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## Evaluation of Occupational Transmission of Hepatitis A Virus Among Wastewater Workers

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This evaluation was conducted as a NIOSH health hazard evaluation.

### Abstract

To provide information concerning potential occupational transmission of hepatitis A virus (HAV) among wastewater workers in a large city in the United States, a cross-sectional survey was performed using a saliva test to detect antibodies to HAV (anti-HAV). Fifty-nine (20%) of 302 participants tested positive for anti-HAV. After controlling for the confounding effects of age and race, wastewater work was not significantly associated with an increase in the prevalence of anti-HAV (prevalence ratio = 1.3; 95% confidence interval 0.7 to 2.4). Additionally, when examining only the wastewater workers, no statistically significant occupational risk factors for anti-HAV were identified. The results of this survey are consistent with the position of the Centers for Disease Control and Prevention regarding groups at risk for HAV infection.

In August 1997 the National Institute for Occupational Safety and Health (NIOSH) received a request from employees of a wastewater treatment facility serving Columbus, Ohio (population over 600,000), to conduct a health hazard evaluation concerning potential occupational transmission of hepatitis A virus (HAV) among wastewater workers. In response to the health hazard evaluation request, NIOSH investigators conducted a survey of the prevalence of antibodies to HAV (anti-HAV) among wastewater workers and a comparison population in that city.

Hepatitis A is a reportable disease within the National Notifiable Diseases Surveillance System of the Centers for Disease Control and Prevention (CDC). From 1990 to 1998, a mean of approximately 27,500 cases of hepatitis A have been reported annually to the CDC (CDC unpublished data). The CDC lists the following groups as being at increased risk for HAV infection: travelers to, or workers in, developing countries; homosexual men; users of injecting and non-injecting drugs; children over age 2 in communities that have high rates of HAV infection and have periodic outbreaks of hepatitis A; persons who have clotting factor disorders; and persons who work with non-human primates (some non-human primates not born in captivity are susceptible to HAV infection). <sup>1</sup> Identification of groups at increased risk is particularly important because an effective vaccine for HAV infection is now available and indications for its use are being evaluated. <sup>1,2</sup> The issue is of special concern for wastewater workers because HAV is spread primarily by fecal/oral routes (often resulting from inadequate hand washing), may be spread by contaminated water, <sup>3</sup> and has been shown to survive in groundwater for weeks or longer. <sup>4,5</sup> Despite the potential for occupational exposure among wastewater workers, work-related cases of HAV transmission among workers exposed to sewage have not been reported to the CDC. <sup>1</sup>

Adequate epidemiologic data from the United States have not been available to help clarify potential occupational risks for HAV infection, <sup>1,6</sup> although cross-sectional studies (based on the presence of anti-HAV, which is an indication of past infection and is protective against future infection) have been done among wastewater workers in other countries. Some have found increased prevalence of anti-HAV among wastewater workers compared with other groups;<sup>7-9</sup> others have not. <sup>10,11</sup> One study found that the prevalence of anti-HAV was not significantly greater among sewage workers than among a comparison group but that exposure to sewage was an independent risk factor for HAV seropositivity. <sup>12</sup> A recent study from the United Kingdom found that reported occupational exposure to raw sewage was a risk factor for past HAV infection. <sup>13</sup> In general, incomplete information regarding the suitability of comparison groups, as well as regional variations in the incidence of HAV infection and anti-HAV prevalence, make it difficult to apply the results of these international prevalence studies to workers in the United States.

## Methods

The objectives of this cross-sectional survey were: (1) to compare the prevalence of anti-HAV among wastewater workers and an appropriate comparison group not working with wastewater; (2) to determine whether occupational risk factors could be identified that may be related to past HAV infection; and (3) to compare the results of saliva and serum anti-HAV testing with regard to sensitivity and specificity. To evaluate these questions, we tested for the presence of anti-HAV among wastewater workers and a group of city workers not occupationally exposed to wastewater. From June 29 through July 1, 1998, the survey was conducted among employees at one of the two wastewater treatment plants serving Columbus. \* From July 14 through 15, 1998, the survey was conducted among wastewater maintenance employees who work throughout Columbus. During the period December 1998 through January 1999, surveys were conducted among groups of electrical and recreation workers in Columbus; these workers served as comparison groups.

