Occupational Exposures to Blood in A Dental Teaching Environment: Results of a Ten-Year Surveillance Study

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Abstract: Evaluation of occupational exposures can assist with practice modifications, redesign of equipment, and targeted educational efforts. The data presented in this report has been collected as part of a ten-year surveillance program of occupational exposures to blood or other potentially infectious materials in a large dental teaching institution. From 1987 to 1997, a total of 504 percutaneous/non-intact skin and mucous membrane exposures were documented. Of these, 494 (98 percent) were percutaneous, and 10 (2 percent) were mucosal, each involving a splash to the eye of the dental care worker (DCW). Among the 504 exposures, 414 (82.1 percent) occurred among dental students, 60 (11.9 percent) among staff, and 30 (6 percent) among faculty. One hundred ninety-one (37.9 percent) exposures were superficial (no bleeding), 260 (51.6 percent) were moderate (some bleeding), and 53 (10.5 percent) were deep (heavy bleeding). Regarding the circumstances of exposure, 279 (54.5 percent) of the injuries occurred post-operatively (after the use of the device), and most were related to instrument clean-up; 210 (41.0 percent) occurred intra-operatively (during the use of the device); and 23 (4.5 percent) occurred when a DCW collided with a sharp object in the dental operatory (eight cases involved more than one circumstance). The overall exposure rate for the college was 2.46±0.11 SD per 10,000 patient visits. The average rate for the student population was 4.02±0.20 SD per 100 person-years, with the highest rates being observed among junior year students. The observed rates of occupational exposures to blood and body fluids in this report are consistent with published reports from several other educational settings. Dental teaching institutions are faced with the unique challenge of protecting the student and patient populations against bloodborne infections. Educational efforts must go beyond mere teaching of universal precautions and should include the introduction of safer products and clinical procedures that can minimize the risks associated with the hands-on aspects of the students' learning process.

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Although adherence to universal precautions and routine use of appropriate barriers provide protection against most microorganisms, health care workers (HCW) are still at risk for infections due to accidental exposures. In the dental environment, compared to many other health care settings, sharps injuries are more likely due to a small operating field, frequent patient movement, and the variety of sharp dental instruments used in everyday practice.[1] It has been established that occupational blood exposures carry a certain risk of transmission for bloodborne infections to the health care worker. The risk of HIV seroconversion following an occupational blood exposure has been estimated to be 0.2–0.3 percent for parenteral exposures and 0.1 percent or less for mucosal exposures.[2-5] The risks associated with a percutaneous exposure to the hepatitis B virus (HBV) are estimated to be 2 percent for HBeAg negative and about 30 percent for HBeAg positive blood.[2,6] The same risk has been reported as 1.8 percent for hepatitis C virus (HCV).[7-10]

Studies of HIV seroprevalence rates among dentists have established that dentistry is associated with a relatively small risk of HIV transmission (0 to 0.08 percent),[3,11,12] and to date, no dental practitioner has been documented by the Centers for Disease Control and Prevention (CDC) to have acquired HIV through an occupational contact.[13] Compared to HIV, seroprevalence studies among dentists have resulted in higher rates for serologic markers of HBV (9 percent),[14] and HCV (1.4 percent)[12] infection.

There are several published reports of occupational blood exposures in dentistry.[1,15-25] These studies vary significantly in their data collection methods, ranging from surveys of practicing dentists/dental residents and dental schools, to cross-sectional analyses of the existing surveillance records, to prospective studies of exposures. Analyses of data collected through these reports and future surveillance systems of dental occupational exposures are crucial to the development of safer dental products, practice modifications, and eventually the creation of a standardized method of data collection.

The main objective of an effective infection control program in a health care environment is to devise and implement policies and procedures that will protect both workers and patients against transmission of a variety of infectious diseases. Although the ultimate goal of such a program may be to create an environment of no risk, in reality, minimizing the risk to the extent possible is the practical goal. Medical and dental schools are faced with an even greater challenge in developing their infection control programs. These teaching institutions have not only the responsibility of protecting the patients but must also provide reasonable safety measures for the students, who have not yet mastered the technical skills necessary for their professions yet are engaged in patient-related activities. Evidence suggests that medical and dental students may be at increased risk of exposure to bloodborne infections.[19,25-29] Close observation of the students' infection control practices and studying the circumstances involved in their occupational blood/infectious body fluids exposures will lead to introduction of safer devices and work practices that will offer students the best possible protection.

In 1987, the New York University College of Dentistry (NYUCD) began to gradually develop a system of documentation, management, and follow-up of occupational exposures to blood and other potentially infectious materials (BOPIM). This surveillance system has resulted in a database consisting of 504 percutaneous and mucosal exposures involving dental students, faculty, and staff over a ten-year period. This is one of the largest databases of its kind from one institution and represents the results of a dynamic post-exposure management and infection control program. Throughout the surveillance period, the ongoing analysis of the data has been followed by appropriate interventions and risk reduction activities. Therefore, the data collection instrument, the management strategies, and the intervention programs have gradually evolved over time. Our aim in this report is to describe the experience of our institution in occupational blood exposures and to provide a comparison between our data and those published by other investigators. We also report the specific intervention activities over the project period.

Methods

The Post-Exposure Protocol

Since its inception, the post-exposure management program at NYUCD has consisted of several key elements: immediate evaluation and counseling of the exposed health care worker, investigation of the circumstances of the exposure, evaluation and/or testing of the source patient whenever possible, assessment of risk, and prophylactic measures, as well as periodic follow-up of the health care worker. According to college policy, exposures were immediately reported to the faculty Infection Control Liaison in the clinical area where the injury occurred. The faculty then supervised the appropriate wound care and initiated an immediate referral to one of the college's counselors, either the Infection Control Officer (ICO, the first author) or the Infection Control Coordinator (ICC, the second author). The counselors investigated the details of exposure and documented the results on the college's standard survey form. Based on the assessment of risk for disease transmission, the counselor proceeded to make specific recommendations for prophylactic measures and explained the rationale for these recommendations to the injured party. In all cases the injured employee/student made his or her own informed decisions.

