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Blood-Borne Pathogens among Firefighters andEmergency Medical Technicians

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COLLECTIVE REVIEW

BLOOD-BORNE PATHOGENS AMONG FIREFIGHTERS AND EMERGENCY MEDICAL TECHNICIANS

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ABSTRACT

Objective. Firefighters and emergency medical services (EMS) personnel have the potential for occupational exposures to blood, which increases their risk for occupational blood-borne infection. To address this concern, the authors conducted a literature review of occupational blood exposures, the seroprevalence of blood-borne pathogens among these workers, and the seroprevalence of blood-borne pathogens among the patients they serve. **Methods.** A MEDLINE search was conducted, and all identified articles that described surveys of exposures to blood or surveillance of blood-borne infections among firefighters and/or emergency medical technicians (EMTs) in the United States were reviewed. For hepatitis B, only seroprevalence surveys conducted after the 1992 requirement by the Bloodborne Pathogens Standard to offer vaccination to potentially exposed employees were included. **Results.** From these data, the expected number of annual occupational hapatitis C virus seroconversions was estimated to be between 5.8 and 118.9 per 100,000 employee-years for EMT–paramedics, between 3.4 and 33.7 per 100,000 for firefighter–EMTs, and up to 3.6 per 100,000 for firefighters (non-EMT). **Conclusions.** This review suggests there are a limited number of studies addressing this issue, and these studies have numerous limitations. Despite the expected occupational seroconversions and recognizing the limitations in drawing conclusions from these studies, it appears that firefighters and EMS personnel do not have an elevated seroprevalence of hepatitis C virus compared with the general population. Improved exposure surveillance programs would clarify exposure risks and identify potential interventions for firefighters and EMS personnel. **Key words:** occupational health; blood-borne pathogens; emergency medical technicians; firefighters; exposure; hepatitis.

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In the course of their work, firefighters, emergency medical technicians (EMTs), and EMT–paramedics have the potential for exposure to blood-borne pathogens such as human immunodeficiency virus (HIV), hepatitis B virus (HBV), and hepatitis C virus (HCV). While the presence of blood at the worksite and the opportunity for exposure are universally recognized, less attention has been paid to these workers' risk of exposure to blood than to that of other health care workers. In 2001, Rischitelli et al.[1] published a review of the risk of acquiring HBV and HCV among law-enforcement, correctional, fire, and emergency medical services (EMS) personnel. Like the Rischitelli article, the present paper reviews the medical literature on the risk of blood-borne infection among firefighters and EMTs but also includes a focus on the limitations of the data and an estimate of the annual number of occupationally acquired cases of HIV and HCV.

Fire department personnel respond to fires, nonfire emergencies, and medical emergencies. Responding to medical emergencies is as much a part of a firefighter's job today as fire suppression. For example, in 2003, 83% of all runs made by the Fire Department of New York's fire service and EMS combined were for medical reasons,[2] and in 2002, 78% of the Phoenix Fire Department's runs were EMS calls.[3] In response to this evolving function, most career fire departments are staffed by firefighters with some level of EMT certification.[4–7] In 2002, between 273,850 and 291,650 career firefighters were employed in the United States.[6–8] Fire departments staffed by volunteer firefighters encourage, but seldom require, EMT certification.[7] In 2002, there were an estimated 816,600 volunteer firefighters.[7]

Emergency medical technicians may work for fire departments, other public agencies, hospitals, or private companies. There are several levels of EMTs: basic (EMT-B), intermediate (EMT-I), and paramedic

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(EMT-P).[9] These increasing levels of EMT certification correspond to increasing levels of responsibility. Paramedics perform advanced life support (ALS) procedures, including starting intravenous (IV) lines, endotracheal intubation, blood drawing, and injection of medications.[4,9,10] Other EMTs can perform similar ALS tasks if authorized by state regulations, but at a minimum, they provide basic life support (BLS), first aid, patient stabilization, assistance to paramedics, transport of patients to hospitals, ambulance cleanup, and other functions. In 2002, an estimated 179,000 EMTs worked in the United States.[9,11]

Unique Exposure Risks

Emergency medical technicians perform life support and other functions under unpredictable and adverse conditions that potentially increase the risk of exposure to blood and other body fluids. As with other health care workers, EMTs are at risk for needlestick injuries (NSIs) when establishing IV lines, drawing blood, giving injections, or assisting in these procedures. However, EMTs face the additional disadvantage that these procedures are performed under emergency circumstances in uncontrolled locations, such as in a moving ambulance, at an accident scene, or in locations with confined space or limited visibility. In addition, many emergency medical calls are for traumatic injuries where patients may be covered with broken glass, and adjacent materials may have sharp edges. Victims may be experiencing uncontrolled bleeding and may be disoriented or combative and injure the EMTs on the scene.[10,12] Under such circumstances, these workers may have a greater potential for exposure to blood, including skin exposure to large quantities of blood (although blood exposures on intact skin are not considered a risk), than health care workers in more controlled circumstances.

As firefighters and EMTs work in the field under uncontrolled circumstances, they face logistic problems in adhering to universal precautions: using and changing gloves (especially if they are punctured at the scene), wearing impervious gowns and protective eyewear, disposing of sharp instruments in a sharps disposal container, and frequently washing their hands. In the past, before concern about blood-borne infections was heightened, EMTs seldom used gloves and other protective clothing or eyewear, frequently got blood on their skin, and were more likely to sustain potential mucous membrane exposures from performing mouth-to-mouth resuscitation without protection.

Because of the potential for occupational exposure to infected blood by EMTs and firefighters and speculation about excessive rates of HCV infection among these workers,[13,14] a literature review of their occupational exposures to blood, prevalence of infection among the patient populations they serve, and seroprevalence surveys for HIV, HBV, and HCV was conducted.

