A Survey on the Status of Hepatitis E Virus Infection Among Slaughterhouse Workers in South Korea

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Objectives: The seroprevalence of hepatitis E virus (HEV) among high-risk groups overseas is high, but studies in these groups are rare in South Korea. We conducted the present study from April to November 2012 to obtain data on the seroprevalence and associated risk factors for HEV among slaughterhouse workers in South Korea.

Methods: Slaughterhouse workers from 80 workplaces nationwide were surveyed in South Korea in 2012. The subjects comprised 1848 cases: 1434 slaughter workers and 414 residual products handlers. By visiting 80 slaughterhouses, which were mixed with 75 of which also performed residual products handling, we conducted a questionnaire survey for risk factors and obtained blood samples in order to determine the seropositivity and seroprevalence of HEV. Anti-HEV IgG and IgM were measured using HEV IgG and IgM enzyme-linked immunospecific assay kits and HEV antigen was measured by reverse transcription polymerase chain reaction (RT-PCR).

Results: The seropositivity of anti-HEV IgG was 33.5% (slaughter workers 32.8% and residual products handlers 36.2%), and among the seropositive individuals the seroprevalence of anti-HEV IgM was 0.5% (slaughter workers 0.5%, residual products handlers 0.7%). The response rate of HEV-antigen as measured by RT-PCR was 0.2%. Risk factors significantly related to anti-HEV IgG seropositivity were age, sex, and working duration (slaughter workers only).

Conclusions: There were significant risk factors (sex, age, and working duration) for HEV identified in our study. All three positive cases for HEV-antigen by RT-PCR were related to pig slaughter but without statistical significance. To prevent HEV, an educational program and working guidelines may be needed for high risk groups.

Key words: Hepatitis E, Slaughterhouse, Zoonoses, Seroprevalence, Risk factors

INTRODUCTION

The prevention and control of zoonoses are of increasing concern among health authorities because of the rise and spread of new zoonotic disease. In a systematic review of 1415 pathogens known to infect humans, 61% were classified as zoonotic [1]. In South Korea, the study of zoonoses has progressed as concerns have increased. Previous studies on zoonoses have investigated brucellosis infections, Q fever, enterohemorrhagic Escherichia coli infections, toxoplasmosis, and Lyme disease in livestock breeders, veterinarians, artificial inseminators, and slaughterhouse workers and inspectors [2-6].

Hepatitis E virus (HEV) causes around 20 million infections per year, resulting in around 3 million cases of acute illness. As of 2010, the HEV virus was responsible for 60,000 deaths annually [7]. In 1996, anti-HEV IgG was detected in 9.5% of healthy adults in South Korea [8]. The seropositivity of anti-HEV IgG was...
11.9% among the Korean population, and among them the seropositivity was 15.0% in those aged 40 to 60 years old and living in rural areas [9]. In another study in 2001, the seropositivity of anti-HEV IgG was 23.1%, and among them the seropositivity was 42.3% in those aged 60 years and above [10]. The nationwide seropositivity of anti-HEV IgG was found to be 5.9% in the Korean population in 2007 to 2009 [11].

The morbidity rate of zoonotic infections is higher in workers who come into frequent contact with animals, and is also correlated with the frequency and type of animal contact, factors which are often based on occupational requirements. In industrialized countries, domestic animals, including swine and cattle, are an important reservoir for HEV [12]. During surveillance, high-risk groups for zoonotic infections include pig farmers, veterinarians, and slaughterhouse workers, who show high morbidity compared to control groups [13]. According to a recent study, slaughterhouse workers have a 1.5 to 3.5 times higher risk for morbidity than other workers who had not had any occupational contact with animals [14]. Therefore the seroprevalence, transmission route, and risk factors for HEV in high-risk groups in South Korea need to be identified. However, the status of or risk factors for zoonotic HEV infection have not been sufficiently investigated in South Korea. This study was therefore conducted to report the status and risk factors associated with zoonotic HEV infection among slaughterhouse workers.