The survey form used for the surveillance program described in this paper was initially developed in 1987. This form gradually evolved over time from a mostly narrative description of the exposure to a form with check boxes establishing the details of the exposure to a statistical program-based customized software program. Although the data collection survey form underwent transformation over the years, the type of information recorded throughout the surveillance program remained relatively constant. This was possible because for a large portion of the surveillance period, most of the data collection was accomplished by the same individuals (the first two authors of this paper). Therefore, a great deal of detail is available on each exposure even during the early years of the program. Further, reliable follow-up serologic data is available for all the exposure cases because all the bloods necessary for the serologic tests were drawn on-site, at the College of Dentistry by a licensed phlebotomist, the ICC or the ICO. The blood samples were sent directly to a contracted laboratory which reported all the results back to the ICO. In addition, to accommodate the appropriate medical intervention when necessary, a close working relationship was established with an infectious diseases specialist at Beth Israel Hospital (within walking distance from the College of Dentistry). This physician was available for immediate consultation and follow-up of all unusual exposure cases (e.g., pregnant dental care worker and high-risk source case), any source case referrals, and all the necessary follow-ups after AZT/multi-regimen prophylaxis of the dental care worker (DCW).

Several strategies were used over the years to maximize compliance with the reporting requirements. These included: a) wide dissemination of the post-exposure management protocol throughout the school in the form of clinic manuals and prominent posting in all clinical areas; b) a detailed description of the protocol during the college's mandatory annual bloodborne pathogens standard training for all faculty and staff; c) discussions with students during several infection control-related lectures and small group seminars; and d) the semi-annual infection control newsletters focussing on infectious disease-related topics.

Data Collection and Analysis

The college's standard survey form recorded the DCW's name, position title, work area, type of exposure (percutaneous, mucosal, human bite), DCW's vaccination status, the use of personal protection equipment (PPE), the circumstance of exposure, and the source case data. We base our institutional definition of an "occupational exposure" on the OSHA Bloodborne Pathogens Standard (29 CFR 1910.1030),[30] which is "a specific eye, mouth, other mucous membrane, non-intact skin, or parenteral contact with blood or other potentially infectious material that results from the performance of an employee's [student's] duties." The exposure was described in detail and included information on the depth of the stick/cut, type of instrument used, circumstances of use (intra- or post-operatively, that is during and after the use of the device, respectively), and the type of practice modification that could have prevented the injury. Data for each case was then coded, and the results tabulated and analyzed using standard statistical procedures incorporated into the SPSS/PC+ program.[31] Standard deviations were estimated from the observed number of events in each observation category, using the Poisson approximation.[32] Data on persons at risk and the number of hours of clinical activities for each position category (i.e., first- to fourth-year and postdoctoral students, faculty, staff), used as denominators in calculating rates, were obtained from the official records of the college, the rosters and registries, and was supplemented by information from the dean's office. The overall clinical hours of responsibility were computed as 333 hours per year for the second-year students, 793 hours for the third-year students, and 1,045 hours for the fourth-year students. The first-year students do not have clinical responsibilities.

Results

From 1987 to 1997, when approximately 2.05 million patient visits were made to NYUCD, a total of 504 occupational BOPIM exposures were recorded. There were relatively few exposures reported during the first two years (6.5 per year). The number of exposures (Figure 1) gradually rose for about the next five years (1989-1994), averaging 50.6 per year. During the last three years (1994-1997), the numbers were steady at 79.3 per year. During the ten-year period, a total of 14,857 person-years (one individual for one academic year) at risk was documented by the college (Tables 1 and 2). Personnel categories at the college during the ten academic years (1987-1997) are shown in Table 1.

Rates and Categories of Exposures

Occupational exposures may be broadly classified into two large groups: a) parenteral/percutaneous/non-intact skin, and b) mucous membrane exposures. Of the total 504 occupational exposures recorded, 494 (98 percent) were percutaneous and 10 (2 percent) were mucosal, each involving a splash to the eye of the DCW. The overall accidental BOPIM exposure rate/10,000 patient visits ± standard deviation (SD) was 2.46 ± 0.11. In view of the lower rate of reporting in the early years of the surveillance program, we considered exposures limited to the last

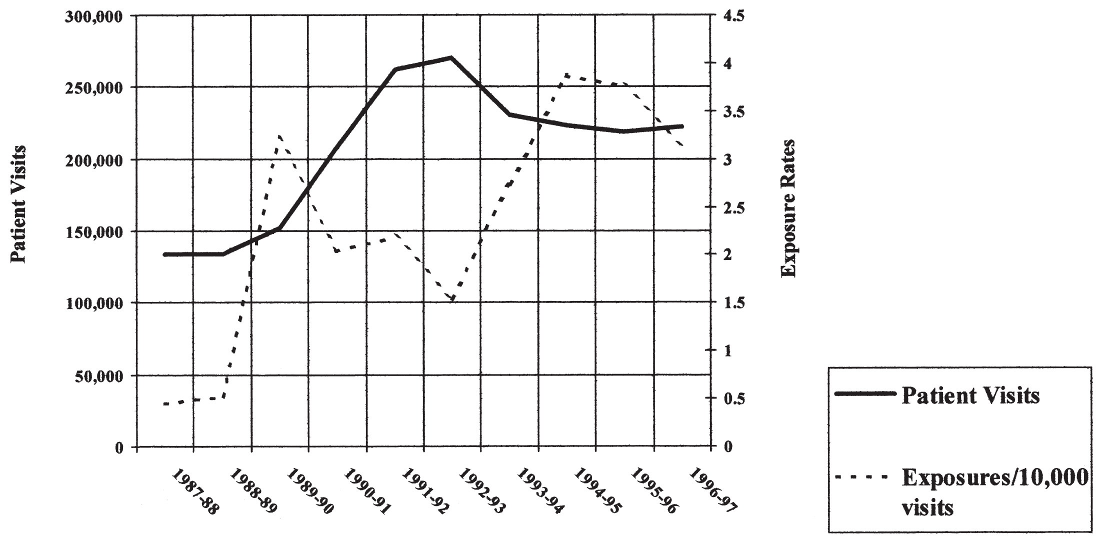

Figure 1. Annual number of patient visits and exposure rates per 10,000 visits

three years and calculated the rate. During the 1994-1997 period, the rate was shown to be 3.59 ± 0.23 per 10,000 patient visits. In order to provide comparison with other published reports, we also calculated the rates as exposures/100 person-years. The rates for the predoctoral students was shown to be 4.07 ± 0.22 /100 person-years, while the same rate for the faculty and staff was 1.97 ± 0.21 /100 person-years (Table 2). A significantly higher rate of exposures was observed for third-year students compared to fourth-year [P< .001]. Indeed fourth-year students had half the reported case rate (3.42 ± 0.37 exposures/100 person-years) despite spending 32 percent more hours in the clinic, compared to the third-year students (7.18 ± 0.52 exposures/100 person-years).