METHODS

Reviews were conducted by two authors (WLB and TH). Articles describing occupational exposure or seroprevalence surveys were identified by a MEDLINE search of the period 1966 to December 2003 using combinations of the terms "emergency medical technicians," "paramedics," "firefighters," "first responders," "public safety," "healthcare workers," "needlestick injuries," "sharps injuries," "occupational diseases," "occupational infections," "hepatitis," "HIV," and "blood-borne pathogens." Titles and abstracts were reviewed, and full-text articles were obtained for those that were possibly relevant. References listed in relevant articles were also reviewed for any additional papers. Papers were included in this review if they contained information on occupational exposures to blood among U.S. firefighters and EMTs or seroprevalence of HIV or HCV among these workers during this period or seroprevalence of HBV since 1992, when hepatitis B vaccination was required.

Articles describing the prevalence of HIV, HBV, and HCV among patients in the United States likely to be assisted by firefighters and EMTs were identified by a MEDLINE search covering the period 1982 to February 2001 using the terms "emergency service, hospital," "emergencies," "trauma centers," "hepatitis," "HIV," "seropositivity," "seroprevalence," and "seroepidemiologic studies." Titles and abstracts were again reviewed, and full-text articles were obtained for those that were possibly relevant. References listed in relevant articles were also reviewed for any additional papers.

Records were not kept on the total number of articles identified during each search; however, it was clear from the title and abstract whether an article contained data pertinent to this review. For these two searches, identified articles meeting the above criteria were included in this review.

RESULTS

Occupational Exposures to Blood

Several studies have examined exposures to blood among firefighters and EMTs. These are summarized in Table 1. To place the data in Table 1 in context, we provide the following information on exposure to blood among hospital workers. McCormick et al.[15] reported the following rates for NSIs and sharps injuries per 1,000 employee-years for hospital workers between 1987 and 1988: environmental services 305.8, nursing personnel 196.5, laboratory personnel 169.9, houseofficers 150.3, and all workers combined 187.8. Reddy and

TABLE 1. Exposures to Blood among Emergency Medical Technicians and Firefighters

Location and Exposure Period	Needlestick Injuries per 1,000 Employee-Years	Mucous Membrane Exposures per 1,000 Employee-Years	Skin Contacts[a] per 1,000 Employee-Years
St. Louis, 1982–1985[17]	Paramedics: 181 Basic EMTs: 87 All EMS: 145		
Florida, 1987[18]	Paramedics: 367[b]		
Portland, 1988–1989[4]	Firefighter–EMTs: 104		
New York City, Chicago, Baltimore, 1989[19]	All EMS: 200[b]	All EMS: 0[c]	All EMS: 12,100[b]
Atlanta, 1991[21]	EMPs: 95[b] Firefighters: 0[d]	EMPs: 63[b] Firefighters: 13[b]	EMPs: 1,222[b] Firefighters: 527[b]
Baltimore, 1992[22]	All EMS: 56[b]		
Fulton County, 1992–1993[23]	Firefighters: 11[b]	Firefighters: 11[b]	Firefighters: 497[b]
Dade County, 1993–1994[24]	Paramedics: 180[b] EMTs: 30[b]	Paramedics: 5,400[b] EMTs: 1,320[b]	Paramedics: 26,640[b] EMTs: 13,680[b]
Tucson, 1998–2000[26]	Firefighters and Paramedics: 16.8[e], 4.2[f]		

EMTs = emergency medical technicians; EMS = emergency medical services; EMPs = emergency medical providers.
[a] All skin contact with blood (both intact and nonintact).
[b] Calculated from data presented in original paper.
[c] 0 mucous membrane exposures among 933 EMTs over an eight-month period.
[d] 0 needlestick injuries among 611 firefighters over a six month period.
[e] Nonretracting lancets were in use.
[f] Retracting lancets were in use.

Emery[16] analyzed NSIs among hospital workers at the Veterans Administration Medical Center in Houston, and from their data we calculated that workers experienced 105.8 NSIs per 1,000 employee-years in 1994 before a needlestick prevention and safety device program was instituted. In 1999, several years after this program began, they experienced 41.8 NSIs per 1,000 employee-years.

Hochreiter and Barton[17] analyzed all NSIs reported to the emergency department of St. Louis City Hospital from February 1982 through March 1985 by basic EMTs and paramedics of the St. Louis Emergency Medical Service. Forty-four NSIs were reported by 43 individuals for an overall incidence of 145 NSIs per 1,000 employee-years (181 NSIs/1,000 employee-years for paramedics and 87 NSIs/1,000 employee-years for basic EMTs, a statistically significant difference). Workers employed less than one year reported a disproportionately large percentage of the NSIs. Seventeen NSIs occurred while performing medical procedures (seven starting an IV, four drawing blood, four administering medications, and two performing cardiopulmonary resuscitation), 14 were due to improper needle disposal, four occurred while recapping needles, and nine occurred from other or unknown activities. When location where the NSI occurred was known, 48% occurred in the patient compartment of the ambulance, 38% in the patient's home, and 14% at the ambulance base station.

Klontz et al.[18] obtained information on NSIs experienced in 1987 from a questionnaire distributed in 1988 to a random sample of 500 Florida certified paramedics. Sixty-nine of the 300 respondents (23%) reported a total of 110 NSIs. Thirty-five percent of the NSIs occurred while recapping needles, 27% during medical procedures (21% inserting IV lines, 4% drawing blood, 1% giving an injection, 1% suturing), 21% from improper needle disposal, 10% during disposal without recapping, 3% from transferring blood samples, and 3% while reaching out with or passing a needle. Seventy percent of the NSIs occurred in the ambulance (36% in a moving ambulance), 16% in the patient's home or on the street, and 9% in a hospital emergency department. In order to provide a rough comparison with the data reported by Hochreiter and Barton,[17] we have calculated that if the 300 respondents worked full time in 1987, their 110 NSIs were equivalent to 367 NSIs/1,000 employee-years.