## Medical Survey

The survey consisted of a questionnaire (including questions concerning work, medical history, and relevant socioeconomic factors), and serum (wastewater workers only) and saliva (both wastewater and comparison groups) tests for anti-HAV. Informed consent was obtained before employee participation. For wastewater workers who had a serum test for anti-HAV performed by the city in the 3 months before the survey, + no additional serum test was done; these participants were asked to complete a medical release form so that NIOSH could obtain that test result. For wastewater workers who had a serum anti-HAV test done by NIOSH, the samples were analyzed by the Hepatitis Reference Laboratory of the CDC using standard assays (hepatitis A virus antibody, Abbott Laboratories, Abbott Park, North Chicago, IL). All participants in the survey had a saliva sample collected using Saliva Sampler(R) collectors (Saliva Diagnostic Systems, Inc, Vancouver, WA); samples were tested for anti-HAV (immunoglobulin G) at the Central Public Health Laboratory in London, England, following published methods. <sup>14</sup> The saliva sample results were used for all comparisons between the groups of workers.

## Analysis

Statistical analyses were performed by Statistical Analysis System software (Version 6.12). Participants whose saliva test result was indeterminate were excluded from statistical modeling. Multivariable regression models were developed to: (1) compare the prevalence of anti-HAV between exposed (wastewater) and unexposed (electrical and recreation) groups, and (2) identify occupational risk factors for HAV infection among wastewater workers. The models controlled for the confounding effects of non-occupational factors and generated adjusted prevalence ratios (PR) and 95% confidence intervals (95% CI) for the PR. Potential confounders that were considered included: race, household contact with a person having jaundice or hepatitis, travel to areas where HAV is common, education level, being born outside the United States, gender, age, and household income level. Potential confounders were retained in models if their exclusion resulted in a large (>10%) change in the PR(s) for the exposure variable or the occupational risk factor(s). Because 19 participants (administrative personnel) from the wastewater sites reported that they never had contact with sewage, they were grouped with the "unexposed" in the model comparing anti-HAV prevalence between the exposed and unexposed workers. In modeling to evaluate potential occupational risk factors for past HAV infection among the "exposed" group (wastewater workers) only, a number of factors were considered (Table 1). Because of the number of factors considered, preliminary analyses were performed to eliminate those that yielded no evidence of a relationship with anti-HAV. A final model was developed that included any confounding factors and the occupational risk factors having the strongest evidence of an association with past HAV infection.

**TABLE 1****Potential Occupational Risk Factors for Past HAV Infection Among Wastewater Workers Assessed in This Survey**

Work as a maintenance worker (relative to work in the treatment plant)

Exposure to the mists from the plant settling ponds

Lack of a place to wash up after completing a task

Contact with sewage as reported by the participant

Expected contact with sewage (as determined for each job title by management and union)

Not washing before eating

Eating in the work area

Lack of a designated eating area

Not eating in the designated eating area

Not wearing face shield

Not wearing gloves

Table 1. Potential Occupational Risk Factors for Past HAV Infection Among Wastewater Workers Assessed in This Survey

**Results**

Participation rates and other characteristics of the participants in the health hazard evaluation by work location (wastewater treatment plant, wastewater maintenance, recreation, electric) are presented in [Table 2](#). Participation rates ranged from 74% to 88%. The group of recreation workers included more women and more persons with at least some college education. The wastewater workers (both treatment plant and maintenance workers) were, on average, older and were more likely to have reported a history of having jaundice or hepatitis than those in the comparison groups. None of the participants had received the hepatitis A vaccine.

**TABLE 2**  
Description of Participants and Participation Rate

	TP <sup>a</sup>	Maint <sup>b</sup>	Recreation <sup>c</sup>	Electric <sup>d</sup>	All Groups
Participants, n (%)	69 (82)	97 (74)	70 (80)	69 (88)	305 (80)
Mean age (range)	47 (23–69)	46 (27–74)	39 (20–63)	38 (20–54)	43 (20–74)
Male, n (%)	67 (97)	95 (98)	42 (60)	66 (96)	270 (89)
Race <sup>e</sup>	62 (90)	56 (58)	30 (43)	59 (86)	207 (68)
Hispanic <sup>f</sup>	2 (3)	3 (3)	2 (3)	0	7 (2)
Education <sup>g</sup>	30 (43)	32 (33)	63 (90)	21 (30)	146 (48)
Income <sup>h</sup>	43 (63)	45 (48)	23 (34)	51 (75)	162 (55)
Travel <sup>i</sup>	35 (51)	40 (41)	25 (36)	29 (42)	129 (42)
Foreign birth <sup>j</sup>	2 (3)	4 (4)	1 (1)	0	7 (2)
Hepatitis <sup>k</sup>	9 (13)	12 (12)	1 (1)	0	22 (7)
Assoc with hepatitis <sup>l</sup>	5 (7)	5 (5)	5 (7)	3 (4)	18 (6)

