Blood Exposures and Hepatitis C Virus Infections Among Emergency Responders

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Background: Blood exposures in the workplace may put first responders, a group which includes firefighters, emergency medical technicians, and paramedics, at increased risk for hepatitis C virus (HCV) infection. To determine the prevalence of antibody to HCV (anti-HCV) and risk factors for infection among first responders, we analyzed data from prevalence surveys conducted among first responders in Atlanta, Ga, in 1991; Connecticut in 1992; and Philadelphia, Pa, in 1999.

Methods: Serum or blood samples from participants of the 3 surveys were tested for anti-HCV. Prevalence of anti-HCV was compared with that in the general US population. First responders in Atlanta reported high rates of skin exposures to blood (174 per 100 person-years) but few mucosal or needle-stick exposures (1 and 0 per 100 person-years, respectively) during the 6 months prior to the survey. Hepatitis C virus infection was not associated with a history of skin exposures to blood (prevalence ratio [PR], 1.1; 95% confidence interval [CI], 0.3-4.2), and HCV prevalence did not increase with longer duration (>10 years) of employment (PR, 1.1; 95% CI, 0.3-4.3). Nonoccupational risk factors associated with HCV infection included history of a sexually transmitted disease (PR, 7.4; 95% CI, 1.6-35.3) among Atlanta participants and histories of illegal drug use (PR, 4.4; 95% CI, 2.6-7.2) and blood transfusion before 1992 (PR, 1.9; 95% CI, 1.1-3.3) among Philadelphia participants.

Results: Prevalence of anti-HCV among the 2946 participants of the 3 surveys ranged from 1.3% to 3.6% and was no different than among appropriate referent groups in the general US population. First responders in Atlanta reported high rates of skin exposures to blood (174 per 100 person-years) but few mucosal or needle-stick exposures (1 and 0 per 100 person-years, respectively) during the 6 months prior to the survey. Hepatitis C virus infection was not associated with a history of skin exposures to blood (prevalence ratio [PR], 1.1; 95% confidence interval [CI], 0.3-4.2), and HCV prevalence did not increase with longer duration (>10 years) of employment (PR, 1.1; 95% CI, 0.3-4.3). Nonoccupational risk factors associated with HCV infection included history of a sexually transmitted disease (PR, 7.4; 95% CI, 1.6-35.3) among Atlanta participants and histories of illegal drug use (PR, 4.4; 95% CI, 2.6-7.2) and blood transfusion before 1992 (PR, 1.9; 95% CI, 1.1-3.3) among Philadelphia participants.

Conclusions: First responders are exposed to blood in the workplace, and standard precautions should be rigorously implemented. Although risk for HCV infection related to percutaneous or mucosal exposures could not be accurately assessed, the low prevalence of HCV infection indicates that routine HCV testing of first responders as an occupational group is not warranted. Testing should routinely be offered to those requiring postexposure management and those with a history of nonoccupational risk factors indicating an increased risk for infection.

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precautions, may have placed them at substantial risk for
HCV infection. To better characterize the prevalence of
HCV infection among firefighters and to examine the
association between HCV infection and possible risk fac-
tors in this group of workers, we analyzed data from sur-
veys of first responders in Atlanta, Ga, Connecticut, and
Philadelphia, and compared the prevalence in these groups
with that among the general US population.

METHODS

STUDY POPULATION

Data were obtained in 3 separate surveys conducted in At-
lanta, Connecticut, and Philadelphia. The surveys varied
with respect to study periods, types of first responders studied, and
exposure history ascertainment.

Atlanta

In 1991, uniformed firefighters from the greater metropolitan
area of Atlanta were offered the opportunity to participate in
an anonymous study of occupational and nonoccupational risk
factors for HBV infection.7 Of the 870 uniformed firefighters,
592 (68%) completed self-administered questionnaires and do-
nated serum samples. Occupational risk factors included du-
rational of employment as a first responder and frequency of dif-
f erent types of blood exposures in the preceding 6 months;
nonoccupational risk factors included history of blood trans-
fusion, injecting drug use, and sexual behaviors. Firefighters
who spent 20% or more of their time working as an EMT were
considered to have occupational risks for HBV similar to health
 care workers and were excluded from the original study. In 2000,
 stored serum samples from this study were tested for antibody
to HCV (anti-HCV) at the Centers for Disease Control and Pre-
cvention (CDC), Atlanta.