METHODS

Study Subjects

In 2012, 85 slaughterhouses in South Korea were registered with the Ministry for Food, Agriculture, Forestry and Fisheries. Eighty of these were selected (two had ceased work and another three refused to participate). Slaughterhouses were distributed all over the country, located in Chungcheongbuk-do (13 sites); Gyeonggi-do (11); Gyeongsangbuk-do (10); Jeollanam-do (10); Chungcheongnam-do (8); Gyeongsangnam-do and Jeollabuk-do (7); Gangwon-do (5); Kwangju-si, Ulsan-si, and Inchen-si (2); Daegu-si, Daejeon-si, and Jeju-do (1). There were 2145 slaughterhouse workers belonging to the 80 slaughterhouses, which were mixed with 75 of which also performed residual product handling (1699 slaughter workers and 446 residual product handlers), and the workers were registered with the Livestock Health Control Association, Korea Centers for Disease Control and Prevention (K-CDC), and Statistics Korea. Of these, 1848 (86.2%) workers (1434 slaughter workers and 414 residual product handlers) were surveyed in 2012.

Development of Questionnaire

The structure of the slaughterhouse, slaughtering process, working characteristics of workers and risk factors for HEV infection were identified through a literature review [15-17]. From this review, separate questionnaires were developed for slaughterhouse workers and residual product handlers. These included contents such as the general characteristics of each worker, as well as any work-related and lifestyle-related risk factors, and whether or not the workers wear personal protective equipment (PPE). In addition, we used a questionnaire modified from a previous study [5].

The statements regarding risk factors were “Always disinfecting working tools and body surfaces after work” and “Being in contact with blood and secretions of livestock around the mouth and body (more than once a week)”. Another set of statements pertained to lifestyle, for example, “eating raw beef, pork, cattle or pig by-products, or raw milk”, “donating blood”, “handling livestock with skin wounds” and “breeding cattle, pigs, goats, dogs or cats”. The statement regarding PPE was “Always wearing protective eyeglasses, protective mask, long protective gloves, protective aprons, protective boots, and disposable protective clothes”. These statements were answered “yes” or “no”.

Survey

Our study team consisted of four or five persons, including one doctor, one medical technologist, and two or three trained interviewers. The study was conducted from June 11 to June 22 in 2012. The questionnaire and official documents for participation in the study were sent to each slaughterhouse, and the questionnaire was completed prior to the study team’s visit. Incomplete questionnaires were completed by verifying questionnaires and interviewing workers individually.

Serological Testing

After sampling blood (10 mL), serum was separated by centrifugation. The serum was given a serial number, stored in a sealed icebox with icepacks, and transferred to the K-CDC for serologic tests. Wantai HEV-IgG and HEV-IgM enzyme-linked immunosorbent assay (ELISA) kits (Wantai Biological Pharmacy Enterprise Co., Beijing, China) were used for qualitative determination of IgG- and IgM-class antibodies to HEV in human serum. The results were calculated by relating each specimen absorbance (A) value to the cut-off value (CO) of the plate. The diagnostic criteria were as follows: 1) Negative results (A/CO < 1);
samples giving an A value less than the CO were negative, indicating that no HEV IgG- or IgM-class antibodies had been detected by the kit, and that therefore there were no serological indications for current infection with HEV. 2) Positive results (A/CO ≥ 1): samples giving an A value equal to or greater than the CO were considered initially reactive, indicating that IgG- and IgM-class antibodies to HEV had probably been detected by the kit. Repeatedly reactive samples could be considered positive for IgG- and IgM-class antibodies to HEV and that therefore there were no serological indications for current infection with HEV. 3) Borderline: (A/CO = 0.9-1.1): samples with an A value to CO between 0.9 and 1.1 were considered borderline and retesting of these specimens in duplicates was required to confirm the initial results. After measuring the antibody titers of HEV, an HEV-IgM test was conducted on samples that were positive for the HEV-IgG test. HEV RNA was detected using reverse transcriptase polymerase chain reaction (RT-PCR) after HEV-IgM titer was confirmed. Seropositivity was defined as a positive result in the HEV-IgG test. Seroprevalence was defined as a positive result in the HEV-IgM test. This study was approved by the institutional review board of Dongguk University Gyeongju Hospital (no. 12-033). Participants made their informed consent prior to enrollment in the study.

