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Management Practices and Risk of Occupational Blood Exposure in U.S. Paramedics: Non-Intact Skin Exposure

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PURPOSE: To estimate the risk of blood exposure to non-intact skin in U.S. paramedics; to estimate risk ratios for selected management practices.
METHODS: A mail survey was conducted among a national sample of licensed paramedics in the United States in 2002–2003.
RESULTS: The adjusted response rate was 55% ($N = 2{,}664$). The overall 12-month risk of non-intact skin blood exposure was 8.7% (95% confidence interval: 6.4–11). As the number of types of personal protective equipment (PPE) always provided by the employer increased, risk decreased. Risk ratios and 95% confidence intervals for selected factors were: not being provided with appropriate PPE, 2.4 (1.6–3.3); job evaluation doesn't include following safety procedures, 1.8 (1.0–2.7); supervisor wouldn't speak to paramedic about not following Universal Precautions, 2.1 (0.9–3.2); both of the above supervisory behaviors, 2.3 (1.3–3.6).
CONCLUSIONS: Providing appropriate personal protective equipment is an effective means of preventing non-intact skin blood exposure and possible consequent bloodborne infection in paramedics. Future research should aim to identify factors limiting the provision of this equipment and to evaluate the advisability of interventions to increase provision. Supervisory behaviors that emphasize safe work practices may also be effective in preventing non-intact skin exposure in paramedics. Future research should develop interventions that apply general knowledge of management behaviors that promote worker safety to the work environment of paramedics.
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KEY WORDS: Blood Exposure, Occupational Exposure, Paramedic, Prehospital, Risk, Safety, Survey.

INTRODUCTION

Paramedics routinely get patient blood on their non-intact skin (e.g., skin that is broken, cut, or abraded) (1). This route of exposure accounts for approximately half of occupational blood exposures among U.S. paramedics. The incidence rate for non-intact skin exposure in U.S. paramedics is twice the rate of either needlesticks or blood exposures to the mucous membranes of the eyes, nose, and mouth (1).

Blood contact with non-intact skin puts paramedics at risk of infection with human immunodeficiency virus (HIV), hepatitis B virus (HBV), and hepatitis C virus (HCV) (2). There is particular concern regarding non-intact skin exposure as a pathway for HBV infection among healthcare workers who are not immunized (3), and HIV infection and HIV/HCV coinfection by non-intact skin exposure have been documented (4). Both the Centers for Disease Control and Prevention's Universal Precautions and the Occupational Safety and Health Administration's Bloodborne Pathogens Standard emphasize prevention of non-intact skin exposure, along with other means of preventing blood exposure, to reduce health care workers' risk of infection with bloodborne pathogens (4, 5).

Little is known about the risk of non-intact skin blood exposure among paramedics, and risk factors have not been identified. The primary means of preventing blood contact with non-intact skin in healthcare workers is provision and use of gloves and protective clothing (personal protective equipment) (2). Studies of hospital healthcare workers have found that certain management practices, i.e., provision of personal protective equipment and behaviors that emphasize or support safe work practices, were associated with increased use of personal protective equipment as well as reduced blood exposure (6–12). However, the relevance of these studies for paramedics, whose work environment is quite different from the controlled environment of a hospital, is uncertain (2, 13).

There are over 150,000 certified paramedics in the U.S. In a previous analysis of this survey, it was estimated that they experience almost 25,000 non-intact skin exposures annually (1). The purpose of this study was to estimate the risk of non-intact skin blood exposure in U.S. paramedics

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Selected Abbreviations and Acronyms

CI = confidence interval
PPE = personal protective equipment
SD = safety devices
UP = Universal Precautions

and to estimate risk ratios for selected risk factors, with a focus on management practices expected to affect the use of personal protective equipment.