Reed et al.[4] tracked exposures to blood and body fluids during 1988 and 1989 among firefighter–EMTs (all levels of EMT) of the Portland (Oregon) Fire Bureau. Over two years there were 14 needlesticks, 15 eye splashes, eight mucous membrane exposures, 38 contacts with nonintact skin, and 120 exposures to intact skin. There were 104 NSIs per 1,000 employee-years and 0.24 NSIs per 1,000 EMS calls. The incidence of NSIs, nonintact skin exposures, and mucous membrane exposures combined was 1.3/1,000 EMS calls, of which the rate was 1.1/1,000 ALS calls and 1.4/1,000 BLS calls. Seventy-one percent of the NSIs were reported by ALS personnel, although they comprised only 9% of the Bureau's EMTs; thus, paramedics (who perform ALS) seemed to have an increased risk of NSIs compared with EMTs.

Marcus et al.[19] interviewed a sample of EMS workers (EMTs, paramedics, cardiac technicians, and others) in Chicago, New York, and Baltimore over an eight-month period in 1989 as their work shifts ended. During this period, the EMS workers reported 61 skin contacts with

blood and one NSI. Thus, EMS personnel reported one NSI per 1,256 worker-shifts and were estimated to have 0.2 NSI/year. We calculated this annual rate was equivalent to 200 NSIs/1,000 employee-years, and the rate for all skin contacts was 12,100/1,000 employee-years.

In 1991, Tandberg et al.[20] reported that surveyed Albuquerque EMTs reported an average of 1.8 NSIs and sharps injuries over a five-year period in comparison with emergency nurses, who reported an average of 2.8, and emergency physicians, who reported an average of 3.8; the difference between emergency physicians and EMTs was statistically significant.

Woodruff et al.[21] surveyed 870 firefighters and emergency medical providers (EMPs) employed by the Atlanta Fire Department in 1991 on exposures to blood within the prior six months. EMPs were defined as workers who spent at least 20% of their time providing emergency medical care; others were classified as firefighters. Of the respondents, six (4.9%) of 126 EMPs and none of 611 firefighters reported NSIs. Four (3.2%) EMPs and four (0.6%) firefighters reported mucous membrane exposure, and 77 (62.1%) EMPs and 161 (26.8%) firefighters reported skin contact with blood. We calculated from the data presented that the exposure rates per 1,000 employee-years for EMPs were 95 NSIs, 63 mucous membrane exposures, and 1,222 skin contacts; for firefighters, the rates were 0 NSI, 13 mucous membrane exposures, and 527 skin contacts.

Gershon et al.[22] conducted a chart review of injury reports of EMS field workers employed in 1992 by a Baltimore County fire department. One hundred ninety-seven EMS field workers reported a total of 11 NSIs. We calculated this was equivalent to 56 NSIs/1,000 employee-years.

In 1992–1993, Averhoff et al.[23] surveyed 189 firefighters employed by the Fulton County, Georgia, Fire Department who spent less than 20% of their time performing EMT duties and who had participated in either blood-borne pathogen training or an HBV vaccination campaign. They were asked about occupational exposures to blood and body fluids in the prior six months. One NSI, three cuts with contaminated objects, no human bites, one mucous membrane exposure, and 47 blood contacts with intact skin were reported by the 189 firefighters. We calculated from the data presented that the exposure rates per 1,000 employee-years were 11 NSIs, 32 cuts with contaminated objects, 11 mucous membrane exposures, and 497 intact skin contacts.

Carrillo et al.[24] conducted a mailed survey to all 1,250 Metro–Dade Fire Service personnel (paramedics, EMTs, firefighters) in 1994. Questionnaires were returned by 296 respondents (24%). The 12-month mean of NSIs reported by the paramedics (0.18) was statistically significantly greater than the mean for the EMTs (0.03). The paramedics' reported 12-month mean for cuts (1.33) was not significantly different from that for the EMTs (1.34). The paramedics also reported significantly more scratches or abrasions over the prior 30 days (0.95) than the EMTs (0.58) and significantly more blood contact with skin (2.22 vs. 1.14). Other reported mean exposures to blood in the prior 30 days were nonsignificantly elevated among the paramedics compared with the EMTs (NSIs 0.03 vs. 0, cuts 0.40 vs. 0.37, and mucous membrane exposures 0.45 vs. 0.11). Using data presented in the paper, we calculated that the paramedics experienced exposures to blood at the following rates per 1,000 employee-years: 180 NSIs, 5,400 mucous membrane exposures, and 26,640 skin contacts with blood. We calculated that the EMTs experienced the following exposures per 1,000 employee-years: 30 NSIs, 1,320 mucous membrane contacts, and 13,680 skin contacts.

Upfal et al.[25] screened Detroit firefighters, EMS personnel, and police officers for HCV and administered a questionnaire asking about occupational and nonoccupational risk factors for HCV. Occupational encounters with blood or body fluids at least once a year were reported by 67.6% of the respondents; 37.6% reported exposures more than five times per year. Almost 60% had experienced a percutaneous or mucosal exposure. These percentages are for the respondents as a whole, a group that comprised 63.8% police, 27.7% firefighters, and 8.5% EMS personnel (their exposures were not stratified by occupation).

Peate[26] conducted a study that in part evaluated an intervention to reduce percutaneous injuries among EMS workers at the Tucson Fire Department from glucometer lancets used for blood glucose testing, which were responsible for the majority of sharps injuries at this department. For the two years preceding the introduction of a self-retracting lancet, lancet sticks occurred at the rate of 17/1,000 employee-years. During the first 12 months of use of a self-retracting lancet, lancet sticks occurred at the rate of 4/1,000 employee-years.