A total of 412 (81.7 percent) of the injuries occurred in the teaching clinics, 38 (7.5 percent) in the Central Sterilization Unit, 24 (4.8 percent) in the emergency clinic, 14 (2.8 percent) in the student laboratories, and 16 (3.2 percent) in other areas such as the student lockers and the supply areas. The latter

Table 1. Number of dental school personnel by year (students, faculty, and staff)

	87-8	88-9	89-0	90-1	91-2	92-3	93-4	94-5	95-6	96-7
First-year PDS *	(152)	152	161	158	153	166	159	156	226	202
Second-year PDS	(171)	(147)	(164)	(158)	(153)	(141)	(178)	(165)	(150)	(217)
Third-year PDS	(165)	165	226	318	397	332	314	259	257	270
Fourth-year PDS	(153)	153	160	222	301	389	315	303	258	257
Postdoctoral	(40)	(40)	(40)	(40)	(40)	38	(40)	43	44	46
International scholars	—	—	—	—	—	—	—	72	69	59
Dental hygiene	—	—	—	40	48	64	70	63	73	63
Dental assisting	73	53	45	42	54	70	75	77	85	139
STUDENT SUBTOTAL	**754**	**710**	**796**	**978**	**1146**	**1200**	**1151**	**1138**	**1162**	**1253**
Full-time faculty	102	100	109	113	122	125	124	125	122	125
Part-time faculty	340	397	423	522	507	510	504	497	365	379
Faculty (FTE)**	170	179	194	217	223	227	225	224	195	201
Staff	(227)	227	236	240	236	261	265	271	275	275
GRAND TOTAL:	**1151**	**1116**	**1226**	**1435**	**1605**	**1688**	**1641**	**1633**	**1632**	**1729**

* PDS = Predoctoral students

** Based on five faculty (part-time) = 1 faculty (full-time)

NOTE: Parentheses indicate estimated or interpolated values where actual data was unavailable. For the student categories, extrapolation was necessary because an Advanced-Standing program was instituted at the college affecting the overall enrollment rate while adequate record of the actual dropouts was unavailable. A national attrition rate published by the American Association of Dental Education was used to estimate the number of students in several categories.

Table 2. Exposure rates among dental college personnel

JOB TITLE	# DCW Cases Recorded	Person-Years at Risk	Rate/100 Person-Years ± SD **
First year PDS	14	1,685	0.83 ± 0.22
Second year PDS	54	1,644	3.28 ± 0.45
Third year PDS	194	2,703	7.18 ± 0.52
Fourth year PDS	86	2,511	3.42 ± 0.37
TOTAL PRE-DOCTORAL	**348**	**8,543**	**4.07 ± 0.22**
Post-doctoral Students*	21	611	3.44 ± 0.75
Dental Hygiene Students	12	421	2.85 ± 0.82
Dental Assisting Students	33	713	4.63 ± 0.81
STUDENT SUBTOTAL	**414**	**10,288**	**4.02 ± 0.20**
Faculty	30	2,056	1.46 ± 0.27
Staff	60	2,513	2.39 ± 0.31
FACULTY/STAFF SUBTOTAL	**90**	**4,569**	**1.97 ± 0.21**
TOTALS	**504**	**14,857**	**3.39 ± 0.15**

* Includes one-year International Scholars Program
** SD = Standard Deviation

two categories involved injuries related to contaminated instruments that were not returned properly to the supply area for processing. The majority of exposures (279 or 54.5 percent) occurred post-operatively, and most (159) occurred during instrument clean-up. Of all exposures, 31 percent occurred during instrument clean-up, almost 10 percent were related to poor instrument handling (picking up a large number of contaminated instruments at once), 7 percent occurred during the needle recapping process (not using a one-handed technique, or trying to recap a bent needle), and nearly 7 percent were due to other handling problems such as careless disassembling or disposal of the anesthetic needle, the cap falling off a recapped needle, or touching broken culture/specimen tubes (Table 3). Of the 41 percent of incidents that occurred during instrument use, almost 23 percent were during the normal use of an instrument, 8.4 percent occurred when an instrument was being used with excessive force, 6.5 percent occurred during needle injection or withdrawal, 2.6 percent because of sudden patient movement, and less than 1 percent while the instrument was being passed between the dental assistant and the dentist/dental student. A relatively small proportion of exposures (4.5 percent) occurred as a result of colliding with an object such as the bur on a hand-piece or with a sharp object held by a co-worker or due to dropping instruments. In terms of the types of instrument involved, hollow bore needles (mostly the

Table 3. Circumstances resulting in exposures (1987-1997)

HOW DID THE INJURY OCCUR	TYPE OF ACTIVITY	NUMBER OF EXPOSURES	PERCENT
Intra-operative N=210 (41.0%)	Performing procedure	117	22.9%
	Using instrument under force	43	8.4%
	Inserting needle in tissue	27	5.3%
	Patient moved	13	2.6%
	Needle withdrawal	6	1.2%
	Passing/transferring instrument	4	0.8%
Collided with sharp object N=23 (4.5 %)	Collided with object in dental unit	12	2.3%
	Dropped object	7	1.4%
	Collided with co-worker	4	0.8%
Post-operative N=279 (54.5%)	Clean-up	159	31.1%
	Picking up instrument by handful	50	9.8%
	Needle recapping	36	7.0%
	Other handling accidents	23	4.5%
	Disassembling device	7	1.4%
	Manipulating specimen	4	0.8%
TOTAL CIRCUMSTANCES		512*	100.0%...

