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Blood Exposure Among Paramedics: Incidence Rates From the National Study to Prevent Blood Exposure in Paramedics

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PURPOSE: The aim of the study is to estimate incidence rates of occupational blood exposure by route of exposure (needlesticks; cuts from sharp objects; mucous membrane exposures to the eyes, nose, or mouth; bites; and blood contact with nonintact skin) in US and California paramedics.
METHODS: A mail survey was conducted in a national probability sample of certified paramedics.
RESULTS: Proportions of paramedics who reported an exposure in the previous year were 21.6% (95% confidence interval [CI], 17.8–25.3) for the national sample and 14.8% (95% CI, 12.2–17.4) for California. The overall incidence rate was 6.0/10,000 calls (95% CI, 3.9–8.1). These rates represent more than 49,000 total exposures and more than 10,000 needlesticks per year among paramedics in the United States. Rates for mucocutaneous exposures and needlesticks were similar (~ 1.2/10,000 calls). Rates for California were one third to one half the national rates. Sensitivity analysis showed that potential response bias would have little impact on the policy and intervention implications of the findings.
CONCLUSION: Paramedics continue to be at substantial risk for blood exposure. More attention should be given to reducing mucocutaneous exposures. The impact of legislation on reducing exposures and the importance of nonintact skin exposures need to be better understood.
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KEY WORDS: Needlestick, Paramedic, Blood Exposure, Incidence, Occupational Exposure, Prehospital, Survey.

INTRODUCTION

There are more than 150,000 certified paramedics in the United States. They are at risk for infection from human immunodeficiency virus (HIV), hepatitis B virus (HBV), and hepatitis C virus (HCV) through exposure to patients' blood (1, 2). Preexposure prophylaxis is available for HBV (3). Postexposure prophylaxis is available for HIV, but its effectiveness depends on the interval between exposure and administration and other factors (4). There is no vaccine or postexposure prophylaxis for HCV (3). Thus, the primary means of preventing occupational HIV and HCV infection and HBV infection in workers who have not been vaccinated or for whom vaccination did not confer immunity is prevention of blood exposure (3).

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The objective of this study is to estimate blood-exposure incidence rates by route of exposure (needlesticks; cuts from sharp objects; mucous membrane exposures to the eyes, nose, or mouth; bites; and blood contact with nonintact skin) for the national paramedic population and California paramedics separately. Separate estimates for California are reported because of the unique situation brought about by that state's needlestick prevention law. Given the potential impact of that law on blood exposure rates, that it was in effect for some years before our survey, and the large paramedic population affected (n ≈ 10,500), it is of interest to examine rates for California separately and compare them with national rates. Route-specific rates are reported because risk factors for exposure, transmission rates, and prevention measures may differ across routes.

Paramedics perform medical procedures under conditions that are conducive to blood exposure and are unique to this population of health care workers (5, 6), yet little is known about their risk for exposure. Most previous studies were of hospital-based health care workers (7–9), which may have limited relevance for paramedics because their work environment is different from the hospital setting in ways that affect risk for exposure. Previous studies of paramedics were limited to local urban populations and one type of employer and did not consider all routes of exposure

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Selected Abbreviations and Acronyms

CI = confidence interval
HBV = hepatitis B virus
HCV = hepatitis C virus
HIV = human immunodeficiency virus

(10–12). Furthermore, these results may not be current with recent developments, such as the use of safety-engineered devices and health care worker safety legislation (13, 14).

METHODS

The National Study to Prevent Blood Exposure in Paramedics was a mail survey conducted during fall and winter 2002 to 2003. The target population was currently practicing paramedics in the United States. Inclusion criteria were a current paramedic certification/licensure; currently working (paid or volunteer) as a paramedic, responding to calls in an emergency vehicle, and having direct patient contact; and having responded to four or more calls in the previous 4 weeks. These criteria were intended to select participants who were engaged in delivering paramedic care to patients as opposed to administrative tasks or training.

A two-stage sample was selected, with states as the first stage and paramedics (from lists provided by the states) as the second stage. The sample included 6500 paramedics, 1500 of whom were from California.