METHODS

The National Study to Prevent Blood Exposure in Paramedics was a mail survey conducted during the fall and winter of 2002/2003. A two-stage national probability sample ($n = 6{,}500$) was selected, with states as the first stage and lists of paramedics provided by the states as the second stage. The questionnaire can be viewed in the online supplemental material to this article. Full details of the study design have been given previously (1). This study was approved by the Human Investigation Committee of the University of Virginia.

Conceptual Model

Fig. 1 shows the directed acyclic graph that guided this analysis (14). Provision of personal protective equipment in the form of disposable gloves, leather gloves, fluid-impermeable lab coats, and fluid-impermeable coveralls was expected to reduce blood contact with non-intact skin by enabling paramedics to place a physical barrier over their non-intact skin and, in the case of leather gloves, to prevent skin from becoming non-intact and exposed during the call (e.g., when extricating a patient from a crashed vehicle). Supervisory emphasis on safe work practices was expected to reduce non-intact skin exposure by directly influencing paramedic behavior (15). Provision of safety devices was expected to reduce non-intact skin exposure by contributing to a positive safety climate (8).

The directed acyclic graph (Fig. 1) shows that there are no known potential confounders for the association between the selected management practices and blood exposure (14). However, there may be effect modification by workload and paramedic characteristics.

Data

Management practices. Paramedics were asked how often their squad or unit provided them with disposable gloves, leather gloves, fluid-impermeable lab coats, and fluid-impermeable disposable coveralls. Responses were indicated on a 5-point scale ranging from "never" to "always." Virtually all paramedics were always provided with disposable gloves (16). Therefore, provision of disposable gloves was not included in this analysis. For the other three types of personal protective equipment, the risk of non-intact skin exposure was estimated for provision of none, one, two, or all three types of equipment. For the risk ratio estimates, the number of types of equipment provided was dichotomized in order to increase precision. Approximately half of the study population fell into the "none" category. Therefore, the number of types of equipment was dichotomized as none vs. one or more.

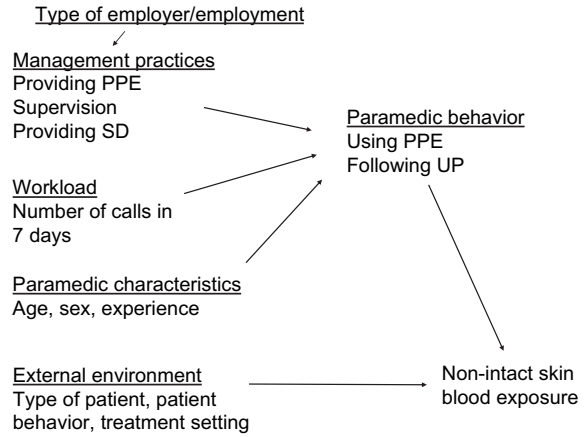

FIGURE 1. Directed acyclic graph showing the causal relations among management practices and non-intact skin blood exposure in paramedics. PPE = personal protective equipment; SD = safety devices; UP = Universal Precautions.

Similarly, paramedics were asked how often their squad or unit provided safety versions of each of five types of medical devices, i.e., shielded winged steel needles, retracting or shielded lancets, pre-filled or cartridge syringes with sliding shields, hinged caps, or retracting needles, syringes (not pre-filled or cartridge) with sliding shields, hinged caps, or retracting needles, and intravenous catheters with shielded or blunted stylets. Response options were the same as above. The risks for provision of safety devices by number always provided (i.e., none, one, etc.) were uninformative. Therefore, provision of safety devices was dichotomized as 0–3 versus 4–5. These categories were chosen to be consistent with a previous analysis (unpublished manuscript), which examined risk factors for needlestick.

Paramedics were asked two questions about supervisory behavior with respect to safe work practices: "If you did not follow Universal/Standard Precautions, would your supervisor speak to you about it?" and "Is following safety procedures part of your job evaluation?" Response options were yes, no, and don't know. Because a supervisory behavior of which the paramedic is unaware is unlikely to influence his/her behavior, responses of "don't know" were included with "no."