**Statistical Analysis**

PASW Statistics version 18.0 (SPSS Inc., Chicago, IL, USA) was used for statistical analyses. HEV-IgG seropositivity by sex, occupational group, risk factors, and wearing PPE was analyzed using chi-square and Fisher’s exact tests, and seropositivity by age group and working duration was analyzed using the chi-square for trend test. Using significant factors associated with HEV IgG positivity, we performed binomial logistic regression. For all tests, p < 0.05 was considered statistically significant.

**RESULTS**

**Hepatitis E Virus Seropositivity and Seroprevalence**

The seropositivity for anti-HEV IgG in slaughter workers and residual products handlers, respectively, was 32.8%, and 36.2%. The seroprevalence for anti-HEV IgM in slaughter workers and residual products handlers was 0.5%, and 0.7%, respectively. The RT-PCR-reactive rate in slaughter workers and residual products handlers, respectively, was 0.2%, and 0.0% (Table 1).

The seropositivity in men (34.0%) was significantly higher (p < 0.001) than that of women (15.4%) among slaughter workers. The seropositivity significantly increased with age (p < 0.001), and seropositivity was highest in subjects aged 60 years and above (60.6%). The seropositivity also significantly increased with working duration (p < 0.001) (Table 2). The seropositivity in men (42.6%) was significantly higher (p = 0.029) than that of women (32.1%) among residual product handlers. The seropositivity increased significantly with age (p < 0.001); seropositivity in the 40 to 49, 50 to 59, and 60 years and over age groups was 23.3%, 36.3%, and 51.9% respectively. There were no significant differences between working duration and seropositivity (Table 2).

Anti-HEV IgM was detected in seven subjects (0.5%). Of these, six were men (85.7%). Five of the slaughterhouse workers who tested positive for anti-HEV IgM were in the 50 to 59 year age group (71.4%) (Table 2). Among residual product handlers, the seroprevalence for anti-HEV IgM was 0.7%. All three positive cases were male. Seroprevalence in the under 40, 40 to 49, and 50 to 59 year age groups was 33.3%, 33.3%, and 33.3% respectively (Table 2).

**Characteristics of Reverse Transcriptase Polymerase Chain Reaction Positivity**

An RT-PCR analysis was completed on ten positive specimens for anti-HEV IgM. The HEV antigen was detected in three subjects. The detection rate of HEV RNA using RT-PCR was 0.2%. All three subjects who were positive for HEV RNA were male slaughterhouse workers. One of these was under 40 years old, while the other two subjects were in the 50 to 59 year age group.

**Table 1. Positive test results for anti-HEV IgG and IgM by ELISA and HEV-antigen by RT-PCR among slaughterhouse workers and residual products handlers**

| Tests                      | Slaughter workers (n = 1434) | Residual products handlers (n = 414) | Total (n = 1848) |
|----------------------------|-----------------------------|-------------------------------------|------------------|
|                            | No. of positive  | %        | No. of positive  | %        | No. of positive  | %        |
| Anti-HEV IgG (seropositivity) | 470  | 32.8    | 150  | 36.2    | 620  | 33.5    |
| Anti-HEV IgM (seroprevalence) | 7   | 0.5     | 3    | 0.7     | 10   | 0.5     |
| HEV-antigen by RT-PCR       | 3   | 0.2     | 0    | 0.0     | 3    | 0.2     |

HEV, hepatitis E virus; ELISA, enzyme-linked immunosorbent assay; RT-PCR, reverse transcriptase polymerase chain reaction.
Risk Factors for Hepatitis E Virus Seropositivity

Seropositivity in slaughter workers was found to be associated with work-related factors, including wearing long protective gloves ($p = 0.008$), protective aprons ($p = 0.001$), boots ($p = 0.049$), and disposable protective clothes ($p = 0.003$). On the other hand, residual product handlers were more likely to become infected with zoonotic HEV through contact with body secretions ($p = 0.009$) (Table 3). Moreover, seropositive slaughter workers were also likely to have consumed raw beef ($p = 0.018$) and raw pork ($p = 0.011$). Residual product handlers had no additional factors contributing to work-related risk factors (Table 4).