A self-administered questionnaire was used to gather data about current jobs and past blood exposures. Respondents were asked the number of times they were exposed to patient blood in the previous 12 months through each of five routes of exposure (sticks from needles or lancets after they had been used on patients; cuts from sharp objects, i.e., scalpel, razor, scissors, or such sharp objects as broken glass or metal; blood in eyes, nose, or mouth; bites that broke the skin; and blood on nonintact skin). To maintain anonymity while enabling follow-up of nonrespondents, a subject identification number was encoded on a postcard. Respondents were instructed to return it separately from the questionnaire. No subject identifier was included on the questionnaire, which can be viewed at www.constellagroup.com/paramedicquestionnaire. This study was approved by the Human Investigation Committee of the University of Virginia.

Incidence rates were calculated by using two different denominators, i.e., blood exposures per 10,000 calls and blood exposures per 10,000 patients. Number of calls was derived from the question, "During the last 7 days, how many calls/runs did you go on in which you personally attended to patients?" The denominator was calculated by multiplying this number by 48, assuming 48 working weeks per year. Number of patients was derived from the number of patients attended to on the last four calls in which the respondent attended to at least one patient. The denominator was calculated by multiplying this number by one fourth of the number of calls. The numerator for the rates was the total number of blood-exposure incidents reported for the respective route of exposure. Sampling weights were adjusted for nonresponse. SUDAAN, version 9.0 (Research Triangle Institute, Research Triangle Park, NC) was used to adjust for unequal probabilities of selection and clustering.

We conducted a sensitivity analysis to examine the impact of potential response bias on estimated incidence rates. We assumed that the relevant mechanism underlying response bias, if it existed, was differential response between paramedics who were and were not exposed to blood during the past year. Because exposure to blood can be a salient experience for health care workers (6, 15), paramedics who had been exposed might be more motivated to participate than other paramedics. Conversely, anecdotal evidence suggests that being exposed carries a stigma (12, 16) that could function to decrease response rates among exposed paramedics. For the sensitivity analysis, we assumed a range of values for the ratio of the response rate among the exposed to the response rate among the unexposed and calculated the range of possible true incidence rates corresponding to these values. These calculations were based on the assumption that average number of exposures per exposed paramedic, average number of calls (or patients) per exposed paramedic, and average number of calls (or patients) per unexposed paramedic were the same among respondents and nonrespondents.

RESULTS

California, Connecticut, Florida, Illinois, Kentucky, Minnesota, North Carolina, Ohio, Pennsylvania, Tennessee, and Texas were selected in the first stage. Illinois refused to participate. Based on mail that was returned undelivered, 5.5% of the sample could not be contacted because of incorrect addresses. A total of 3378 questionnaires were received from the 6142 paramedics presumed to have been contacted. Of these respondents, 78.9% met the eligibility criteria, giving a final sample size of 2664. Assuming that the proportion of ineligible persons among nonrespondents was the same as that among respondents, the response rate was 55% (2664 of 4844 questionnaires). A total of 3064 postcards were returned, including 16 duplicates (i.e., pairs from the same respondent, one or both from follow-up mailings).

Respondents were predominantly white non-Hispanic males. More than 70% were 30 to 49 years old, and more than 60% had greater than 5 years of experience (Table 1).

Proportions of paramedics who reported at least one exposure from any route were 21.6% (weighted; 95%

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TABLE 1. Characteristics of respondents to the National Study to Prevent Blood Exposure in Paramedics, United States, 2002 to 2003 (n = 2664)

Characteristic	n	%
Age (years)*		
19	1	
20–29	540	21
30–39	1182	45
40–49	714	28
50+	209	8
Male	2171	82
White or Caucasian	2397	95
Non-Hispanic	2414	92
Years since paramedic certification		
≤2	433	16
3–5	539	20
6–10	733	28
11+	928	35

confidence interval [CI], 17.8–25.3) for the national sample and 14.8% (95% CI, 12.2–17.4) for California. Table 2 lists incidence rates for blood exposure for the national sample. The overall rate was 6.0 exposures/10,000 calls (95% CI, 3.9–8.1) and 3.7 exposures/10,000 patients (95% CI, 2.4–5.0). These rates represent an estimated more than 49,000 total exposures and more than 10,000 needlesticks per year among paramedics in the United States. Rates per patient were less than rates per call because paramedics sometimes treated more than one patient in a call. The relative magnitude of rates across routes of exposure is similar for the two denominators. The greatest incidence rate was from exposures to nonintact skin (3.0/10,000 calls; 95% CI, 1.7–4.2). Incidence rates for needlesticks and mucocutaneous exposures were similar (∼1.2/10,000 calls). Of mucocutaneous exposures, 45% were exposures to the eyes; 29%, to the mouth; 3%, to the nose; and 23%, to multiple sites (data not shown). The weighted proportion of respondents who reported getting blood or body fluid containing visible blood on *intact* skin on the last call that required attending to a patient was 30.1% (95% CI, 28.3–32.0; data not shown).