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TABLE 1. Distribution of management practices, workload, and personal characteristics among U.S. paramedics, 2002–2003 ($n = 2,664$)

Management practice, workload, and personal characteristics	%
Management practice	
Provides 1+ types of personal protective equipment*	64
Following safety procedures is part of job evaluation	74
Supervisor would speak to paramedic if he/she didn't follow UP	72
Following safety procedures is part of job evaluation and supervisor would speak to paramedic if he/she didn't follow UP/SP	61
Provide ⩾3 types of safety devices†	24
Workload	
Made 15+ calls in past 7 days	44
Personal characteristic	
Female	20
Age <30 years	19
Experience <5 years	22

SP = Standard Procedures; UP = Universal Precautions.
*Equipment provided could be leather gloves, fluid-impermeable lab coats, and fluid-impermeable disposable coveralls.
†Devices provided could be safety versions of winged steel needles, lancets, prefilled or cartridge syringes, syringes (not prefilled or cartridge), and intravenous catheters.

Workload. Workload was defined as the number of calls in which the paramedic attended to a patient in the last 7 days.

Paramedic Characteristics. Age, sex, and year of paramedic certification were self-reported. Experience was defined as the number of years since paramedic certification.

Non-intact Skin Exposure. A paramedic was categorized as exposed if he/she indicated having gotten patients' blood or body fluid containing visible blood on non-intact skin at least once during the previous 12 months.

Classification with Respect to Job-Specific variables. Twenty percent of the sample worked two jobs (including volunteer positions). Questions about the work environment (management practices and workload) were asked for each job held at the time of the survey. For non-cases, the job-specific data for Job 1 on the questionnaire were used.

The exposure question was not job-specific. Thus there was some ambiguity about how to classify cases who had two jobs with respect to the work environment variables. This issue was addressed by comparing the date of the most recent exposure with the dates the paramedic started the two jobs. In most cases, the exposure occurred after the start of one job only, or it occurred after the start of both jobs, but the work environment measures for the two jobs were identical. In the small number of cases where the two jobs had different work environment measures ($n = 9–17$, depending on the measure), the data from Job 1 were used. The analysis was repeated excluding these cases (data not shown), which caused little change in the results and no change in the conclusions.

Statistical Analysis

Risk was defined as the percentage of paramedics who experienced a non-intact skin exposure in the previous 12 months (17). SAS proc surveyfreq (version 9.1; SAS Institute, Cary, NC) was used to calculate proportions and confidence intervals weighted to adjust for unequal probabilities of selection and clustering.

A sensitivity analysis was conducted to assess the possible impact of response bias on the results (18). First, a mechanism was postulated by which differential response would produce biased risk estimates. Then the risk estimates were recalculated adjusting for the hypothetical bias (19). To compare response bias under different assumptions, it was assumed, first, that nonresponse would be greater, relative to other paramedics, for cases who were subject to at least one of the supervisory behaviors, and alternately, for cases who were not subject to either behavior. To adjust for the hypothetical bias, the sampling weights of paramedics who fell into the lower response category were increased by 50%, and the risk estimates were recalculated using the adjusted data. This was equivalent to correcting for a response rate among the selected group that was two thirds the response rate of other groups in the sample (19).

Three items asking the paramedic's opinions were used in the sensitivity analysis. These were "Reporting blood exposures helps management protect paramedics from future exposures to patients' blood," "I should be given more training in how to use safety devices," and "I should be given more training in how to use PPE." Response options were 1, labeled "disagree," to 5, labeled "agree." A summary measure was constructed that counted the number of times (up to 3) that the paramedic indicated a "1" or "2" for the first item and, a "4" or "5" for the other two items.

RESULTS

Ten states were selected in the first stage. One state (Illinois) refused to participate. Assuming that the proportion of ineligibles among nonrespondents was the same as among respondents, the response rate was 55% ($n = 2,664$).