Seroprevalence of HIV, HBV, and HCV among Source Patients

The patients/victims whom EMTs and firefighters encounter have a higher seroprevalence of HIV, HBV, and HCV, on average, than the general U.S. population, although prevalences vary geographically (Table 2).

Expected Number of Occupational Seroconversions

The expected numbers of occupational seroconversions to HIV and HCV were estimated from the limited data available. These rates were calculated by multiplying exposure rates (NSIs) by ranges of patient seroprevalence by average occupational seroconversion rates for HIV and HCV. HBV seroconversion rates were not estimated due to the increasing use of hepatitis B vaccine. Since transmission rates for HIV and HCV are higher and better defined for needlesticks than for other routes

TABLE 2. Seroprevalence of HIV, HBV, and HCV among Emergency Department and Emergency Medical Services Patients and the General Population

Location and Date of Data Collection	HIV	HBV	HCV[b]	At Least One Virus	Source Patients
Johns Hopkins Hospital, Baltimore, 1986[53]	3%				Consecutive adult critically ill or severely injured patients from the emergency department of an inner-city, Level I trauma center
Johns Hopkins Hospital, Baltimore, 1987[54]	5.2%				Consecutive adult patients from the emergency department of an inner-city, Level I trauma center
University of Maryland, Baltimore, 1987–1988[55]	1.7%				Consecutive patients of shock trauma center
Johns Hopkins Hospital, Baltimore, 1988[56,57]	6% overall, 4% of those arriving by ambulance	5%[a]	18%	24%	Consecutive adult patients from the emergency department of an inner-city, Level I trauma center
Portland, Oregon, 1988[58]	0.45%	12%[c] 0.6%[a]		13%	All emergency department patients requiring phlebotomy from seven metropolitan hospitals
Henry Ford Hospital, Detroit, 1988–1989[59]	4.1%				Adult, critically ill, resuscitated, urban emergency department patients
New York City, Chicago, Baltimore, 1989[60]	6.7%[d] 0.47%[e]				Sample of emergency department patients in one inner-city and one suburban hospital from each of three cities with high AIDS incidences
New York City, Chicago, Baltimore, 1989[19]	8.3% 7.7% 4.1%				Patients transported by ambulance to three inner-city emergency departments
California, 1989[61]	1.4% average, 0–2.8% range	2.6% average, 0–6.1% range[a]			Trauma victims >12 years old admitted to one of ten California hospitals through the emergency department
Medical University of South Carolina, Charleston, 1990[62]	3.2%	1.7%[a]	7.7%	12.6%	Consecutive adult trauma patients seen in an urban tertiary referral center
HCA Wesley Medical Center, Wichita, 1987–1991[63]	0.15%				Consecutive patients from a Level II trauma center
Seattle, 1989–1993[64]	0.5%				Adults treated for out-of-hospital cardiac arrest by paramedics
University of Maryland Medical Center, Baltimore, 1993[65]	4%	20%[c]	14%	26%	Shock trauma unit patients
Los Angeles County–UCLA Medical Center, 1990[66]	2.1%				Inner-city emergency department patients not previously identified as HIV-positive
General population	0.32%[67]	4.9%[f,68] 0.42%[g,68]	1.8%[39]		

HIV = human immunodeficiency virus; HBV = hepatitis B virus; HCV = hepatitis C virus; AIDS = acquired immunodeficiency syndrome.
[a] HBsAg (HBV surface antigen).
[b] Anti-HCV (antibody to HCV).
[c] HBcAB (antibody to HBV core antigen).
[d] Mean for four high-HIV-seroprevalence hospitals.
[e] Mean for two low-HIV-seroprevalence hospitals.
[f] Past and chronic HBV infections.
[g] Chronic HBV infection (HBsAg and HBcAB).

of exposure, only needlestick rates were used.[27–29] The estimate focused on EMT–paramedics because the literature suggests they have the highest NSI rates (Table 1), firefighter–EMTs because many fire departments currently require firefighters to be certified EMTs, and firefighters who are not EMTs (non-EMT). Finally, an assumption was made that postexposure prophylaxis was not available for HIV; this treatment would have reduced (prevented) seroconversion.

Table 3 presents the calculations for HIV. We would expect between 0.1 and 9.1 seroconversions among EMT–paramedics per 100,000 employee-years, between 0.1 and 2.6 for firefighter–EMTs, and less than 1 for firefighters (non-EMT). For HCV (Table 4), we would expect between 5.8 and 118.9 seroconversions per 100,000 employee-years for EMT–paramedics, 3.4 to 33.7 for firefighter–EMTs, and up to about 3.6 for firefighters (non-EMT).

Serosurveys of Firefighters and EMTs

HIV/AIDS

For HIV/AIDS, the Centers for Disease Control and Prevention (CDC) obtains information on occupational infections among health care workers, including EMTs

TABLE 3. Expected Seroconversions to HIV Following an Occupational Needlestick Injury (NSI)

Occupation	NSI Exposure Rate per 1,000 Employee-Years[a]		Source Patient Seroprevalence[b]		HIV NSI Seroconversion Rate[c]	Expected Seroconversions per 100,000 Employee-Years	
	Low Estimate	High Estimate	Low Estimate	High Estimate	Average	Low Estimate	High Estimate
EMT–paramedics	180	367	0.15%	8.3%	0.3%	0.1	9.1
Firefighter–EMTs	104		0.15%	8.3%	0.3%	0.1	2.6
Firefighters (non-EMT)	0	11	0.15%	8.3%	0.3%	0	0.3

HIV = human immunodeficiency virus; EMT = emergency medical technician.
[a] From Table 1.
[b] From Table 2.
[c] From Reference 51.