Needlestick rates for California were about a fourth of the national rate, and their CIs are markedly narrower (Table 3). Rates for other routes of exposure are about half the comparable national rates. The weighted proportion of respondents who reported getting blood or body fluid containing visible blood on intact skin on the last call that required attending to patients was 19.4% (95% CI, 16.4–22.3; data not shown).

Tables 4 and 5 list results of sensitivity analyses. Varying the ratio of the response rate among the exposed to the response rate among the unexposed from 0.25 to 4 yields possible "true" national incidence rates of 2.0 to 13.0 exposures/10,000 calls. The comparable range for California is 0.8 to 7.3 exposures/10,000 calls.

DISCUSSION

Previous research and prevention efforts gave priority to blood exposure from needlesticks because this route is thought to have considerably greater transmission rates than other routes (3). However, the risk from other routes of exposure has been quantified only partially, and the Centers for Disease Control and Prevention's Universal Precautions emphasize prevention of exposure from all routes (17). Our results provide an opportunity to compare exposure rates among the different routes in a general paramedic population.

Nonintact skin exposures were more than twice as frequent as needlesticks and accounted for approximately half of all exposures. This is consistent with the overall high frequency of blood contact with skin, which suggests that uncovered nonintact skin is likely to come into contact with patient blood. In our informal contacts with paramedics, they discounted the potential for such exposures to lead to infection. Although transmission rates by this route are apparently less than those by other routes, nonintact

TABLE 2. Twelve-month incidence rates for exposure to blood by route of exposure and two different denominators, The National Study to Prevent Blood Exposure in Paramedics, United States, 2002 to 2003

	Per 10,000 calls		Per 10,000 patients		
Route of exposure	Rate	95% CI	Rate	95% CI	n
Needlestick	1.3	0.5–2.0	0.8	0.3–1.3	132
Cut from sharp objects	0.5	0.1–1.0	0.3	0.1–0.6	83
Eyes, nose, mouth	1.1	0.8–1.4	0.7	0.5–0.8	147
Nonintact skin	3.0	1.7–4.2	1.8	1.0–2.7	508
Bite	0.1	0.1–0.2	0.1	0.0–0.1	25
Total	6.0	3.9–8.1	3.7	2.4–5.0	895

CI = confidence interval.

TABLE 3. Twelve-month incidence rates for exposure to blood by route of exposure and two different denominators, California paramedics only, National Study to Prevent Blood Exposure in Paramedics, 2002 to 2003

	Per 10,000 calls		Per 10,000 patients		
Route of exposure	Rate	95% CI	Rate	95% CI	n
Needlestick	0.3	0.2–0.4	0.2	0.1–0.3	19
Cut from sharp objects	0.3	0.1–0.4	0.2	0.1–0.3	19
Eyes, nose, mouth	0.6	0.4–0.8	0.4	0.3–0.5	41
Nonintact skin	1.5	0.9–2.2	1.0	0.6–1.4	102
Bite	0.0	0.0–0.1	0.0	0.0–0.0	2
Total	2.7	2.0–3.5	1.8	1.3–2.3	183

CI = confidence interval.

TABLE 4. Sensitivity analysis of blood exposure incidence rates, The National Study to Prevent Blood Exposure in Paramedics, United States, 2002 to 2003

Ratio of response rate among exposed paramedics to response rate among unexposed paramedics	Incidence rate/ 10,000 calls		Incidence rate/ 10,000 patients	
	Total exposures	Needlestick exposures	Total exposures	Needlestick exposures
0.25	13.0	3.7	8.1	2.3
0.50	9.3	2.3	5.8	1.4
0.75	7.3	1.6	4.5	1.0
1.0	6.0	1.3	3.7	0.8
2.0	3.6	0.7	2.3	0.4
3.0	2.6	0.5	1.6	0.3
4.0	2.0	0.4	1.3	0.2

skin exposure may be an important pathway for HBV infection in health care workers who are not immunized (3); HIV infection and HIV/HCV coinfection by this route have been documented (17, 18). Further research to determine paramedics' risk from nonintact skin exposure and develop effective interventions seems warranted.