Two thirds of paramedics were always provided with at least one type of personal protective equipment (from among leather gloves, fluid-impermeable lab coats, and fluid-impermeable coveralls). Three fourths of paramedics were subject to at least one of the supervisory behaviors emphasizing safe work practices (Table 1). The overall 12-month risk of non-intact skin exposure was 8.7% (95% confidence interval, 6.4–11). The risk was greater for paramedics who had made 15+ calls in the previous 7 days and for male paramedics (Table 2).

There was a dose-response relationship between provision of personal protective equipment and risk of non-intact

TABLE 2. Twelve-month risk of non-intact skin exposure in U.S. paramedics, by selected characteristics, 2002–2003 ($n = 2,664$)

Characteristic	Risk (%)	95% CI
Overall	8.7	6.4–11
<15 calls/7 days	8.1	6.8–9.4
15+ calls/7 days	10	5.2–15
Female	5.1	2.9–7.2
Male	9.7	7.1–12
Age <30 years	8.8	5.5–12
Age 30+ years	8.7	6.4–11
<5 years experience	9.3	5.9–13
5+ years experience	8.6	6.2–11

CI = confidence interval.

skin exposure, as shown in Fig 2. The strong effect of providing at least one type of personal protective equipment is reflected in the sharp angle in the curve at "1". The risk for paramedics who were not always provided with at least one type of equipment was two and a half times the risk for paramedics who were always provided with one or more types of equipment (Table 3). The effect of being provided with personal protective equipment was greater for paramedics who had made fewer than 15 calls in the previous 7 days compared to those who had made more calls, for paramedics under age 30 years compared to older paramedics, and for paramedics with less than 5 years' experience compared to those with more experience. The risk for paramedics who were not subject to the supervisory behaviors was approximately twice the risk for paramedics who were subject to the supervisory behaviors. The precision of some of these estimates is low.

The sensitivity analysis was based on alternate assumptions about which group of cases had a lower response rate relative to other paramedics. Correcting first for a lower response rate among paramedics who were subject to at least one of the supervisory behaviors gave hypothetical risks that were greater than the unadjusted risks, both for paramedics who were and were not subject to the management practices. The risk ratios based on these hypothetical risks were lower than the unadjusted risk ratios, that is, 2.2, 1.5, 1.7, and 2.0 for provision of personal protective equipment, the job evaluation and Universal Precautions supervisory behaviors, and both supervisory behaviors together, respectively. Alternatively, correcting for a lower response rate among paramedics who were not subject to either of the supervisory behaviors gave hypothetical risks that were greater than or equal to the unadjusted risks. The risk ratios based on these hypothetical risks were higher than the unadjusted risk ratios, that is, 2.6, 2.3, 2.5, and 2.7, respectively. Regarding the opinion questions, approximately 31% of paramedics who were subject to the supervisory behaviors had a value of 3 on the summary measure, compared with 19% of paramedics who were not subject to the supervisory behaviors.

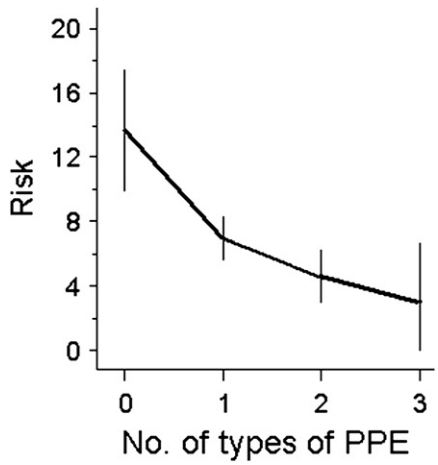

FIGURE 2. Risk of blood exposure to non-intact skin by number of types of personal protective equipment (PPE) always provided by the employer. The vertical bars indicate 95% confidence intervals.