* For eight cases, the injury resulted from more than one circumstance.
❭ Individual percentages may not add up to subtotal percentages due to round-off errors

anesthetic needle) accounted for 36.7 percent of exposures (Table 4). Periodontal instruments accounted for another 24 percent of exposures, while restorative and endodontic instruments comprised 9.7 percent and 5 percent of exposures, respectively. No information was collected in regard to the specific anatomic area involved (i.e., dominant vs. non-dominant hand).

Severity of Exposure

Exposures were classified as superficial (no bleeding)—191 (37.9 percent); moderate (some bleeding)—260 (51.6 percent); and deep (heavy bleeding)—53 (10.5 percent). The presence or absence of visible blood on the instrument was recorded in 320 cases. Of these, 286 (89 percent) cases involved instruments that were visibly contaminated with blood, and 34 (11 percent) that were not.

Source Case Data

Thirty-eight patient source cases (7.5 percent) reported being HIV-positive at the time of exposure. In addition, among source cases who consented to HIV testing following the accidental exposure, another twenty (4.0 percent) were later confirmed as HIV-positive, resulting in a total of fifty-eight (11.5 percent) known HIV-positive source cases. A total of six source cases were asymptomatic carriers for hepatitis B, one was an active hepatitis B carrier, and two cases were reported to be hepatitis C antibody positive.

Providers' HBV Immunity

Among all exposures, 316 (62.7 percent) of the 504 DCWs exposed had completed the HBV vaccination series before the exposure. Of these, 277 were students (66.9 percent of the student cases), 23 were staff (38.3 percent of the staff cases), and 16 were faculty (53.3 percent of the faculty cases). Ninety-five individuals (18.8 percent), including 65 students (15.7 percent of the student cases), 23 staff (38.3 percent of the staff cases), and 7 faculty (23.3 percent), had not been vaccinated. Ninety-three persons (18.3 percent) had started but not yet completed the HBV vaccination series, including 72 students (17.3

Table 4. Types of instruments involved in exposures

Class of Instrument	Type	Number of Exposures	Percent
Hollow Bore Needle N=185 (36.7%)	Anesthetic	170	33.7%
	Irrigation	14	2.8%
	Other	1	0.2%
Periodontal Instruments N=121 (24.0%)	Scaler	52	10.3%
	Explorer	49	9.7%
	Curette	11	2.2%
	Probe	5	1.0%
	Knife	2	0.4%
	Cavitron tip	2	0.4%
Miscellaneous N=109 (21.6%)	Waxing instrument	89	17.7%
	Orthodontic wire	18	3.6%
	Utility knife	2	0.4%
Restorative Instruments N=49 (9.7%)	Bur	46	9.1%
	Matrix band	3	0.6%
Endodontic Instruments N=25 (5.0%)	File	12	2.4%
	Explorer	10	2.0%
	Spreader	4	0.8%
Surgical N=11 (2.2%)	Scalpel	10	2.0%
	Surgical wire	1	0.2%
Solid Needle	Suture	3	0.6%
TOTAL INSTRUMENTS		504 (100%)	

percent of the total student cases), 14 staff (23.3 percent of the total staff cases), and 7 faculty (23.3 percent of the total faculty cases).

Serological Testing of the DCWs

According to the college protocol, testing for antibody to HB surface antigen (anti-HBs) was recommended for any DCW who did not have prior serological proof of immunity against HB. A total of 162 individuals (32.2 percent of all exposures) were tested for the evidence of HBV immunity. Of these, 126 (25.0 percent of the total) were shown to be anti-HBs positive, 14 (2.8 percent of the total) were low positive, and 22 (4.4 percent of the total) were negative. HBsAg testing was not performed on those individuals with negative anti-HBsAg.

HCV antibody testing became a component of the college's post-exposure management in 1994, and was only recommended for known HCV-antibody positive or very high risk source cases (such as injection drug users or recipients of transfusions or organ transplants prior to 1992). The anti-HCV testing was recommended at baseline and at six months follow-up. Two exposures led to HCV antibody testing, with no evidence of seroconversion at six-month follow-up.

HIV testing was recommended and offered at baseline and repeated at six weeks, three months, and at six months following the exposure. If the exposed DCW did not consent to HIV testing at baseline, then the blood sample obtained was stored for a period of ninety days to allow for future testing if appropriate consent could later be obtained. Ninety (17.9 percent) of the DCWs were tested for HIV. Of these, eighty-two were students (19.8 percent of the student cases), five were faculty (16.7 percent of the faculty cases) and three were staff (5 percent of the staff cases). For those tested, including the 58 (11.5%) DCWs exposed to an HIV-positive source case, there were no HIV seroconversions up to six months after their exposures.

Number Receiving Prophylactic Measures

Three cases with no HB immunity (negative anti-HBs) who were exposed to HBV-positive or high-risk source cases received hepatitis B immunoglobulin (HBIG). Twenty-six cases (5.2 percent, including twenty-two students and four staff) who had inadequate levels of immunity against hepatitis B (low or negative anti-HBs) received booster doses of the HBV vaccine. Four students (1.0 percent of the total student cases) and four staff (6.7 percent of the total staff cases) received tetanus toxoid following their occupational exposure.

Thirteen individuals (2.6 percent of all exposures, including twelve students and one staff) who had moderate to deep exposure to HIV-positive or high-risk source cases received zidovudine (AZT) prophylactically following their exposure. The AZT was administered anywhere from one to twenty-four hours after the exposure. Of these, two individuals received AZT as part of the multiple anti-retroviral drug regimen that became the recommended standard of care after 1996.[33,34] All the cases of prophylaxis with AZT were managed and followed by the college's consulting infectious disease physician. The length of time for prophylactic AZT coverage varied significantly (from twenty-four hours to six weeks), mostly as a result of the DCW's personal decision and in consultation with the supervising physician. One exposed worker discontinued the AZT after the source case testing indicated that he was HIV-negative. No other details are available on the exact reason for discontinuation of the anti-HIV medication by the other individuals who did not complete the regimen.

