

**Table 11: Computation of range of costs and benefits for safety needles in US hospitals**

| Safety vs conventional needles | Cost of postexposure treatment | | |
|---|---|---|---|
| | $500 | $1,500 | $2,500 |
| 1.5 x more costly | -47 | **21** | **90** |
| 2.5 x more costly | -129 | -60 | **9** |
| 3.5 x more costly | -374 | -306 | -237 |

Shaded areas show where benefits exceed costs

## Costs and benefits

Within the background set out, the cost and benefit scenarios with different scenarios for postexposure prophylaxis treatment costs, and different scenarios for cost of safety devices (from 1.5 times to 3.5 times more expensive than conventional needles) are set out in Table 11.

Scenarios with higher costs of safety relative to conventional needles, and lower costs for postexposure treatment, are generally more costly.

Scenarios with lower relative costs between safety and conventional devices and higher costs of postexposure treatment are generally cost saving.

In this computation, no allowance was made for the possible longer term costs, and costs of litigation or compensation, which might be expected to balance the cost argument more towards the use of safety devices.

## Comment

The GAO has drawn together available information that could inform the argument about the benefits and costs of safer needles, and has produced a balanced report within the limits of that information. In its pages it gives the assumptions behind the costs it assumes, so that even with a little brain we can follow their argument.

The results are balanced. The range of possibilities encompasses a cost to US hospitals of $374 million a year to a saving of $90 million a year. That is either a lot of money, or no big deal, depending where one stands. But increased use of safety devices should drive costs down (or else purchasing managers are not doing their job), and the longer-term costs omitted in the calculation favour a cost saving scenario.

And there are the people. Modern healthcare is stressed enough, so reducing one more risk would be a real benefit to individuals as well as workers.

Many countries will probably take a narrower and more jaundiced view, focussing on increased acquisition costs and forgetting the benefits, because that's someone else's budget. We shouldn't.

# References

1 J Perry et al. EPINet report: 2001 percutaneous injury rates. Advances in Exposure Prevention 2003 6: 3: 33-36.

2 ZA Memish et al. Epidemiology of needlestick and sharps injuries in a tertiary care center in Saudi Arabia. American Journal of Infection Control 2002 30: 234-241.

3 DH Newsom, JP Kiwanuka. Needle-stick injuries in an Ugandan teaching hospital. Annals of Tropical Medicine & Parasitology 2002 96: 517-522.

4 J Shiao et al. Estimation of the risk of bloodborne pathogens to health care workers after a needlestick injury in Taiwan. American Journal of Infection Control 2002 30: 15-20.

5 HA Abu-Gad & KA Al-Turki. Some epidemiological aspects of needle stick injuries among the hospital health care workers: Eastern province, Saudi Arabia. European Journal of Epidemiology 2001 17: 401-407.

6 AS Karstaedt, L Pantanowitz. Occupational exposure of interns to blood in an area of high HIV seroprevalence. South African Medical Journal 2001 91: 57-61.

7 V Puro et al. Risk of exposure to bloodborne infection for Italian healthcare workers, by job category and work area. Infection Control and Hospital Epidemiology 2001 22: 206-210.

8 AJ Alzahrani et al. Needlestick injuries and hepatitis B virus vaccination in health care workers. Communicable Disease and Public Health 2000 3: 217-218.

9 G Moens et al. Prevalence of hepatitis C antibodies in a large sample of Belgian healthcare workers. Infection Control and Hospital Epidemiology 2000 21: 209-212.

10 M Varma, G Mehta. Needle stick injuries among medical students. Journal of the Indian Medical Association 2000 98: 436-438.

11 PC Cassina et al. The real incidence of percutaneous injuries in the operating room - a prospective study. Swiss Surgery 1999 5: 27-32.

12 TC Goob et al. Bloodborne exposures at a United States army medical centre. Applied Occupational and Environmental Hygeine 1999 14: 20-25.

13 G Ippolito et al. Surveillance of occupational exposure to bloodborne pathogens in health care workers: the Italian national experience. Eurosurveillance 1999 4: 33-36.

14 CH Lee. Occupational exposures to blood among emergency medicine residents. Academic Emergency Medicine 1999 6: 1036-1043.

15 C Shen et al. Risk of needle stick and sharp object injuries among medical students. American Journal of Infection Control 1999 27: 435-437.

16 HJ Wise, RN McCormick. Re-enforcing hygiene practices of anaesthetists. Anaesthesia 1999 54: 1220-1221.

17 VM Knight, NJ Bodsworth. Perceptions and practice of universal blood and body fluid precautions by registered nurses at a major Sydney teaching hospital. Journal of Advanced Nursing 1998 27: 746-751.

18 B Gumodoka et al. Occupational exposure to the risk of HIV infection among health care workers in Mwanza region, United Republic of Tanzania. Bulletin of the WHO 1997 75: 133-140.

19 F Resnic, MA Noerdlinger. Occupational exposure among medical students and house staff at a New York City medical center. Archives of Internal Medicine 1995 155: 75-80.

20 J Smedley et al. Management of sharps injuries and contamination incidents in health care workers: an audit in the Wessex and Oxford regions. Occupational Medicine 1995 45: 273-275.