Connecticut

In 1992, 809 Connecticut public safety workers who had re-
cently completed the 3-dose hepatitis B vaccination series were
invited to enroll in a study of the serologic response to the vac-
cine, of whom 553 (68%) agreed to participate.14 Participants,
who included volunteer and professional firefighters, EMTs,
paramedics, police officers, and corrections officers from 3 ur-
bans and 3 suburban or rural locations in Connecticut, do-
nated blood samples and completed questionnaires on demo-

graphic characteristics. The survey did not include questions
about occupational or nonoccupational risk factors for HBV in-
fection. In 2000, stored serum samples from this study were retrieved, unlinked from the original study. In 2000,
 stored serum samples from this study were tested for antibody
to HCV (anti-HCV) at the Centers for Disease Control and Pre-
cvention (CDC), Atlanta.

Philadelphia

In 1999, representatives from Home Access Health Corpora-
tion (Hoffman Estates, Ill), the manufacturer of a specimen col-
clection kit for hepatitis C testing (Hepatitis C Check), offered
free, anonymous HCV testing to the approximately 4400 ac-
tive and retired members of the Philadelphia local firefighters
union. Of these, 2127 (approximately 48%) agreed to partici-
pate. Firefighters were provided with specimen collection kits
that they mailed to Home Access for anti-HCV testing. Par-
ticipants received their results by calling a toll-free number, at which
time they were asked about prior HCV testing as well as their
demographic characteristics and nonoccupational risk factors
(e.g., blood transfusion and illegal drug use). Home Access pro-
vided these data, which contained no personally identifying in-
formation, to the CDC for analysis.

LABORATORY TESTING

Anti-HCV testing of serum samples from participants in the At-
lanta and Connecticut studies was performed at the CDC. Sam-
ples were tested using an enzyme immunoassay (EIA 3.0;Ortho
Diagnostic Systems, Inc, Raritan, NJ). Samples that were
repeatedly reactive by EIA underwent supplemental testing us-
ing the recombinant immunoblot assay (RIBA 3.0;Chiron Cor-
poration, Emeryville, Calif). Only samples testing positive by
RIBA were considered anti-HCV positive.

Anti-HCV testing of samples from participants in Phila-
delphia was performed by Home Access. Blood samples, col-
clected as dried blood spots on filter paper, were eluted and tested
for anti-HCV. For Hepatitis C Check, the Food and Drug Ad-
ministration–approved conditions for reporting a positive anti-
HCV result require a repeatedly reactive EIA and a positive
 supplemental test result. However, in this survey, 21% of the
 samples that were initially reactive by EIA had insufficient
blood volume to complete the testing algorithm.

For this study, samples for which adequate volume al-
lowed completion of the testing algorithm were classified as
“positive,” “negative,” or “indeterminate.” Samples that were
repeatedly reactive by EIA for which further testing could not be performed were also considered positive if the signal-cutoff ratio was 3.8 or greater.15 Repeatedly reactive samples with signal-
cutoff ratios less than 3.8 (n=1) and samples initially reactive
by EIA for which further testing could not be performed (n=8)
were excluded from the analysis.

STATISTICAL ANALYSIS

All univariate and stratified analyses were performed with Epi-
Info version 6 (Epidemiology Program Office, CDC). Differ-
ces in proportions were compared by 2-tailed χ²
tests or 2-tailed Fisher exact tests. Adjustment for age or race was per-
formed using stratified Mantel-Haenzel χ² tests. Prevalence ra-
tios and 95% confidence intervals (CIs) were calculated, and
P<.05 was considered significant. Multiple logistic regression
was performed with SAS software, version 8 (SAS Institute, Cary,
NC). All variables were added to the model in a stepwise for-
ward manner and removed if not significant. First-order inter-
actions between variables were also evaluated.

Exposure rates were calculated using person-years. For ex-
ample, a worker reporting 2 skin exposures in a 6-month pe-
riod would have a rate of 4 skin exposures per person-year.

Prevalences of anti-HCV among participants of the 3 stud-
ies were compared with age- and sex-matched groups from the
Third National Health and Nutrition Examination Survey
(NHANES III), a nationally representative sample of civilian,
noninstitutionalized Americans performed during 1988 to
1994.16,17 To offset any bias created by the “healthy worker
effect,” only NHANES III participants who were actively em-
ployed at the time of the survey were included in the analysis.