The rate of exposure to mucous membranes of the eyes, nose, and mouth was similar to the rate for needlesticks. The transmission rate for HCV by this route was estimated at 0.4% (19), greater than the HIV needlestick transmission rate of 0.3% (20, 21). The transmission rate for HBV in unvaccinated workers by this route also may be high (22). The mucocutaneous transmission rate for HIV was estimated at 0.09% (23). Thus, mucocutaneous exposures represent half of all exposures by routes of known or suspected high transmission for two of the three major pathogens of concern. Moreover, there is some evidence that mucous membrane exposure is an important pathway for HBV infection in health care workers (3). Given that the risks of exposure and transmission are similar between needlestick injuries and mucocutaneous exposures and mucocutaneous exposures potentially are preventable by the use of goggles, face masks, and face shields (24), future research should investigate ways to increase the use of personal protective equipment among paramedics to prevent these exposures, as well as improve the effectiveness of the equipment (25).

TABLE 5. Sensitivity analysis of blood exposure incidence rates, California paramedics only, The National Study to Prevent Blood Exposure in Paramedics, 2002 to 2003

Ratio of response rate among exposed paramedics to response rate among unexposed paramedics	Incidence rate/ 10,000 calls		Incidence rate/ 10,000 patients	
	Total exposures	Needlestick exposures	Total exposures	Needlestick exposures
0.25	7.3	1.0	4.4	0.7
0.50	4.7	0.6	2.9	0.4
0.75	3.5	0.4	2.2	0.2
1.0	2.7	0.3	1.8	0.2
2.0	1.5	0.1	1.0	0.1
3.0	1.0	0.1	0.7	0.1
4.0	0.8	0.1	0.5	0.1

Exposures from percutaneous injuries other than needlesticks (e.g., broken glass) and from bites together accounted for less than 15% of total exposures. Transmission rates from these sources have not been quantified, but are thought to be low, at least for HCV and HIV (3).

California needlestick rates were about one fourth of the national rates, and the other route-specific rates were about half the corresponding national rates (Tables 2 and 3). One possible explanation for the lower rates in California is that state's early passage of a needlestick injury prevention law: AB 1208, passed in 1998 (14). AB 1208 required emergency medical service agencies to provide safety-engineered sharps devices to protect paramedics from accidental needlestick injury. Although some other states subsequently passed needlestick prevention laws, the mandatory provision of safety devices to paramedics was implemented first in California. Use of safety devices was shown to reduce blood exposure in the hospital setting (26–28). California paramedics' access to and experience with safety devices for some years preceding our survey could have led to the observed lower rates of needlesticks for this population. In addition, although the legislation did not directly address other routes of exposure, implementation of the needlestick prevention law may have been accompanied by overall improvements in safety practices, e.g., provision of more and better personal protective equipment to paramedics and increased use of the equipment by paramedics, which led to reduced exposure rates from the other routes, as well. Several states have since passed some form of needlestick safety legislation, and the national Needlestick Safety and Prevention Act became law in 2000 (14). Future research should evaluate the impact of needlestick prevention laws on blood exposure in paramedics.

Alternatively, the lower exposure rates in California could be the result of differential response among exposed and unexposed California paramedics relative to the other states. Survey packets in California included a letter from the state Emergency Medical Services Administration stating that identifying information was not provided to the study team and expressing support for the survey, which was not the case for the other states. If this expression of support discouraged exposed paramedics from participating in the study relative to unexposed paramedics because it heightened their concern about state access to their survey responses, it would have biased incidence rates downward relative to the national sample. Conversely, the state agency's validation of respondents' anonymity may have resulted in greater participation by exposed paramedics.

Sensitivity analysis showed that response rates among exposed relative to unexposed paramedics in California would have had to be less than one fourth the corresponding national ratio (Tables 4 and 5) for response bias to have caused the lower rates in California. A difference of this magnitude seems unlikely. In this regard, it should be noted that national and California overall response rates were similar.

The numerator for our incidence rates was based on recall of exposures during the previous 12 months. The literature suggests that occupational blood exposures are sufficiently rare and salient events for respondents' recall to be reliable during this period (6, 15, 29). The denominators were calculated by extrapolating from the number of calls during the previous week and number of patients on the previous four calls to the number of calls and patients during the previous 12 months. To the extent that numbers of calls and patients varied during the 12-month period relative to the data-collection period, our estimates may reflect measurement error in the denominators. Extrapolation of denominator data for respondents who had held their current job(s) for less than 12 months could be a particular source of error because variation in the denominator data may be greatest between (as opposed to within) jobs. More than 90% (weighted) of respondents' paid jobs and volunteer positions had been held for 12 months or more.