<sup>a</sup> Treatment plant; <sup>b</sup> maintenance workers; <sup>c</sup> recreation workers work among 26 different centers; employees from 22 (85%) of the centers participated in the survey; <sup>d</sup> electric workers; <sup>e</sup> no. (%) white; <sup>f</sup> no. (%) reporting Spanish or Hispanic ancestry; <sup>g</sup> no. (%) reporting at least some college education; <sup>h</sup> no. (%) of respondents reporting family income of \$40,000 or greater; <sup>i</sup> no. (%) reporting travel at least once to Mexico, South America, Central America, Asia, Africa, or the Carribean; <sup>j</sup> no. (%) reporting birth outside the United States; <sup>k</sup> no. (%) of positive responses to question concerning ever having jaundice or hepatitis; <sup>l</sup> no. (%) of positive responses to question concerning ever living with a person who had jaundice or hepatitis.

Table 2. Description of Participants and Participation Rate<sup>a</sup> Treatment plant; <sup>b</sup> maintenance workers; <sup>c</sup> recreation workers work among 26 different centers; employees from 22 (85%) of the centers participated in the survey; <sup>d</sup> electric workers; <sup>e</sup> no. (%) white; <sup>f</sup> no. (%) reporting Spanish or Hispanic ancestry; <sup>g</sup> no. (%) reporting at least some college education; <sup>h</sup> no. (%) of respondents reporting family income of \$40,000 or greater; <sup>i</sup> no. (%) reporting travel at least once to Mexico, South America, Central America, Asia, Africa, or the Carribean; <sup>j</sup> no. (%) reporting birth outside the United States; <sup>k</sup> no. (%) of positive responses to question concerning ever having jaundice or hepatitis; <sup>l</sup> no. (%) of positive responses to question concerning ever living with a person who had jaundice or hepatitis.

Among the wastewater workers, 34 agreed to have the serum anti-HAV test performed by NIOSH, and medical records were obtained for 123 other participants; therefore, serum anti-HAV results were available for 157 (95% of the 166 participating) wastewater workers. All 305 participants (wastewater and comparison groups) provided saliva samples. Three participants had saliva test results of "indeterminate"; these three were excluded from statistical modeling. Comparison of the matched serum and saliva testing for anti-HAV for the 157 participants with both types of tests done shows that the saliva test, as used in this survey, was 99% specific and 84% sensitive relative to the serum test (Table 3).

**TABLE 3**  
Comparisons of the Serum and Saliva Testing for Anti-HAV

Serum Test	Saliva Test			Total
	Positive	Negative	Indeterminate	
Positive	41 <sup>a</sup>	6	2	49
Negative	0	107 <sup>b</sup>	1	108
Total	41	113	3	157

<sup>a</sup> Sensitivity of saliva test, 41 of 49 (84%).  
<sup>b</sup> Specificity of saliva test, 107 of 108 (99%).

Table 3. Comparisons of the Serum and Saliva Testing for Anti-HAV<sup>a</sup> Sensitivity of saliva test, 41 of 49 (84%).<sup>b</sup> Specificity of saliva test, 107 of 108 (99%).

Overall, 59 (20%) of participants tested positive for anti-HAV. The maintenance group had the highest percentage of workers who tested positive for anti-HAV (31%). Crude results of the anti-HAV saliva testing by work location are presented in Table 4. Among the 22 participants who reported a history of jaundice or hepatitis in the past (21 of whom were wastewater workers (Table 2), only 9 (41%) tested positive for anti-HAV. Eighteen participants reported having household contact with a person who had jaundice or hepatitis in the past; of those, only five (28%) tested positive for anti-HAV.