When comparing results of the participants in the Phila-
delphia survey (1999) with those of participants in NHANES III
(midpoint, 1991), 8 years were added to the ages of the NHANES
III participants to compensate for the substantial cohort ef-
fects observed in both surveys.17,18 For comparisons of overall
prevalence between the 3 study groups and the general work-
ing population, prevalences from all groups were age- and race-
standardized to the 2000 resident population and SEs were esti-
atmed using SUDAAN software (SAS Institute). Only data from
male participants were used in the age-standardized analysis
because of the small number of female participants in the first-
responder surveys.
Most (92%-98%) participants in all 3 studies were male (Table 1). More than 80% of participants in Atlanta and Connecticut were younger than 50 years compared with 48% of those in Philadelphia. In the Connecticut and Philadelphia studies, participants were predominantly white; in Atlanta, almost half of participants were black.

The prevalences of anti-HCV among participants were 1.3% (95% CI, 0.4-3.0) in Connecticut, 2.1% (95% CI, 0.9-3.9) in Atlanta, and 3.6% (95% CI, 2.9-4.5) in Philadelphia (Table 1). In the Philadelphia study, anti-HCV prevalence was significantly higher among the 130 participants who stated that they had previously been tested for HCV than among the 1997 with no history of testing (16.2% vs 2.8%; P<.001). After stratifying on age and race, prevalence among participants of the Philadelphia study was significantly higher (P<.05) than among participants of the Atlanta or Connecticut studies.

In all 3 studies, patterns of anti-HCV prevalence mirrored patterns observed in the general population. Anti-HCV was most prevalent among men, blacks, and participants aged between 30 and 49 years (Table 1). None of the 57 female participants of the 3 studies tested positive for anti-HCV.

COMPARISONS WITH THE ACTIVELY EMPLOYED GENERAL POPULATION

The overall age- and race-standardized prevalence of anti-HCV among the male first responders in each of the 3 studies was not significantly different from the age-standardized prevalence among the actively working men in NHANES III (P=.05 for all comparisons, Figure 1). Similarly, the age- and sex-specific anti-HCV prevalences of participants in Philadelphia were not significantly different from the actively employed general population after adjusting for the cohort effect (P=.05 for all comparisons, Figure 2).
Atlanta first responders were with intact skin (174 per 100 person-years). Contaminated needle sticks (0) and mucosal exposures to blood (1 per 100 person-years) were relatively rare. Hepatitis C virus infection was not significantly associated with increasing duration of employment ($P = .89$) or with any of the occupational exposures that could be evaluated, including, mucosal exposures ($P = .88$), intact skin exposures ($P = .92$), administering injections ($P = .86$), inserting intravenous lines ($P = .23$), or being bitten ($P = .74$) (Table 2).

Data on nonoccupational risk factors for HCV infection, including blood transfusion, injecting drug use, and high-risk sexual behaviors, were collected from participants in the Atlanta study, and data on blood transfusion and illegal drug use (snorting or injecting) were collected from participants in the Philadelphia study (Table 3). Among the Atlanta participants, HCV infection was associated with a history of more than 10 lifetime sexual partners ($P = .048$) and a history of a sexually transmitted disease ($P = .006$). Only the latter remained significant after stratification on age ($P = .006$) or race ($P = .03$). Among the Philadelphia participants, history of a blood transfusion before July 1992 ($P = .02$) and illegal drug use ($P < .001$) were each significantly associated with HCV infection. In a logistic regression model, 3 variables were independently associated with anti-HCV among the Philadelphia participants: history of illegal drug use (odds ratio [OR] 5.0; 95% CI, 2.8-8.8), transfusion before 1992 (OR, 2.2; 95% CI, 1.2-3.9), and race (OR for black vs others, 2.1; 95% CI, 1.2-3.6).

**COMMENT**

Results of the 3 surveys reported here showed that the prevalence of HCV infection among first responders was similar to that in the general US population. Furthermore, HCV prevalence varied according to the same demographic characteristics as those observed in the general population, with the highest prevalences among middle-aged men and African Americans. These findings are consistent with results of 5 other published surveys among first responders conducted in Ohio,10 Maryland,11 Pittsburgh, Pa,19 Miami-Dade County, Florida,19 and Detroit, Mich.13 In these studies, which included firefighters, EMTs, and paramedics, prevalences ranged from 0% (0/255)11 to 3.2% (5/154)19 and also were not significantly higher than those observed in NHANES III.19