(but not firefighters). Documented occupational transmissions are defined as cases in which a health care worker reported an occupational exposure to blood or body fluids, was HIV-negative at baseline, had a documented seroconversion following exposure, and had no other identifiable risk factors for HIV infection. Possible occupational transmissions are defined as cases in which a health care worker reported a percutaneous or mucocutaneous occupational exposure and had no other identifiable risk factors for HIV infection, but HIV seroconversion resulting specifically from an occupational exposure was not documented (Beltrami E, CDC, personal communication, June 2001).

As of December 2002, of 57 documented occupational transmissions of HIV/AIDS, none occurred among EMTs or EMT–paramedics. However, among 139 possible occupational transmissions of HIV/AIDS, 12 occurred in EMTs or EMT–paramedics.[30] It should be noted that the CDC's case definitions for both documented and possible occupational transmission are definitions by exclusion; the presence of any other risk factor precludes occupational transmission. This exclusionary case definition underestimates occupational transmission, particularly given that many occupational exposures go unrecognized or unreported.[20,31] This review was unable to find any published serosurveys of HIV/AIDS among firefighters or EMS personnel.

HBV and HCV

There is no national surveillance of occupational HBV or HCV infection among EMTs and firefighters, and few serosurveys of HBV among emergency response workers have been published since the Occupational Safety and Health Administration (OSHA) Bloodborne Pathogen Standard required vaccination of potentially exposed workers starting in 1992. On the other hand, several serosurveys of HCV prevalence among firefighters and EMTs have been conducted (Table 5).

In 1991, Woodruff et al.[21] conducted a cross-sectional HBV serosurvey of firefighters and EMPs employed by the Atlanta Fire Department. Of the 870 eligible participants, 68.0% provided blood samples and completed the questionnaire; 80.5% of these were firefighters, and 19.5% were EMPs. The researchers found no significant difference of past or current HBV infection between firefighters (7.6%) and EMPs (8.7%). Occupational exposures to blood (percutaneous, mucous membrane, bite, or skin exposure) were assessed only for the previous six months; none was significantly associated with HBV infection. In 2000, researchers at the CDC analyzed stored blood from this study for antibody to HCV (anti-HCV) using enzyme immunoassay (EIA) 3.0 and recombinant immunoblot assay (RIBA) 3.0.[32] Blood from 74% of the original 592 samples (combined firefighters and EMPs) was analyzed; 2.1% was anti-HCV-positive. HCV infection was associated with sexually transmitted disease, but not with occupational risk factors, blood transfusion, or illicit drug use.

In 1992–1993, Averhoff et al.[23] conducted a cross-sectional HBV serosurvey of firefighters employed by the Fulton County, Georgia, Fire Department and law-enforcement personnel employed by other agencies. Of 306 firefighters who were invited to participate in a blood-borne pathogen training session and/or a

TABLE 4. Expected Seroconversions to Hepatitis C Virus (HCV) Following an Occupational Needlestick Injury (NSI)

Occupation	NSI Exposure Rate per 1,000 Employee-Years[a]		Source Patient Seroprevalence[b]		HCV NSI Seroconversion Rate[c]	Expected Seroconversions per 100,000 Employee-Years	
	Low Estimate	High Estimate	Low Estimate	High Estimate	Average	Low Estimate	High Estimate
EMT–paramedics	180	367	1.8%	18%	1.8%	5.8	118.9
Firefighter–EMTs	104		1.8%	18%	1.8%	3.4	33.7
Firefighters (non-EMT)	0	11	1.8%	18%	1.8%	0	3.6

EMT = emergency medical technician.
[a] From Table 1.
[b] From Table 2.
[c] From Reference 51.

TABLE 5. Prevalence of Hepatitis C among Firefighters and Emergency Medical Technicians (EMTs)

Location	Year of Data Collection	Occupational Category	Prevalence of Antibody to Hepatitis C Virus		Occupational Risk Factors Assessed	Nonoccupational Risk Factors Assessed
			n/Total	%		
Atlanta[21,32]	1991	EMPs and firefighters	9/437	2.1[a]	√	√
Maryland[33,34]	<1994	Career firefighters and paramedics	5/225	2.2[a]	√	
		Career and volunteer firefighters and paramedics	9/532	1.7[b]		
Ohio[35]	1992	EMS workers	1/107	0.9		√
Connecticut[32,36]	1992	Firefighters and other public safety personnel	5/382	1.3[a]		
Tucson[26]	1998	Firefighters and paramedics	7/477	1.5[a]	√	
Philadelphia[32]	1999	Firefighters	64/2,136	3.0[a]		√
Miami[32,37]	2000	Firefighters, paramedics, and EMTs	35/1,314[c]	2.7[b]	√	
			70/3,362[d]	2.1		
Pittsburgh[32]	2000	Paramedics	5/154	3.2[b]	√	
Detroit[25]	<2001	EMS	6/209	2.8[b]	√	√
		Firefighters	16/678	2.3[b]		
Oregon[38]	<2002	Firefighters and EMTs	5/411	1.2[a]	√	√

EMPs = emergency medical personnel; EMS = emergency medical services.
[a] EIA (enzyme immunoassay) with supplemental RIBA (recombinant immunoblot assay).
[b] EIA only.
[c] Preliminary data.
[d] Complete data.

hepatitis B vaccination campaign, 189 met the inclusion criterion of spending less than 20% of their time working as an EMT and agreed to answer a questionnaire; of these, 178 had their blood drawn. The prevalence of HBV infection was 4.3% among the firefighters. Occupational exposures to blood were assessed only for the previous six months and were not associated with HBV infection by multivariate analysis (which included law-enforcement personnel).