Discussion

Because a standardized data collection tool is not currently available in dentistry, dental schools or private practice environments must develop a method of documenting occupational BOPIM exposures that is suitable for their worker population. Within any health care setting, periodic analysis of the occupational exposures and comparison with similar work environments are critical to assessing the effectiveness of the intervention programs. At the College of Dentistry, we have attempted to develop and refine a data collection tool that best represents the minute details of dental exposures (copies of this survey form are available upon request from the first author). Utilizing the information collected, we have also created a computerized database of the exposures that enables us to periodically analyze the circumstances leading to exposures and plan the intervention efforts accordingly. Accordingly, our goal for this article was to compare our experience to that published by other investigators and to describe our ongoing intervention programs.

The Post-Exposure Protocol

Investigating and documenting circumstances of exposure are critical elements in determining source case risk factors, performing necessary serologic testing, initiating appropriate prophylactic measures, and providing medical follow-up for the dental care worker (DCW). Although it is difficult to quantify the risk for seroconversion, the risk assessment process will allow quantitative determination of the severity of risk. Moreover, analysis of the collected data may assist in evaluating and modifying current practice or engineering controls, which will reduce the possibility of future incidents for all DCWs.

Systematic investigation of each occupational BOPIM exposure should involve documentation of several key elements: the nature of the procedure, the type of instrument involved, the depth of injury, the amount of BOPIM involved (the size of inoculum), the time elapsed between the use of the instrument and the exposure, the type of first aid administered, and the kind of personal protection worn at the time of exposure. Other factors critical to the risk assessment process are the source case's disease state (infectivity and viral titer) and the health care worker's immune status.[34] Current CDC guidelines call for postvaccination testing for antibody to hepatitis B surface antigen (anti-HBs) response for health care workers who are at risk for injuries with sharp instruments or needlesticks.[35] Knowledge of antibody response of the health care worker as well as the infectious status of the source case aid in determining appropriate postexposure prophylaxis. The source person should be tested for hepatitis B and hepatitis C and HIV infections.[34] If the source is known to have an HIV infection, available information about this person's stage of infection (i.e., asymptomatic or AIDS), CD4 T-call count, results of viral load testing, and current and previous anti-retroviral therapy should be gathered for consideration in choosing an appropriate prophylaxis regimen.[34] In the event that the source patient is infected with the hepatitis B virus and the exposed health care worker does not have the protective anti-HBs response, then hepatitis B immunoglobulin (HBIG) and an appropriate dose of the hepatitis B vaccine are strongly recommended. The rate of compliance with hepatitis B vaccination among dentists increased during the ten-year period from 22 percent to 85 percent.[14] In the same study, the rate of HBV infectivity among dentists declined from 14 percent to 9 percent and was highly correlated with the number of years of experience in practice, emphasizing the need for vaccination of all dentists early in their training. In this study, we found that 19 percent of the exposed DCWs had not been vaccinated (mostly faculty and staff) and 18 percent had started the vaccination series but not completed it by the time of exposure. Although the number of vaccinated DCWs appears to be low, it does reflect the cumulative data over the ten-year period. Some of incidents occurred in the early years of the surveillance program, prior to the implementation of OSHA Bloodborne Pathogen standard. In 1992, to address the problem of incomplete vaccination among the students, the student HBV vaccination policy was modified so that the students would begin the HBV vaccination process during the summer prior to the beginning of the first academic year in the fall.

To date, the practice of universal precautions including the use of barrier techniques has been shown to be the only prevention strategy against occupational transmission of hepatitis C in health care settings, including dentistry.[36] We report two exposures to hepatitis C-infected source cases with no seroconversion in the DCW after six months of follow-up.

Post-exposure prophylaxis against HIV after exposure to an HIV-positive or high-risk source person's BOPIM consists of either the basic regimen of AZT and lamivudine (3TC) for exposures involving a small inoculum size or the expanded regimen of AZT, 3TC and indinavir (IND) for a larger inoculum size and/or for a higher HIV titer in the blood of the source case.[34] We report 2.6 percent of all exposures involving anti-retroviral prophylaxis including individuals receiving AZT and two DCWs receiving the extended regimen. We have inadequate data in terms of the reason for discontinuation of the regimen as it relates to the drugs' side effects, but fully support the universal use of rapid HIV testing of the source person, whenever possible, in order to reduce the need for prescription of the regimen.[39]

What Are the Most Common Types of Injuries?

Percutaneous injuries are considered the most probable portal of entry for microorganisms during accidental occupational exposures. This is documented by the surveillance data compiled by the CDC from 1981 to 1999. During that nineteen-year period, there were a total of fifty-six documented cases of occupationally acquired HIV infections reported in the United States. Forty-eight of these (86 percent) were confirmed as due to percutaneous exposures, while only five (9 percent) were confirmed from mucous membrane contacts.[13] We report that, out of 494 percutaneous exposures, almost 63 percent were related to instrument punctures or cuts and 38 percent to needlesticks. This breakdown appears to be consistent among all the published reports from dental teaching institutions. In a recently released study of 428 parenteral exposures to blood or other body fluids, conducted at four teaching clinics in San Francisco (three clinics affiliated with UCSF and one clinic affiliated with UOP), 60 percent resulted from instrument punctures or cuts, and 36 percent were due to needlesticks.[17] In another recently released study of eighty-one percutaneous BOPIM exposures at the UMDNJ school, 69 percent of exposures were puncture wounds or cuts from a variety of instruments (burs, explorers, scalers, laboratory knives, etc.), and 31 percent were needlesticks.[18] In a 1994 report of fifty percutaneous exposures at Marquette School of Dentistry, the breakdown of punctures/cuts versus needlesticks was 64 percent and 36 percent respectively.[19]

In terms of the severity of dental exposures, information on the depth of injury and presence or absence of visible blood on the instrument is not consistently available from the published reports. It appears that the majority of exposures in the dental environment are of a superficial nature (51.6 percent in this report and 83 percent in the Ramos-Gomez et al. study).[17] Deep exposures are relatively uncommon (10 percent in this report and 5 percent reported previously).[17] We also report that 89 percent of exposures involved instruments visibly contaminated with blood. It must be emphasized that collecting information on the details of exposure is crucial to the process of risk assessment. Epidemiologic and laboratory studies suggest that factors such as the depth of an injury or the volume of blood involved in an exposure affect the risk of HIV transmission after an occupational exposure.[37,38]

Which Instruments Are More Likely to Cause Exposures?