Seasonal variation in the number of calls or patients is another potential source of bias. Our data were collected during February to April 2003 for California and primarily during September to early December 2002 for the other states. We are not aware of published data on seasonal variation in emergency medical service use with which to assess this factor. Unpublished data on the monthly number of patients seen by the Durham County, NC, emergency medical service in 2003 (Fig. 1) suggests that the bias would be less than 3% for national estimates and approximately 7% for California. Although the degree to which the seasonal variation shown in Figure 1 is representative of the entire country or of California is unknown, average seasonal variation across states would have to be markedly different from this to have produced important bias in national incidence rates. Similarly, seasonal variation in California would have to be substantially different from the rest of the country for bias from this source to have produced the lower rates found for California.

More questionnaires were returned than postcards (3378 versus 3064). Because it was not possible to identify who returned a particular questionnaire, it is possible that some data represent duplicate responses from paramedics who were sent follow-up survey packets and returned more than one questionnaire. Only 0.5% of returned postcards were duplicates from the same individual, suggesting that duplicate questionnaires had at most a negligible impact on our results.

The adjusted response rate of 55% raises the possibility of response bias. In our informal contacts with paramedics, we were impressed with the number who said they would not report a blood exposure to their employer because of negative repercussions (e.g., being blamed for the exposure because of carelessness). This suggests that the most likely mechanism underlying possible response bias would have been reduced response from paramedics who experienced an exposure because of reluctance to reveal that information. Sensitivity analysis showed that differential response rates would have had a substantial impact on the magnitude of the estimated incidence rates if the differentials were large (Tables 4 and 5). If exposed paramedics were one fourth as likely to

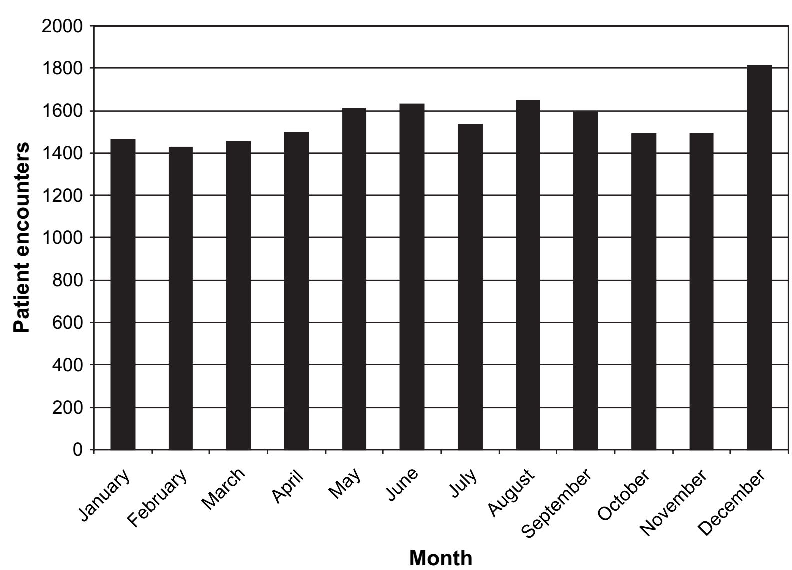

FIGURE 1. Number of patient encounters for the Durham County, NC, Emergency Medical Service in 2003 by month.

participate in the survey as unexposed paramedics, the unbiased exposure rates would be qualitatively different from the observed rates. Lower differentials would have little impact on the policy or intervention implications of our findings. We currently have no data with which to assess differential response by exposure status, but differences of this magnitude seem extreme.

Nonintact skin was the route of exposure with the greatest incidence rate and accounted for half of all exposures (Tables 2 and 3). Emergency medical services use varying definitions of what constitutes nonintact skin (Kathy West, personal communication, March 2004), which might have introduced unreliability or bias into this estimate. Future research should aim to verify or adjust rates of exposure from this route.

This study provides the most comprehensive assessment to date of occupational blood exposure incidence for US paramedics. The results are generalizable to the national paramedic population, excluding Illinois. Our findings indicate that paramedics remain at substantial risk for blood exposure, and further interventions to prevent such exposure are needed. The markedly lower rates in California suggest that safety device legislation may be a particularly effective means of reducing exposure, but this could not be verified in the present study. Future research should aim to provide information that will support the development and implementation of effective interventions to prevent occupational blood exposure among paramedics.

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