Among the first responders in the Atlanta survey, occupational exposures most likely to transmit HCV infection (ie, needle-stick injuries or mucosal splashes) were rare, and the survey could not determine the degree to which these were associated with HCV infection. In addition, the cumulative frequency of exposures in this population could not accurately be determined since exposures were determined only for the 6 months prior to the survey, and many older firefighters may have been promoted to positions with few opportunities for recent exposure to blood. In addition, the Atlanta survey excluded EMTs and paramedics among whom percutaneous exposures to blood would have been more frequent. In prior studies among such emergency medical service workers, needle-stick injuries occurred at rates of 10 to 37 per 100 person-years,20,21 which are similar to rates observed among hospital-based health care workers.24,30

Among emergency responders and other public safety workers, skin exposure to blood is the most common type of occupational exposure reported, occurring 10 to 60 times more frequently than needle-stick exposures.20,26,31 In the Atlanta survey, more than 30% of the first responders reported blood exposures to intact skin in the 6 months before the survey, for a rate of 174 per 100 person-years. Even with the higher frequency of this type of exposure, however, the lack of association between HCV infection and intact skin exposures is consistent with the fact that no transmission of HCV (or other blood-borne viruses) from intact skin exposures to blood has been documented in any setting. In addition, HCV transmission rarely occurs from mucous membrane or nonintact skin exposures to blood, and after an unintentional needle stick from an HCV-positive source, the average risk for HCV infection is 1.8%.2 These data indicate that HCV is not transmitted efficiently through occupational exposures.

Based on the rate of HCV transmission from a needle-stick injury, a paramedic who receives 0.2 percutaneous blood exposures per year (20 per 100 person-years) in a population in which the prevalence of chronic HCV infection is 1.2%,17 would have a 0.09% risk of acquiring HCV infection over a 20-year career. Similarly, a firefighter would have a risk of 0.02% if he or she received 0.05 percutaneous blood exposures per year, 5 times the observed rate of mucosal exposure in the Atlanta study. Thus, even when we account for underascertainment of exposures, the cumulative risk of acquiring HCV infection for emergency responders is relatively low and is consistent with both the overall prevalence of infection found in this and other studies and the lack of association with duration of employment.

A low prevalence of HCV infection also has been found among hospital-based health care workers in the
United States, both before and after implementation of universal precautions. Only one of these studies demonstrated an association between HCV infection and history of a specific occupational exposure, that is, needle-stick injuries. This study of 1677 hospital-based health care workers conducted during 1983 found an anti-HCV prevalence of 1.4%. Hepatitis C virus infection was directly associated with frequency of needle-stick injuries (reported by 68% of workers), but not with frequency of blood or patient contact (reported by 75% and 79% of workers, respectively). Another study of more than 3000 orthopedic surgeons conducted in 1991 found a prevalence of less than 1.0%. Although 39% of the surgeons reported percutaneous exposures to blood during the previous month and 82% during the previous year, there was no association between a history of these exposures and HCV infection. However, prevalence of HCV infection was significantly related to age, number of years of practice, and current full-time clinical practice status. Even in hospital settings in which the prevalence of HCV infection among patients is high (18%), which presumably would increase the opportunity for exposure to HCV-infected blood, the prevalence of HCV infection among health care workers is low (0.7%).

In contrast, prior to routine hepatitis B immunization (and implementation of universal precautions), both the incidence and prevalence of HBV infection were substantially higher among hospital-based health care workers than among the general population, and infections were consistently associated with the degree of occupational blood exposure. A higher than expected HBV prevalence also was found among EMTs and paramedics, but not among firefighters who spent less than 20% of their time as EMTs. Although firefighters reported too few percutaneous or mucosal exposures to blood to evaluate their association with HBV, there was no association with intact skin exposures, and HBV is approximately 10 times as transmissible as HCV. Most of the HBV infections in this group were associated with nonoccupational characteristics or risk factors.

The absence of an epidemiologic association between HCV infection and percutaneous or mucosal occupational exposures to blood among first responders in the studies presented here does not rule out that HCV infections were occupationally acquired in some of the participants. Only 1 study (Atlanta) ascertained occupational exposures. Because of the infrequency with which percutaneous or mucosal exposures relative to skin exposures occurred and the limited period of exposure ascertainment, the sample size of the study would not have been sufficient to have detected associations with low-frequency events. Similarly, the small proportions of persons in the Atlanta study who reported histories of blood transfusion before 1992 or ever injecting illegal drugs may have been the reason a study of this size was not able to detect associations with these commonly recognized risk factors.