When comparing the types of instruments involved in each published report, there are significant inconsistencies in the way authors categorize dental instruments or present circumstances of exposures. These inconsistencies are most probably related to the variable methods of data collection among dental institutions or the recollection of the practicing dentists in the survey studies. These variations in reporting underscore the need for development of a nationwide standard method of data collection.

In reviewing reports from various dental schools, the rate of injuries from anesthetic needles are consistent: 36 percent,[19] 34 percent (by us), 33 percent,[17] and 31 percent.[18] Burs are reported to be involved in 26 percent,[8] 17 percent,[17] 9 percent (in this report), and 8 percent.[19] We report scalers and curettes to be involved in 12 percent of cases (10 percent and 2 percent, respectively); in the Ramos-Gomez et al. data set, these instruments are categorized together as causing 8 percent of exposures.[17] An unexpected finding in our data was the rate of exposure related to the waxing instruments (17.7 percent), used during chair-side or laboratory prosthetic procedures.

What Are the Reported Rates of Exposure?

The occupational exposure rates reported in the dental literature are expressed either in terms of the number of exposures per 10,000 patient visits or the number of exposures per 100 person-years (or variations of these). In a recently published report, Kennedy and Hasler attempted to establish a benchmark for the rate of occupational exposures within dental schools in the United States.[25] In that report, in which twenty-eight of fifty-three U.S. dental schools responded to the mailed survey, the average exposure rate was reported as 4.0/10,000 patient visits for the third- and fourth-year dental students and 1.30/10,000 patient visits for the faculty in the faculty practice clinics. Other rates described in the literature include 3.53/10,000 visits reported by Ramos-Gomez and colleagues (a prospective study of 428 documented exposures over a five-year period at four dental teaching clinics in San Francisco),[17] and 12.5/10,000 patient visits reported by Cleveland and colleagues (an observational study of 45 dental residents over a six-month period in New York City).[22] In this report, there were approximately 2.05 million patient visits made to NYUCD during the study period. The overall accidental BOPIM exposure rate/10,000 patient visits ± standard deviation (SD) was 2.46 ± 0.11. This rate, however, encompasses the entire ten-year period. As the number of reported cases increased over the years, the rates also showed a gradual increase. Thus during 1994-1997 the rate was 3.59 ± 0.23 per 10,000 patient visits, similar to that reported by other centers.

The annual total number of students, faculty, and staff working at NYUCD clinics during the study period ranged from 1,116 to 1,729 persons (Table 1). The calculated exposure rate per 100 person-years for all dental students was 4.07/100 person-years. The rate for third- and fourth-year students only was 5.37/100 person-years. Both rates are lower than the national average for dental schools as reported by Kennedy and Hasler (10.6 per 100 person-years for dental students)[25] and that reported by Ramos-Gomez and colleagues (8.4/100 person-years for dental students and 5.3/100 person-years for the residents),[17] and is significantly lower than the rates reported by Cleveland and colleagues (396/100 person-years for the dental residents)[22] and by Siew and colleagues (280/100 person-years for the practicing dentists).[15] The variations observed among these reports may be related to the differences in the methods of data collection. The study reported by Siew and colleagues consisted of self- reports of exposures documented in a diary over a twenty-day period by participating dentists. The data reported by Cleveland et al. was based on the actual observation of dental residents during the exposures. In both studies the rate of accurate reporting of exposures may have been higher than some of the reports from dental school environments which rely on the exposed DCW's compliance with oftentimes complicated post-exposure management protocols.

Fifty-seven percent of the student exposures during 1987-1997 were reported by female students while females comprised only 38 percent of the total student population during this period. Gender differences in the reported rate of exposures were also noticed by Siew and colleagues in the practicing dentists survey study.[15] It is unclear whether the female DCWs experienced more blood borne exposures than their male counterparts, whether they were more likely to report an exposure, or both. This is an area that future investigations should explore more carefully.

The Risk of HIV Seroconversion

Based on the results reported in this study as well as other published reports, the risk of HIV transmission in dentistry remains very low. To date, there are no dentists reported by the CDC to have developed an occupationally acquired HIV infection.[13] In this report, 11.5 percent of exposures involved an HIV seropositive source case, with no seroconversions of the DCW after six months of follow-up. This percentage of HIV seropositive source cases is similar to that recorded among all the new patient registrations at the college (11 percent to 13 percent annually). Similarly, the Ramos-Gomez et al. report involved 17 percent of exposures with HIV-positive BOPIM, also with no report of DCW seroconversions.

General Intervention Efforts

It is widely recognized that many occupational BOPIM incidents are not appropriately reported. In large institutional settings, the underreporting problem may be related to the perceived low severity of the exposure, the complexity of the process involved in reporting an incident, or the perceived low risk of the source case.[25] The relatively small number of reported exposures in 1987 and 1988 at the college is likely attributable to underreporting. Cognizant of the possible underreporting problems and in an attempt to improve the work practices in general, several intervention programs were instituted at NYUCD:

- Since 1989 a series of specifically targeted training programs focusing on infection-control-related issues had been offered during student and faculty orientations.
- In 1990, vaccination or demonstration of proof of immunity against HBV became a requirement for admission to the dental school. In the same year a network of faculty Infection Control Liaisons was developed. Through intense in-service training and regular monthly meetings, these individuals became the backbone of the clinical infection control activities at the college.