	TP <sup>b</sup>	Maint <sup>c</sup>	Subtotal "Wastewater"	Recreation	Electric	Subtotal "Comparison"	Total
No. of tests	67	96	163	70	69	139	302
No. (%) positive	12 (18)	30 (31)	42 (26)	14 (20)	3 (4)	17 (12)	59 (20)

<sup>a</sup> Three indeterminate saliva test results were excluded from this table.  
<sup>b</sup> Treatment plant.  
<sup>c</sup> Maintenance workers.

Table 4. Saliva Anti-HAV Testing by Work Location<sup>aa</sup> Three indeterminate saliva test results were excluded from this table.<sup>b</sup> Treatment plant.<sup>c</sup> Maintenance workers.

### Analysis of Anti-HAV Prevalence Between Exposed and Unexposed Groups

The non-occupational risk factors that demonstrated an effect on the relationship between exposure (being a wastewater worker) and past HAV infection included age and race. After controlling for these factors, work as a wastewater worker was not significantly associated with anti-HAV status (PR = 1.3; 95% CI 0.7 to 2.4).

### Analysis of Potential Risk Factors Among Wastewater Workers

Among the non-occupational risk factors evaluated, age and race were again found to be the important factors related to both the potential occupational risk factors and past HAV infection. The final multivariable model included the confounders (age and race) and the potential risk factors found to have the strongest evidence of a relationship with past HAV infection. A positive association, though not statistically significant, was found between prevalence of anti-HAV and eating in the work area (PR 1.6; 95% CI 0.7 to 3.5) and work as a maintenance worker (relative to work in the treatment plant) (PR 1.4; 95% CI 0.6 to 2.9).

### Discussion

Our survey found that the group of participating wastewater workers had a prevalence of past HAV infection of 26%, compared with 12% in the comparison group. However, after controlling for age (increased age is known to be related to increased prevalence of past HAV infection) and race (possibly a surrogate for socioeconomic status, which has been related to prevalence of HAV infection), the prevalence of HAV infection between the two groups was found not to differ significantly.

Among the wastewater workers, no specific workplace risk factors for HAV infection were identified. The data reveal an increase (not statistically significant) in the prevalence of anti-HAV among those workers who reported eating in the work area and other related factors (such as lack of a designated eating area). Maintenance work, compared with work in the treatment plant, was also associated with increased (not statistically significant) prevalence of anti-HAV. Interestingly, neither exposure to sewage as reported by the employee nor predicted "high" exposure to sewage as determined by job title appeared to be associated with an increased prevalence of anti-HAV.

This survey has several limitations. Original survey plans called for surveying workers from the second treatment plant in Columbus; however, that survey was not completed. Although the demographic characteristics of the workers and the sewage handling procedures at the two plants are similar, we are not able to comment on the prevalence of past HAV infection among workers at the plant that was not surveyed. In addition, it is possible that a larger number of participants would have allowed a greater ability to detect statistically significant differences between the groups being evaluated. Second, the saliva test used was found to have a sensitivity of 84% compared with the serum test. Published studies using the saliva test in similar surveys have reported a higher sensitivity than was found in this study. [13,14](#) Reasons for the differing sensitivity of the test in our survey could include differences in specimen collection and handling in the field and/or assay variability in the laboratory. Because there is no reason for the sensitivity of the saliva test to differ between the exposed and unexposed groups, there is no reason to believe that the sensitivity of the saliva test is a major factor in the negative findings of this survey. However, if a test with a higher sensitivity were used, it might have improved the ability of the survey to detect differences between the groups.

When performing this survey, one of our goals was to find a comparison (unexposed) group that accurately reflected the background prevalence of anti-HAV in the community in which we were surveying. The true background prevalence of anti-HAV in this community, however, is not known. The CDC reports that, in one survey, anti-HAV prevalence in the general population of the United States was found to vary from between 19% (20 to 29 years of age) to 33% (40 to 49 years of age). <sup>1</sup> Another survey found the prevalence of anti-HAV to be 12% among non-Hispanics in a different part of the United States (CDC, unpublished data); this is the same as the background rate of anti-HAV found in our survey. We note, but cannot account for, the low anti-HAV prevalence in the electric workers we surveyed.