### Table 2. Prevalence of Hepatitis C Virus (HCV) Infection Among First Responders in Atlanta, Ga, by Occupational Exposures

<table>
<thead>
<tr>
<th>Occupational Exposure</th>
<th>Anti-HCV Positive, % (No. Positive/Total Tested)</th>
<th>Unadjusted Prevalence Ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;10 Years of employment</td>
<td>2.2 (4/181)</td>
<td>2.0 (5/256)</td>
</tr>
<tr>
<td>Within prior 6 mo</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Needle stick</td>
<td>0 (0/0)</td>
<td>2.1 (9/431)</td>
</tr>
<tr>
<td>Mucosal exposures</td>
<td>0 (0/1)</td>
<td>2.1 (9/425)</td>
</tr>
<tr>
<td>Skin exposures</td>
<td>2.2 (3/135)</td>
<td>2.1 (6/289)</td>
</tr>
<tr>
<td>Performed CPR</td>
<td>2.7 (1/37)</td>
<td>2.0 (8/393)</td>
</tr>
<tr>
<td>Administered injections</td>
<td>1.8 (1/56)</td>
<td>2.1 (8/374)</td>
</tr>
<tr>
<td>IV needle insertions</td>
<td>5.6 (1/18)</td>
<td>1.7 (7/413)</td>
</tr>
<tr>
<td>Received human bite</td>
<td>0 (0/5)</td>
<td>2.1 (9/430)</td>
</tr>
</tbody>
</table>

**Abbreviations:** Anti-HCV, antibody to HCV; CI, confidence interval; CPR, cardiopulmonary resuscitation; IV, intravenous.

### Table 3. Prevalence of Hepatitis C Virus (HCV) Infection Among First Responders by Nonoccupational Risk Factors

<table>
<thead>
<tr>
<th>Nonoccupational Risk Factor</th>
<th>Atlanta, Ga</th>
<th>Philadelphia, Pa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood transfusion (before 1992)</td>
<td>0 (0/38)</td>
<td>2.4 (9/381)</td>
</tr>
<tr>
<td>Ever injected illicit drugs</td>
<td>0 (0/1)</td>
<td>2.1 (9/434)</td>
</tr>
<tr>
<td>Ever snorted or injected illicit drugs</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>&gt;10 Lifetime sexual partners</td>
<td>2.7 (7/261)</td>
<td>0 (0/140)</td>
</tr>
<tr>
<td>&gt;2 Sexual partners in the last 6 mo</td>
<td>1.5 (2/134)</td>
<td>2.4 (7/289)</td>
</tr>
<tr>
<td>Ever paid prostitute for sex</td>
<td>1.2 (1/83)</td>
<td>2.3 (8/343)</td>
</tr>
<tr>
<td>Ever diagnosed with STD</td>
<td>5.1 (7/138)</td>
<td>0.7 (2/293)</td>
</tr>
</tbody>
</table>

**Abbreviations:** Anti-HCV, antibody to HCV; CI, confidence interval; ND, no data available; STD, sexually transmitted disease.

*P<.05, adjusted for age and race.
The limitations of the results of these studies include potential for selection bias and comparability of the reference population. Given that participation rates varied from 48% in Philadelphia to almost 70% in Atlanta and Connecticut, the prevalences estimated in this study may be subject to bias if persons with known risk factors or who knew they were HCV positive were more or less likely to participate. Furthermore, finding an ideal reference population against which to compare these prevalences is difficult because certain characteristics of career firefighters and EMTs may differ from other workers in ways that cannot be measured. However, the finding of anti-HCV prevalences among firefighters and EMTs similar to those in the general population is consistent with findings in studies of hospital-based health care workers, including those who work with high-risk patients, which have not shown a higher prevalence of anti-HCV compared with the general population.

The results of our study have 2 major implications. The first is that first responders are exposed to blood in the workplace, and standard (universal) precautions should apply. First responders should be educated about transmission of blood-borne pathogens, trained in proper safety measures, and provided with appropriate protective equipment. They also should be vaccinated against hepatitis B and be informed of protocols if percutaneous or permucoosal exposures to blood occur. The second is that routine HCV screening of first responders is not recommended. Although occupational exposure to blood is a risk factor for HCV infection, the prevalence of HCV infection among first responders as a group is substantially lower than the prevalences among groups for which routine testing is recommended. As recommended for health care workers, first responders should be tested for HCV if they have a history of nonoccupational risk factors placing them at increased risk for infection (eg, transfusion before July 1992 or injecting drug use) or as part of postexposure management after a percutaneous or permucoosal exposure to known HCV-positive blood.

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