A questionnaire and serosurvey of HBV and HCV was conducted among career and volunteer firefighters and paramedics of the Anne Arundel County, Maryland, Fire Department prior to initiation of a hepatitis B vaccination program. Among career and volunteer workers combined, the prevalence of anti-HCV was 1.7% by EIA, and the prevalence of past HBV infection was 3.2%.[33] Among career workers, the prevalence of anti-HCV was 2.2% by EIA and RIBA, and the prevalence of past HBV infection was 4.4%.[34] The prevalence of HCV and HBV infections was not associated with age, gender, or duration of service; prevalence of HCV and HBV was nonsignificantly associated with history of percutaneous exposure to hepatitis B and frequent controlling of bleeding.[34]

In 1992, Werman and Gwinn[35] conducted a questionnaire and serosurvey of HBV and HCV among career and volunteer personnel of the Coshocton County Emergency Medical Services in rural Ohio as part of a hepatitis B immunization program; workers were excluded if they had been previously immunized or had a diagnosed infection with HBV or HCV. The county is served by 110 volunteer basic EMTs, ten paramedics, and 200 public-safety first responders. The study participants comprised 102 EMTs, one paramedic, and four first responders; none of the workers were excluded for previous HCV infection. One sample tested positive for both HBV and HCV; this worker had previously received a blood transfusion.

In 1992, Roome et al.[36] tested Connecticut public-safety workers who had been vaccinated for hepatitis B within the previous six months in order to assess the adequacy of their antibody response. The majority were firefighters; others were EMS, police, and miscellaneous town employees. No information on occupational or nonoccupational risk factors for blood-borne infections was collected. Approximately 27% were volunteers rather than paid staff. In 2000, the CDC tested stored blood from 382 of the original 528 workers in this study for anti-HCV using EIA 3.0 and RIBA 3.0; 1.3% of this group of workers was positive.[32]

Peate[26] reports that in 1998, 477 active-duty EMS personnel (firefighters and paramedics) at the Tucson Fire Department underwent baseline screening for HCV antibody and hepatitis B surface antigen and antibody. Seven (1.5%) were confirmed anti-HCV positive by RIBA 2.0 and qualitative polymerase chain reaction (PCR). No new infections were detected in 1999–2000 when the workers were retested. Two workers were positive for hepatitis B surface antigen in 1998, but no additional case was detected at retesting in 1999–2000.

In 1999, the Philadelphia Firefighters Union conducted an HCV screening of its active and retired members through a biomedical company that markets a home testing kit. In 2000, the CDC reanalyzed the results from this survey, which had used EIA 3.0 and RIBA 3.0, and reported that 3.0% of the workers were anti-HCV-positive. History of blood transfusion before 1992 and illicit drug use were significantly associated with HCV infection.[32] Participants were asked about nonoccupational, but not occupational, risk factors.

In 2000, researchers at the University of Pittsburgh and a patient advocacy group screened Miami–Dade County fire department firefighters, paramedics, and EMTs for HCV. No data on nonoccupational risk factors were collected. Using EIA 3.0 only, 2.7% were positive for anti-HCV. No information was provided on how occupational risk factors were assessed, but infection was reportedly not associated with exposures to blood, occupation, or duration of employment.[32] An abstract was subsequently published describing additional findings on Florida public-safety personnel screened during the hepatitis C education program. A total of 3,362 participated, 85% of whom were firefighter/paramedics. The prevalence of HCV antibody was 2.1%. Of the HCV antibody-positive workers, 81.4% reported a history of occupational exposures to blood or body fluids; 40% had experienced NSIs.[37]

Also in 2000, the same University of Pittsburgh researchers reported that 3.2% of Pittsburgh paramedics were positive for HCV by EIA 2.0. No data on nonoccupational risk factors were collected. Occupational exposures to blood were not associated with anti-HCV infection.[32]

In 2001, Upfal et al.[25] reported an HCV screening among Detroit firefighters, EMS workers, and police. Participation rates were 48% for firefighters ($n = 678$) and 70% for EMS ($n = 209$). Using EIA-2, the prevalences of anti-HCV were 2.3% among firefighters and 2.8% among EMS. The survey did not include questions on injection/illicit drug use or high-risk sexual activity. The strongest predictor for HCV in the study's final model was occupation in EMS [odds ratio (OR) = 9.46, $p = 0.00$] or as a firefighter (OR = 5.18, $p = 0.00$), compared with police officers. Surprisingly, the frequency of encountering blood (OR = 1.38, $p = 0.33$ for firefighters; OR = 1.03, $p = 0.97$ for EMS) or percutaneous/mucosal exposure was not significantly associated with infection (ORs not provided); however, details on how occupational exposures were assessed were not provided.

In 2002, Rischitelli et al.[38] reported a RIBA-confirmed HCV seroprevalence of 1.2% [$n = 5$, 95% confidence interval (CI), 0.4–2.8%] among 411 active urban and rural Oregon firefighters and EMTs. In tests that also included 308 other public-safety workers, no association was found with length of employment, NSIs, or other occupational exposures to blood. Five nonoccupational risk factors were assessed in a single yes/no question, which was also not significantly associated with HCV-positive status (OR = 4.33; 95% CI, 0.40–27.07).

Healthy Worker Effect

Injection/illicit drug use is a major risk factor for HCV infection.[39–41] As job applicants, firefighters and EMTs are typically screened for illegal drug use. Applicants with positive drug tests are excluded from entering the workforce. For example, this was the policy in Detroit and in four of the five fire departments reported in the *MMWR*[32] (personal communication with the Philadelphia, Miami–Dade, Pittsburgh, Atlanta, and Detroit fire departments, 2000). (The fifth survey was a statewide sample of public-safety personnel, and information about departmental drug screening policies could not be ascertained.) Although such drug screens do not rule out past or prevent future illicit drug use, their use attracts employees less likely to use illicit drugs. In fact, studies found that between 0% and 0.8% of first responders reported ever using injection drugs,[21,35,42] while a national survey found that 1.7% of men in the general population reported ever using injection drugs.[43] Because firefighters and EMS personnel are less likely to use illegal drugs, studies of these occupations should find a lower prevalence of HCV infection, absent an occupational source, than the general population.