DISCUSSION

Provision of personal protective equipment had a strong effect on the risk of non-intact skin exposure. Paramedics who were not always provided with at least one of the three types of equipment intended to prevent non-intact skin exposure had more than double the risk of exposure compared to other paramedics (see Table 3). This effect appears to derive directly from making the equipment available, rather than indirectly through improved safety climate (20). If the effect were through improved safety climate, then provision of safety devices should have had a similar effect. In fact, the risk ratio for safety devices was near the null (see Table 3).

Provision and use of personal protective equipment is the cornerstone of public health efforts to prevent non-intact skin exposure in healthcare workers (2), and provision of the equipment is required under the Bloodborne Pathogens Standard (5). Yet, in a previous analysis from this study, we found that 50% to 80% of paramedics were not always provided with leather gloves, fluid-impermeable lab coats, or fluid-impermeable disposable coveralls (16). The present findings of reduced risk of blood exposure with increased provision of the equipment highlight the need for greater provision. Future research should focus on factors limiting provision of the equipment as well as factors limiting the effectiveness of the Bloodborne Pathogens Standard in ensuring that the equipment is provided.

Supervisory behaviors that emphasize safe work practices had a moderate to strong effect on the risk of exposure. Paramedics whose job evaluation criteria included following

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TABLE 3. Twelve-month risk (%) of non-intact skin blood exposure, by selected management practices and paramedic characteristics, U.S. paramedics, 2002–2003 ($n = 2,664$)

	Paramedic is subject to management practice			Paramedic is not subject to management practice			Risk ratio	
Management practice and paramedic characteristic	No. of cases	Risk	95% CI	No. of cases	Risk	95% CI	RR	95% CI
Provides 1+ types of PPE*	109	5.7	4.4–7.1	95	14	10–18	2.4	1.6–3.3
< 15 calls/7 days	46	4.3	2.4–6.2	47	15	12–18	3.3	1.9–4.8
15+ calls/7 days	59	7.4	4.4–10	41	15	7.6–23	2.0	0.7–3.4
Age <30 yr	16	3.1	0–6.5	21	17	12–21	5.5	0–12
Age 30+ yr	92	6.3	5.3–7.3	72	13	8.8–18	2.1	1.3–2.9
< 5 yr experience	20	3.9	1.4–6.3	29	18	11–24	4.6	1.2–7.9
5+ yr experience	87	6.2	4.6–7.8	64	13	9.2–17	2.1	1.3–2.9
Following safety procedures is part of job evaluation	137	7.2	5.6–8.9	59	13	8.2–19	1.8	1.0–2.7
Supervisor would speak to paramedic if he/she didn't follow UP	132	6.8	5.2–8.3	64	14	6.9–21	2.1	0.9–3.2
Following safety procedures is part of job evaluation and supervisor would speak to paramedic if he/she didn't follow UP	107	5.8	4.1–7.5	89	13	7.0–20	2.3	1.0–3.6
Provides >3 types of safety devices†	54	7.0	4.7–9.3	144	9.1	5.7–12	1.3	0.7–1.9

CI = confidence interval; RR = risk ratio; PPE = personal protective equipment; UP = Universal Precautions.
*PPE provided could be leather gloves, fluid-impermeable lab coats, and fluid-impermeable disposable coveralls.
†Devices provided could be safety versions of winged steel needles, lancets, prefilled or cartridge syringes, syringes (not prefilled or cartridge), and intravenous catheters.

safety procedures or whose supervisors actively responded to failure to follow Universal Precautions had approximately half the risk of paramedics who were not subject to these management practices (see Table 3). Previous research has shown that similar management practices have an important effect on injury rates among hospital workers (21), and this principle is recognized in the general occupational safety literature (22). Future research should develop interventions that apply general knowledge of management behaviors that promote worker safety to the work environment of paramedics (23–25).

Low precision prevented a full examination of the risks associated with paramedic characteristics and of modification of the effects of the management practices by these characteristics. The increased risk for paramedics who made more calls could be the result of elevated job demands, or it could simply reflect their greater opportunity for exposure. Further research is needed to understand the role of workload in increasing the risk of non-intact skin exposure among paramedics.