- In 1991 and 1992, the passage and implementation of the OSHA Bloodborne Pathogens Standard provided the impetus for a series of engineering controls and practice modifications at the college. In addition, a full-time infection control coordinator position was created at the college, which greatly facilitated the on-site post-exposure serologic testing, the follow-ups, and the periodic monitoring of students' infection-control practices. In general, these activities resulted in a heightened college-wide awareness of safety issues.
- In 1993, an extensive infection control curriculum was developed and integrated into the predoctoral and postgraduate programs. This curriculum consists of specific infection control lectures incorporated into Microbiology, Oral Medicine, Oral Pathology, and the behavioral sciences courses (first through third year). Interactive small group discussions were added to the Special Patient Care clinic rotations (during the fourth year). Similar changes were made in the postgraduate training programs.
- In 1994, infection control training became a requirement for obtaining and renewing professional licenses in New York state. This new requirement forced professionals in the fields of medicine, dentistry, and nursing to seek such training at academic institutions. NYUCD provides this training to all the dental and dental hygiene faculty, in addition to the ongoing annual bloodborne pathogens training.
- 1n 1995, a central sterilization facility was built at the college that eliminated the need for individual student's instrument clean-up. In the same year, an infection control certification process became a requirement for the second-year students prior to the beginning of their clinical responsibility.

Due to the relatively small number of annual exposures, a definite correlation between the reported rates of BOPIM exposures and specific infection control activities cannot be established. However, the time trends in the rate of reported exposures may in part be related to the overall improvement of work practices. One of the shortcomings of the NYUCD surveillance program was that the reporting compliance was never specifically measured. Based on the authors' s day-to-day interactions with the students, it was our impression that the reporting compliance improved over time. This was likely because the reporting protocol became less and less complicated over the years and also because the students and college employees gained confidence in the confidentiality of the entire reporting process. In order to develop an estimate for the reporting rate of occupational BOPIM exposures at the college, strategies have been developed to conduct a voluntary survey of all the members of this academic year's graduating class for their level of compliance with the reporting requirements.

Practice Modifications

In conjunction with the general improvements in the didactic aspects and clinical procedures related to infection control, several specific intervention programs were instituted at the college in response to the reported injuries. For example, as it became clear (Table 3) that a large percentage of all exposures (41 percent) occurred post-operatively, during instrument clean-up and transport, major new efforts were made to adequately train the students in the correct instrument handling process. This training also addressed the 13 percent of exposures that were related to anesthetic needle-handling accidents, such as the cap coming loose while on the bracket table (7 percent) or during disassembling, transport, and disposal (6 percent). Also to address these problems, individual sharps containers were installed in each student cubicle, which eliminated the need for transporting the recapped needles to a central location for disposal. Finally, because accidental injuries continued to occur related to instrument clean-up, a decision was made to eliminate the need for the students performing their own instrument clean-up and packaging all together. Therefore, a central sterilization unit (CSU) was built in 1995 that exclusively utilized an instrument cassette system. Although the new unit resulted in a slight increase in the number of exposures experienced by the staff during the first three months of operation, with adequate observation and training the rate of staff exposures was reduced to levels lower than those recorded for the 1987-1995 period.

To further minimize injuries related to contaminated anesthetic needles, another policy change was immediate disposal of all anesthetic needles following an injection. The use of a fresh sterile needle for all re-injections during the procedure eliminated the possibility of accidental exposure to a poorly capped contaminated needle because of clutter on the operating surface. At the same time, because 7 percent of exposures were related to the recapping process, extensive training efforts, including hands-on practices, were instituted to reinforce the correct one-handed recapping technique. To prevent needlesticks following injection with a bent needle (i.e., a palatal injection), the use of a forceps for this recapping was advised. At the same time, self-sheathing needles and recapping devices introduced to the market were continually evaluated for use as alternatives.

To address exposures that occurred during operating procedures, during needle insertion or withdrawal, and when using instruments under force (Table 3), work practice modifications such as alternative positioning of the non-dominant hand during these procedures were adopted. Furthermore, there were 4.5 percent of exposures resulting from colliding with a sharp object in the cublicle. Instances involving the bur on a handpiece not in use included grazing one's forehead on the bur while bending over, backing into the bur, injuries sustained while attempting to remove an item from the bracket table, and scratching one's hand on the bur. To prevent these types of injuries, the correct placement of the hand piece in the bracket table (i.e., sideways and away from the operator or the operating field) was instructed and required.

The Level of Experience of DCWs

Evaluation of the accidental BOPIM exposures at the college showed a significantly higher rate of exposures for third-year students compared to fourth-year. Although this may in part represent differences in the reporting habits between the third- and fourth-year students, it would appear largely to reflect differences in the levels of clinical competence between these two classes. It is important to note that, although Siew and colleagues did not find a relationship between the number of years of clinical experience and the rate of injuries among practicing dentists, a number of other investigators have documented a relatively higher rate of reported blood exposures among dental students compared to residents or faculty.[17-19,25] We also noted a difference in the rate of exposure between faculty and students as well as the predoctoral and postgraduate students, although these differences did not reach statistical significance. Even though it is possible that the apparent differences observed between dental students and faculty, dental students and residents, or the significantly higher rates of exposure recorded for the third-year students compared to the fourth-year students may be entirely related to the level of compliance with the reporting requirements, it seems likely that the level of clinical experience during predoctoral training does have an impact on the rate of accidental injuries. This has significant implications in the design of the dental curriculum as well as the nature of predoctoral clinical responsibilities and warrants further investigation.

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REFERENCES

1. Porter KM, Scully C, Porter S, Theyer Y. Needlestick injuries to dental personnel. J Dentistry 1990;18:258-62.
2. Gerberding JL. Management of occupational exposures to bloodborne viruses. N Eng J Med 1995;332(7):444-51.
3. Gruninger SE, Chakwan S, Chang S-B, et al. Human immunodeficiency virus type 1 infection among dentists. J Am Dent Assoc 1992;123:57-64.
4. Henderson DK, Fahey BJ, Willy M, et al. Risk of occupational transmission of human immunodeficiency virus type 1 (HIV-1) associated with clinical exposure. Ann Intern Med 1990;113:740-6.
5. Ippilito G, Puro V, DeCarli G, et al. The risk of occupational human immunodeficiency virus infection in health care workers, Italian multicenter study. Arch Intern Med 1993;153:1451-8.
6. Alter HJ, Seeff LB, Kaplan PM, et al. Type B hepatitis: the infectivity of blood positive for e antigen and DNA polymerase after accidental needlestick exposure. New Eng J Med 1976;295:909.
7. Lanphear BP, Linnemann CC Jr, Cannon CG. Hepatitis C virus infection in health care workers: risk of exposure and infection. Infect Control Hosp Epidemiol 1994;15:747-50.
8. Mitsui T, Iwano K, Masuko K, et al. Hepatitis C virus infection in medical personnel after needlestick accidents. Hepatology 1992;16:1109-14.
9. Zuckerman J, Clewley G, Griffiths P, Cockroft A. Prevalence of hepatitis C antibodies in clinical health-care workers. Lancet 1994;343:1618-20.
10. Puro V, Petrosillo N, Ippolito G. Italian study group on occupational risk of HIV and other bloodborne infections: risk of hepatitis C seroconversion after occupational exposure in health-care workers. Am J Infect Control 1995;23:273-7.