21 HP Chia et al. A study of needle-stick injuries among house officers in a major hospital. Singapore Medical Journal 1994 35: 41-43.

22 JL Stotka et al. An analysis of blood and body fluid exposures sustained by house officers, medical students, and nursing personnel on acute-care general medical wards: a prospective study. Infection Control and Hospital Epidemiology 1991 12: 583-590.

23 RD McCormick et al. Epidemiology of hospital sharps injuries: a 14-year prospective study in the pre-AIDs and AIDs eras. American Journal of Medicine 1991 91: 301S-307S.

24 A McGeer et al. Epidemiology of needlestick injuries in house officers. Journal of Infectious diseases 1990 162: 961-964.

25 J-L Caillot et al. The occupational viral risk run by French surgeons: a disturbing perspective. AIDS 2000 14: 2061-2062.

26 LJ Yee et al. Risk factors for acquisition of hepatitis C virus infection: a case series and potential implication for disease surveillance. BMC Infectious Diseases 2001 1: 8 (www.biomedcentral.com/1471-2334/1/8).

27 A Alberti et al. Prevalence of liver disease in a population of asymptomatic persons with hepatitis C virus infection. Annals of Internal Medicine 2002 137: 961-964.

28 SS Ross et al. Risk of hepatitis C transmission from infected medical staff to patients. Archives of Internal Medicine 2000 160: 2313-2316.

28 MS Sulkowski et al. Needlestick transmission of hepatitis C. JAMA 2002 287: 2406-2413.

29 DN Irish et al. Identification of hepatitis C seroconversion resulting from nosocomial transmission on a haemodialysis unit: implications for infection control and laboratory screening. Journal of Medical Virology 1999 59: 135-140.

30 DM Cardo et al. A case-control study of HIV seroconversion in health care workers after percutaneous exposure. New England Journal of Medicine 1997 337: 1485-90.

31 M Russi et al. Antiretroviral prophylaxis of health care workers at two urban medical centres. Journal of Occupational and Environmental Medicine 2000 42: 1092-1100.

32 B Rogers, L Goodno. Evaluations of interventions to prevent needlestick injuries in health care occupations. American Journal of Preventive Medicine 2000 18 (4S): 90-98.

33 SE Beekmann et al. Temporal association between implementation of universal precautions and a sustained, progressive decrease in percutaneous exposures to blood. Clinical Infectious Diseases 1994 18: 562-569.
34 IB Hatcher. Reducing sharps injuries among health care workers. A sharps container quality improvement project. Joint Commission Journal of Quality Improvement 2002 28: 410-414.
35 H Wang et al. A training programme for prevention of occupational exposure to bloodborne pathogens: impact on knowledge, behaviour and incidence of needle stick injuries among student nurses in Changsha, People's Republic of China. Journal of Advanced Nursing 2003 41: 187-194.
36 AB Zafar et al. Effect of a comprehensive program to reduce needlestick injuries. Infection Control and Hospital Epidemiology 1997 18: 712-715.
37 R Gershon et al. The impact of multifocused interventions on sharps injury rates at an acute-care hospital. Infection Control and Hospital Epidemiology 1999 20: 806-811.
38 M Mendelson et al. Evaluation of safety devices for preventing percutaneous injuries among health-care workers during phlebotomy procedures - Minneapolis-St.Paul, New York City, and San Francisco, 1993-1995. MMWR 1997 46: 2 (Jan 17).
39 J McCleary et al. Guarded fistula needle reduces needlestick injuries in hemodialysis. Nephrology News & Issues, 2002, May: 66-72.
40 T Asai et al. Prevention of needle-stick injury. Efficacy of a safeguarded intravenous cannula. Anaesthesia 1999 54: 258-261.
41 SG Reddy, RJ Emery. Assessing the effect of long-term availability of engineering controls on needlestick injuries among health care workers: a 3-year preimplementation and postimplementation comparison. American Journal of Infection Control 2001 29: 425-427.
42 SP Clarke et al. Organizational climate, staffing, and safety equipment as predictors of needlestick injuries and near misses in hospital nurses. American Journal of Infection Control 2002 30: 207-216.

## Afterwords

This essay was written in July 2003. More information about needlestick injuries and how to prevent them will come to the fore, perhaps particularly about safety devices and their effectiveness. Though we have performed electronic searches for studies, there will be some we have not found, perhaps because they were not cited in the databases we searched, or because we could not search all databases.

Readers who know of important studies that would add to the essay, either old ones we missed, or new ones we might add, are invited to let us know by emailing bandolier@pru.ox.ac.uk.

### Acknowledgements and sponsorship

Many people have contributed to the thoughts and ideas and knowledge contained in this essay, and it has drawn on very considerable work by others. It is almost certain that some important evidence was beyond our capacity to find, and if readers know of material that might be added at a later revision, please email bandolier@pru.ox.ac.uk.

This essay was sponsored by an unconditional educational grant from Astrazeneca Limited. The original concept and ideas came from Bandolier. We thank the AstraZeneca group of companies for providing the resources to make this essay freely available through the Bandolier Internet site to anyone, anywhere, with an Internet connection. The views expressed here are those of the authors, and are not necessarily those of AstraZeneca group of companies.