Career emergency first responders in many fire departments undergo preplacement and periodic medical evaluations. These evaluations typically include tests of liver function. Many volunteer firefighters undergo a similar preplacement medical evaluation, and some volunteers undergo a periodic medical evaluation. Due to the heavy physical demands placed on firefighters, those with advanced liver disease (coagulopathy, cirrhosis, or chronic active hepatitis) are probably precluded from entering the workforce or may be required to exit the workforce.[44] This could reduce the prevalence of HCV infection in active-duty emergency first responders. However, only about 50% of people who are HCV-seropositive have abnormal liver function tests, and most are mildly abnormal and clinically asymptomatic, even after 20 years. Therefore, it is unlikely that this type of selection bias significantly affected the HCV seroprevalence among firefighters and EMTs.

DISCUSSION

This review suggests there are limited data in the peer-reviewed literature to adequately describe the rate of exposure to blood among firefighters and EMTs or to assess whether their occupational risk for blood-borne infection puts them at greater risk than the general population for infection with HIV, HBV, or HCV.

Regarding exposure, only nine published reports provide rates of exposure to blood among EMS personnel and firefighters (Table 1). The limited data in this table suggest that paramedics have higher rates of NSI, mucous membrane, and skin exposure than other EMTs and that EMTs in general have higher rates for all these routes of exposure than firefighters who lack EMT certification. This pattern is consistent with the duties of these occupations. The observed variability in rates may be due to underreporting of exposures (as has been substantiated among health care workers),[20,31]

participation or recall bias, or the way in which employees were grouped by occupation. There is a need for employers to encourage employees to report all exposures to blood and potentially infectious body fluids and for more exposure surveys to be conducted. Preferably, these would utilize more than one denominator where feasible (e.g., person-time, runs, patients cared for, devices used, procedures performed), so findings from different studies could be compared, and would calculate rates by all routes of exposure separately by job title.

Regarding the risk of HCV infection, although most of the ten serosurveys reviewed (Table 5) concluded that firefighters and EMS personnel do not have elevated HCV seroprevalence compared with the general population and/or occupational exposures that were associated with HCV seroprevalence, these surveys have too many limitations (described below) to develop an evidence-based opinion on these matters.

The first set of limitations involves study design and incomplete reporting issues. Most of the surveys were not designed as comprehensive studies of occupational and nonoccupational risk factors for prevalence of hepatitis C among firefighters and EMS personnel. The Philadelphia[32] and Miami[32,37] surveys were HCV infection screening projects not originally intended to be prevalence studies (letter dated September 15, 2000, from Schaitberger HA, general president of the International Association of Fire Fighters, to the Secretary of the Department of Health and Human Services). Reports of three of the surveys (Philadelphia,[32] Miami,[32,37] and Pittsburgh[32]) consist only of single paragraphs; no complete, detailed report of these surveys has been published in the peer-reviewed literature.

The next set of limitations involves study participation. Only the Philadelphia[32] survey included retired workers; all of the other surveys may have underestimated prevalence of HCV if workers left their employment because of the effects of infection. Also, infection rates may have been underestimated if known seropositive workers did not participate, which was an issue raised for the Ohio[35] survey and asserted by the International Association of Fire Fighters for the Philadelphia[32] and Miami[32,37] surveys (letter dated September 15, 2000, from Schaitberger HA, general president of the International Association of Fire Fighters, to the Secretary of the Department of Health and Human Services). Thirdly, participation rates were reported for only the Atlanta[21] (68%), Detroit[25] (firefighters 48%, EMS 70%), Maryland[33] (40%), and Oregon[38] (92% for all public-safety workers) surveys. Lastly, participants in the Connecticut[32,36] survey may not have been representative of the state firefighter/EMS population because the analysis was limited to workers who had been vaccinated for hepatitis B in the previous six months, other occupations were included, and 27% of the participants were volunteers (and thus may have had fewer opportunities for exposure to blood than career employees).

The third set of limitations involves the assessment of occupational exposure. Details on how occupational exposures to blood were assessed was missing in most of these reports, and two of the surveys (Connecticut[32,36] and Philadelphia[32]) included no questions on occupational risk factors. Except for the Oregon survey,[38] when occupational exposures were evaluated, a comprehensive assessment of occupational exposures was not done or exposure history was not analyzed in conjunction with prevalence of HCV, and it is not clear whether these surveys distinguished on a career basis between high-risk workers who went out on emergency calls and low-risk office-bound workers. Information bias is an issue for most of these surveys, since self-reported exposure information was collected retrospectively. The Atlanta[21,32] investigation assessed only exposures to blood in the previous six months; only nine EMPs and eight firefighters reported any percutaneous, mucous membrane, or bite exposure to blood. Given the seroprevalence of HCV in the patient population, it is doubtful this study had sufficient power to detect an association between occupational exposures to blood and HBV or HCV, if one existed. The six-month period also may not have been representative of a worker's exposures over his or her entire career. As these infections may remain undiagnosed for a substantial period of time, it is important to take into consideration career exposures to blood, but from the information provided in the reports, it is not clear that any other than the Oregon,[38] Miami,[37] and possibly Detroit[25] and Maryland[34] investigations did so. In addition, as Table 1 suggests, exposure to blood may vary by occupation, probably because opportunities for exposure vary with the duties performed by each occupational group. Therefore, grouping different occupations together may have masked differences in exposure and seroprevalence. Small sample sizes and insufficient data on occupational risk factors collected, analyzed, or presented in these surveys do not allow conclusions about the potential contribution of occupational exposures to be made at this time.