Potential Bias

The two major potential sources of bias in this study were differential response and differential recall. Potential response bias was examined in a sensitivity analysis based on the assumption that one group of cases had a lower response rate than other paramedics because they were concerned about suffering negative consequences if their employer learned of their exposure. Although such concern may be a source of response bias for needlesticks (1), in informal contacts with the research team paramedics tended to dismiss non-intact skin exposure as unimportant. Furthermore, paramedics did not report 62% of their non-intact skin exposures to their employer because "it was not a significant exposure," as opposed to other reasons, compared to 18% for needlesticks (26). This suggests that paramedics would not be concerned about their employer learning of their non-intact skin exposures. Nevertheless, because of the potential for response bias given the 55% response rate, the effect of possible differential response on the risk ratios was examined.

The literature on organizational environment and worker safety suggests that if one of the groups of cases had the above concern, it would have been cases who were not subject to the supervisory behaviors. The supervisory behaviors examined in this study are similar to factors that contribute to a positive safety climate; a positive safety climate is marked by encouragement from management to report blood exposures without suffering negative consequences (21). Consistent with this literature, paramedics who were subject to the supervisory behaviors indicated being more likely to report non-intact skin exposures and total blood exposures to their employers compared to paramedics who were not subject to the supervisory behaviors (approximately 38% vs. 18%–23% for non-intact skin exposures and 56% vs. 43% for total blood exposures (26)). Furthermore, the three opinion questions are similar to items typically included in safety climate scales (8, 27). As reported above, paramedics who were subject to the supervisory behaviors were more likely to respond to these questions in a manner compatible with a positive safety climate.

The sensitivity analysis suggests that if nonresponse were, in fact, greater among cases who were not subject to the supervisory behaviors, the true risk ratios would be higher than the risk ratios shown in Table 3. This, in turn, suggests that the true effects of the management practices are at least as great as the effect estimates found in this study. It is

possible, however, that the assumption about which group of cases is underrepresented in the sample is erroneous, in which case any bias would be in the opposite direction. In that case, the sensitivity analysis would suggest that the effects found in this study are overestimates. It is important to note that the bias under either assumption is small.

Paramedics were asked to recall non-intact skin exposures over the past 12 months. If, as suggested above, they attached little importance to these exposures, it seems likely that recall would be incomplete and the risks found in this study would be underestimates. If paramedics who were subject to the supervisory behaviors had greater recall because they were encouraged by their management to note and report such exposures, the risk ratio estimates would be biased toward the null, making the risk ratios shown in Table 3 lower than the true risk ratios.

Finally, it seems likely that there was some misclassification with respect to the management practices for both cases and non-cases. One could argue that the mechanism generating the misclassification was unlikely to be related to the management practices and therefore the misclassification would be nondifferential. In any event, the small number of ambiguous cases and the slight impact on the results of excluding those cases suggests that any bias from this source would be minor. Considering all of the above potential sources of bias together, the strongest conclusion is that the effects of the management practices found in this study may be underestimates to some degree, but they are unlikely to be overestimates. Thus, they provide a reasonable basis for developing policy and intervention programs.

CONCLUSIONS

Paramedics who are provided with appropriate personal protective equipment are half as likely to experience a non-intact skin exposure as paramedics who are not provided with the equipment. Thus, this study supports the conclusion that providing personal protective equipment is an effective means of preventing bloodborne infections from non-intact skin exposure in paramedics. Public health guidelines and occupational health regulations call for the provision of this equipment, but many paramedics are not receiving the benefit of these guidelines and regulations. Future research should aim to identify factors limiting the provision of this equipment and to evaluate the advisability of interventions to increase provision.

Supervisory behaviors that emphasize safe work practices had a moderate to strong effect on the risk of non-intact skin exposure. Future research should develop interventions that apply general knowledge of management behaviors that promote worker safety to the work environment of paramedics.

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