Multivariate Analysis with Risk Factors

Table 5 shows the results of the multivariate logistic regression that identified factors associated with seropositivity. The significant factors associated with seropositivity were male sex, old age, wearing protective aprons and eating raw beef in slaughter workers. Among residual products handlers, the statistically significant factors associated with seropositivity were male sex and old age.
Table 3. Comparison of risk factors related to wearing shields, working, and disinfection among slaughter workers and residual products handlers

| Risk factor                              | Slaughter workers                      | Residual products handlers                                      |
|------------------------------------------|----------------------------------------|------------------------------------------------------------------|
|                                          | Anti-HEV IgG (+) group                  | Anti-HEV IgG (-) group                                           |
|                                          | n Yes %                                | n Yes %                                                          |
|                                          | Total n Yes %                          | Total n Yes %                                                    |
|                                          | p-value 1                              | OR (95% CI)                                                      |
|                                          |                                        |                                                                  |
| Always wearing protective eyeglasses     | 459 70 15.3                            | 965 156 16.3                                                     | 615 226 16.0 | 0.922 (0.679, 1.254) |
|                                          | 1415 226 16.0                          | 393 72 18.3                                                      | 1.00 (1.00, 1.00) | 0.999 (0.587, 1.701) |
| Always wearing protective mask          | 459 171 37.3                           | 953 352 36.9                                                     | 1412 523 37.0 | 0.914 (0.805, 1.277) |
|                                          | 1444 44 30.6                           | 253 77 30.4                                                      | 0.98 (1.00, 1.00) | 1.006 (0.645, 1.568) |
| Always wearing long protective gloves    | 463 246 74.7                           | 951 645 67.8                                                     | 1414 991 70.1 | 0.008 1.403 (1.093, 1.801) |
|                                          | 1477 127 86.4                          | 257 225 87.5                                                     | 0.74 (1.00, 1.00) | 0.903 (0.496, 1.645) |
| Always wearing protective apron         | 448 429 91.7                           | 959 817 85.2                                                     | 1427 1246 87.3 | 0.001 1.912 (1.317, 2.777) |
|                                          | 1448 138 93.2                          | 261 249 95.4                                                     | 0.35 (1.00, 1.00) | 0.665 (0.280, 1.579) |
| Always wearing protective shoes         | 469 453 96.6                           | 960 904 94.2                                                     | 1429 1357 95.0 | 0.049 1.754 (0.995, 3.092) |
|                                          | 1449 145 97.3                          | 263 258 98.1                                                     | 0.60 (1.00, 1.00) | 0.703 (0.186, 2.658) |
| Always disinfecting disposable protective clothes | 456 214 46.9                           | 948 366 38.6                                                     | 1404 580 41.3 | 0.003 1.406 (1.122, 1.762) |
|                                          | 1437 76 53.1                           | 254 133 52.4                                                     | 0.88 (1.00, 1.00) | 1.032 (0.685, 1.556) |
| Always disinfecting working tools after operation | 465 395 84.9                           | 956 779 81.5                                                     | 1421 1174 82.6 | 0.11 1.282 (0.948, 1.734) |
|                                          | 1461 124 84.9                          | 255 205 80.4                                                     | 0.25 (1.00, 1.00) | 1.375 (0.794, 2.380) |
| Always disinfecting body surfaces after work | 470 443 94.3                           | 962 896 93.1                                                     | 1432 1339 93.5 | 0.42 1.209 (0.761, 1.918) |
|                                          | 1448 135 91.2                          | 260 245 94.2                                                     | 0.25 (1.00, 1.00) | 0.636 (0.294, 1.376) |
| Being in contact with blood around the mouth (more than once a week) | 488 72 15.4                            | 961 149 15.5                                                     | 1429 221 15.5 | 0.95 0.991 (0.730, 1.345) |
|                                          | 1448 19 12.8                           | 257 38 14.8                                                      | 0.59 (0.90, 0.90) | 0.849 (0.470, 1.535) |
| Being in contact with blood around the body (more than once a week) | 467 125 26.8                            | 961 300 31.2                                                     | 1428 425 29.8 | 0.08 0.805 (0.630, 1.030) |
|                                          | 1449 28 18.8                           | 259 56 21.6                                                      | 0.50 (0.90, 0.90) | 0.839 (0.506, 1.392) |
| Being in contact with secretions around the body (more than once a week) | 467 93 19.9                            | 961 198 20.6                                                     | 1428 291 20.4 | 0.76 0.958 (0.727, 1.262) |
|                                          | 1447 32 21.8                           | 262 89 34.0                                                      | 0.003 (0.90, 0.90) | 0.541 (0.339, 0.864) |