The last set of limitations involves the assessment of nonoccupational risk factors. HCV is known to be associated with injection/illicit drug use, high-risk sexual activity, and blood transfusions before 1992, and varies by age and gender.[32,39] Five of the ten surveys (Connecticut,[36] Tucson,[26] Miami,[32,37] Pittsburgh,[32] and Maryland[33,34]) did not collect information on nonoccupational risk factors. The five surveys that did collect some of this information did not necessarily ask about all nonoccupational risk factors and did not consistently find an association with HCV. Selection bias is one possible explanation for these findings. Firefighters and EMTs undergo periodic medical examinations, are employed in physically demanding jobs, and are less

likely to use illegal drugs. Therefore, they are likely to be healthier than the average American, and the "healthy worker effect" should have modulated the effect of any increased occupational risk.

Data Needs

This review indicates that several different types of information would help elucidate the true occupational risk of HCV infection among firefighters and EMTs. One need is for a suitable referent population that matches firefighters and EMTs not only by age, gender, and employment status, but also by drug and health screening, which tend to make this occupational group healthier than average.[45] One report, by Upfal et al.,[25] does allow a comparison of HCV seroprevalence between police officers (a relatively suitable occupational comparison group) and firefighters and EMS workers. Using their data, we calculated a prevalence ratio of 3.8 (2.3%/0.6%) comparing firefighters with police and a prevalence ratio of 4.7 (2.8%/0.6%) comparing EMS workers with police. This indicates an increased seroprevalence among firefighters and EMS workers compared with police officers. In another report,[38] too few police officers ($n = 29$, all HCV-negative) were included with compare to the HCV prevalence of 1.2% among firefighters and EMTs. Datta et al.[46] combined and reanalyzed data from the Atlanta,[21] Connecticut,[36] and Philadelphia[32] surveys and found no difference in HCV prevalence compared with a referent group consisting of age- and gender-matched actively employed participants in the third National Health and Nutrition Examination Survey (NHANES III). While using an age- and gender-matched actively working referent group is a step in the right direction, this analysis was still subject to the limitations of the original surveys (e.g., participation bias), and the working population still had substantial differences from firefighters and EMTs (i.e., medical and physical requirements of the job and preemployment drug testing).

A second piece of helpful information would be the calculation of expected occupational HIV and HCV seroprevalence. The estimates generated from our review (Tables 3 and 4) are seroconversion rates, not seroprevalences. While HCV disease characteristics would allow an estimate of prevalence from incidence data (i.e., long disease duration), characteristics of the cohort (i.e., migration of firefighters/EMTs out of the study group or the fire service) would not.[47]

Another need is to compare the rate of new HCV infections among these occupational groups with that of a suitable reference group (e.g., possessing similar nonoccupational risk factors). Unfortunately, conducting such a study would be impractical due to sample size considerations. For example, in 2001 the CDC estimated 3,866 new acute cases of HCV; after adjusting for underreporting and asymptomatic infections, they estimated 25,000 new HCV infections.[48] Using this figure and the 2001 U.S. population estimate of 285 million from the U.S Census Bureau,[49] the annual incidence rate is approximately 9 cases per 100,000. The estimated incidence rate among firefighter–EMTs is the reference rate (9 per 100,000) plus the expected occupational rate (ranges from 3.4 to 33.7 per 100,000, Table 4), resulting in an annual incidence rate from 12.4 to 42.7 cases per 100,000. Using an alpha of 0.05 and a beta of 0.20, sample size calculations indicate that somewhere between 35,000 and 1.4 million firefighter–EMTs and an equal number of referents would need to be studied.[50]

Therefore, current knowledge leaves several questions unanswered. The true contribution of occupational exposures to the overall prevalence of HCV infection among firefighters and EMTs cannot be determined. There are three possibilities why published studies report a similar HCV seroprevalence between firefighters and EMTs and the general population after controlling for age and gender. One, they are truly similar. Two, firefighters and EMTs have a higher seroprevalence, but NSI underreporting and participation bias make them appear similar. Three, the baseline HCV seroprevalence is actually lower than the general population because of the healthy worker effect (e.g., medical and drug screening), but occupational seroconversions raise the prevalence to that of the general population.

CONCLUSIONS

Compared with the seroprevalence of the general U.S. population, the lower HCV seroprevalences that might be expected among firefighters and EMTs because of their general good health and work-related screening were not generally seen in the reviewed surveys. It is entirely possible that firefighters and EMTs are at lower risk of nonoccupational HCV infection, but their additional occupational risk results in an overall HCV prevalence similar to the general public.

Limited data are currently available to evaluate the risks of exposure to blood or infection from blood-borne pathogens among firefighters and EMTs, although they suggest NSI rates comparable to those of hospital workers. Nevertheless, scientific exposure and infection surveillance programs could clarify exposure and infection risks for these workers and identify opportunities for intervention, as may case reports of any documented seroconversions, so publication of the findings from these programs or cases would be beneficial.

It is important, however, to focus on prevention of occupational exposures to blood. Employers must ensure their compliance with applicable state and federal regulations on preventing exposures to blood-borne pathogens. Employers should develop comprehensive programs to prevent NSIs that include worker training, engineering controls (in particular, devices engineered to prevent percutaneous injuries), involving workers in

the selection of devices with safety features, personal protective equipment, safe work practices, hepatitis B vaccination, and procedures for reporting and medically managing employee exposures.[51,52] This is particularly true for non-EMT firefighters who, although they have less exposure to blood-borne pathogens, probably have less blood-borne pathogen education and training, which increases their individual risk.

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