11. Klein RS, Phelan JA, Freeman K, et al. Low occupational risk of human immunodeficiency virus infection among dental professionals. N Eng J Med 1988;318:86-90.
12. Gerberding JL. Incidence and prevalence of human immunodeficiency virus, hepatitis B, hepatitis C, and cytomegalovirus among health care personnel at risk for blood exposure: final report from a longitudinal study. J Infect Dis 1994;170:1410-7.
13. Centers for Disease Control and Prevention. HIV/AIDS surveillance report 1999. 11(2): Table 17.
14. Cleveland JL. Hepatitis B vaccination and infection among US dentists, 1983-1992. J Am Dent Assoc 1996;127:1385-90.
15. Siew C, Grunninger MS, Miaw CL, Neidle EA. Percutaneous injuries in practicing dentists. J Am Dent Assoc 1995;126:1227-34.
16. Siew C, Chang SB, Gruninger SE, et al. Self reported percutaneous injuries in dentists: implications for HBV and HIV/transmission risks. J Am Dent Assoc 1992;123:37-44.
17. Ramos-Gomez F, Ellison J, Greenspan D, Bird W, Lowe S, Gerberding JL. Accidental exposures to blood and body fluids among health care workers in dental teaching clinics: a prospective study. J Am Dent Assoc 1997;128:1253-61.
18. Panagakos FS, Silverstein J. Incidence of percutaneous injuries at a dental school: A 4-year retrospective study. Am J Infect Control 1997;25:330-4.
19. Gonzalez CD, Pruhs RJ, Sampson E. Clinical occupational bloodborne exposure in a dental school. J Dent Educ 1976;58(3):217-20.
20. Winsom C, De Paola L, Overhoster CD, et al. A five-year study of parenteral exposures in dental health-care workers (Abstract P163). In: Abstracts of the 5th national forum on AIDS, hepatitis and other bloodborne diseases. Atlanta, 1993.
21. Gooch BF, Cardo DM, Marcus R. Percutaneous exposures to HIV infected blood among dental care workers enrolled in the CDC needlestick study. J Am Dent Assoc 1995;126:1237-42.
22. Cleveland JL, Lockwood SA, Gooch BF, Mendelson MH, Chamberland ME, Valuri DV, Roistacher SL, Solomon JM, Marianos DW. Percutaneous injuries in dentistry: an observational study. J Am Dent Assoc. 1995;126:745-51.
23. Cottone JA, Dillars RL, Dove SB. Frequency of percutaneous injuries in dental care providers (Abstract #14). J Dent Educ 1992;56(1):34.
24. Gooch BF, Siew C, Cleveland JL, Grunninger SE, Lockwood SA, Joy ED. Occupational exposure and HIV infection among oral and maxillofacial surgeons. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1998;85:128-34.
25. Kennedy JE, Hasler JF. Exposures to blood and body fluids among dental school-based dental health care workers. J Dent Educ 1999;63(6):464-9.
26. Osborn EHS, Papadakis MA, Gerberding JL. Occupational exposures to body fluids among medical students. Ann Intern Med 1999;30:45-51.
27. Rosenthal E, Pradier C, Keita-Perse O, Altare J, Dellamonica P, Cassuto JP. Needlestick injuries among French medical students (abstract). J Am Med Assoc 1999;281:1660.
28. Koenig S, Chu J. Medical students' exposure to blood infectious body fluids. Am J Infect Control 1995;23:40-3.
29. O'Neil TM, Abott AV, Radecki SE. Risk of needlesticks and occupational exposures among residents and medical students. Arc Intern Med 1992;152:1451-6.
30. OSHA Bloodborne Pathogens Standard. U.S. Code of Federal Regulations 1997; Vol 29. Part 1910, Section 1030:293.
31. Norusis M. SPSS/PC+ for the IBM PC/XT/AT. Chicago: SPSS Inc., 1986.
32. Pagano M, Gauvreau K. Principles of biostatistics. Belmont, CA: Duxbury Press, 1993:153-5.
33. Update: provisional Public Health Service recommendations for chemoprophylaxis after occupational exposure to HIV. MMWR 1996;45:468-80.
34. Public Health Service guidelines for the management of health-care worker exposures to HIV and recommendations for postexposure prophylaxis. MMWR 1998;47(RR-7):1-28.
35. Centers for Disease Control and Prevention. Immunization of health-care workers; recommendations of the Advisory Committee on Immunization Practices (ACIP) and the Hospital Infection Control Practices Advisory Committee (HICPAC). MMWR 1997;46(RR-18):1-51.
36. Centers for Disease Control and Prevention. Recommendations for follow-up of health-care workers after occupational exposure to hepatitis C virus. MMWR 1993;42(RR-8):1-12.
37. Cardo DM, Culver DH, Ciesielski CA, et al. A case-control study of HIV seroconversion in health care workers after percutaneous exposure. N Engl J Med 1993;337:1485-90.
38. Mast ST, Woolwine JD, Gerberding JL. Efficacy of gloves in reducing blood volumes transferred during simulated needlestick injury. J Infect Dis 1993;168:1589-92.
39. Kassler WJ, Haley C, Jones WK, et al. Performance of a rapid, on-site Human Immunodeficiency Virus Antibody Assay in a public health setting. J Clin Microbiol 1995;33:2899-902.