The results of this survey are consistent with the CDC position regarding groups at risk for HAV infection. However, because of the limitations of our survey, further data addressing the potential for occupational transmission of HAV among wastewater workers in the United States are needed. In addition, further study regarding the sensitivity of the saliva test for anti-HAV is needed before it is used routinely. Wastewater workers desiring to obtain immunity from HAV infection should discuss risk factors for HAV infection, past testing for anti-HAV (if done), and administration of the HAV vaccine by their personal physician or another qualified health care professional.

Sewage and wastewater at various treatment stages inherently contains potentially infectious organisms. Management and employees should institute appropriate health and safety precautions to minimize employee exposure to sewage and wastewater. Some exposures are unpredictable and may be unavoidable; however, many routine duties are known to have potential for direct contact with sewage. To minimize exposure to raw sewage and increase employee awareness of the importance of good hygiene and the appropriate use of personal protective equipment while at work, a number of recommendations can be made, including: (1) periodic training regarding standard hygiene practices (including frequent and routine hand washing, use of personal protective equipment, cleaning of soiled personal protective equipment after use, use of on-site showers and lockers, and use of laundry services for washing work clothes) should be required for all employees; (2) hand-washing stations with clean water and mild soap should be readily available wherever contact with wastewater, sewage, or sludge may occur; and (3) appropriate personal protective equipment (possibly including goggles, face shields, liquid-repellant coveralls, and gloves) should be required for all job duties likely to result in exposure to sewage, untreated or partially treated wastewater, or sludge. The data from this survey do not support conducting medical surveillance specifically for HAV infection among wastewater workers; however, medical surveillance for other potential occupational health risks among these workers may be beneficial. <sup>15</sup>

## Acknowledgments

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## FOOTNOTES

+ The city performed medical examinations yearly for many of the wastewater workers. [\[Context Link\]](#)

\* The second wastewater treatment plant in Columbus was not surveyed in this health hazard evaluation because of logistic constraints. [\[Context Link\]](#)

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**TABLE 1**  
**Potential Occupational Risk Factors for Past HAV Infection Among Wastewater Workers Assessed in This Survey**

- Work as a maintenance worker (relative to work in the treatment plant)
- Exposure to the mists from the plant settling ponds
- Lack of a place to wash up after completing a task
- Contact with sewage as reported by the participant
- Expected contact with sewage (as determined for each job title by management and union)
- Not washing before eating
- Eating in the work area
- Lack of a designated eating area
- Not eating in the designated eating area
- Not wearing face shield
- Not wearing gloves

Table 1

**TABLE 2**  
**Description of Participants and Participation Rate**

	SP <sup>a</sup>	MP <sup>b</sup>	Maintenance <sup>c</sup>	Sludge <sup>d</sup>	All Sectors
Participants, n (%)	24 (24)	97 (74)	11 (8)	66 (49)	198 (94)
Mean age (range)	47 (21-68)	48 (21-74)	53 (24-63)	48 (24-74)	47 (21-74)
Male, n (%)	12 (50)	66 (68)	11 (100)	66 (68)	273 (68)
Race <sup>e</sup>	12 (50)	66 (68)	11 (100)	66 (68)	127 (68)
White <sup>f</sup>	2 (17)	2 (2)	2 (18)	2 (3)	7 (5)
Hispanic <sup>g</sup>	10 (83)	64 (66)	9 (82)	64 (66)	144 (83)
Black <sup>h</sup>	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Other <sup>i</sup>	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Foreign born <sup>j</sup>	1 (4)	1 (1)	1 (9)	1 (1)	4 (1)
Hispanic <sup>k</sup>	1 (4)	1 (1)	1 (9)	1 (1)	4 (1)
Other <sup>l</sup>	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Always with hepatitis <sup>m</sup>	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

Table 2

**TABLE 3**  
**Comparison of the Serum and Saliva Testing for Anti-HAV**

Serum Test	Saliva Test			Total
	Positive	Negative	Indeterminate	
Positive	6	1	1	8
Negative	0	157	2	159
Total	6	158	3	167

Table 3

**TABLE 4**  
**Saliva Anti-HAV Testing by Work Location<sup>a</sup>**

	SP <sup>b</sup>	MP <sup>c</sup>	Maintenance <sup>d</sup>	Sludge <sup>e</sup>	All Sectors <sup>f</sup>	Total
No. of tests	21	86	10	66	123	206
No. of positives	1 (5)	10 (12)	1 (10)	1 (1)	13 (11)	16 (8)

Table 4

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