HEV, hepatitis E virus; OR, odds ratio; CI, confidence interval.

1 Tested by chi squared test.
2 Tested by Fisher's exact test.
Table 4. Comparison of risk factors related to lifestyle and keeping animals among slaughter workers and residual products handlers

| Risk factor                                           | Anti-HEV IgG (+) group | Anti-HEV IgG (-) group | Total | $p$-value | OR (95% CI) |
|------------------------------------------------------|------------------------|------------------------|-------|-----------|-------------|
|                                                     | n Yes %                 | n Yes %                 | n Yes % |           |             |
| Eating raw beef                                      | 468 20 4.3             | 963 20 2.1             | 1431 40 2.8 | 0.016$^2$ | 2.105 (1.121, 3.952) |
| Eating cattle by-products (raw liver, stomach or intestine$^1$) | 468 7 1.5             | 962 7 0.7             | 1430 14 1.0 | 0.17$^2$ | 2.072 (0.722, 5.941) |
| Eating raw pork                                      | 467 4 0.9              | 961 0 0.0             | 1428 4 0.3 | 0.011$^3$ | -           |
| Eating pig by-products (raw liver, stomach or intestine$^1$) | 468 2 0.4             | 961 1 0.1             | 1429 3 0.2 | 0.25$^3$ | 4.120 (0.373, 45.556) |
| Eating raw milk of cow or goat$^1$                   | 469 8 1.7              | 966 21 2.2            | 1425 29 2.0 | 0.54$^2$ | 0.773 (0.340, 1.758) |
| Donating blood or receiving a blood transfusion$^1$  | 467 25 5.4             | 961 47 4.9            | 1428 72 5.0 | 0.71$^2$ | 1.100 (0.668, 1.810) |
| Handling livestock with skin wounds$^1$              | 470 64 13.6            | 964 123 12.8          | 1434 187 13.0 | 0.65$^2$ | 1.078 (0.779, 1.491) |
| Breeding cattle                                      | 457 19 4.2             | 940 36 3.8            | 1397 55 3.9 | 0.77$^2$ | 1.089 (0.618, 1.921) |
| Breeding goats                                       | 458 4 0.9              | 949 2 0.2             | 1407 6 0.4 | 0.09$^3$ | 4.172 (0.761, 22.861) |
| Breeding pigs                                        | 456 3 0.7              | 947 5 0.5             | 1396 8 0.6 | 0.72$^3$ | 1.238 (0.295, 5.205) |
| Breeding dogs as livestock                           | 456 45 9.9             | 947 63 6.7            | 1403 108 7.7 | 0.03$^2$ | 1.536 (1.030, 2.292) |
| Breeding dogs as pets                                | 465 71 15.3            | 951 124 13.0          | 1416 195 13.8 | 0.25$^2$ | 1.202 (0.877, 1.648) |
| Breeding cats                                        | 465 6 1.3              | 951 10 1.1            | 1416 16 1.1 | 0.69$^2$ | 1.230 (0.444, 3.405) |

HEV, hepatitis E virus; OR, odds ratio; CI, confidence interval.

1In the last year.

2Tested by chi squared test.

3Tested by Fisher's exact test.
In this study, we examined HEV seropositivity and seroprevalence in slaughterhouse workers in South Korea. Compared to previous studies [9-11,14], seropositivity for anti-HEV IgG among slaughterhouse workers in South Korea is relatively high. Furthermore, in our analyses, the seroprevalence of anti-HEV IgM might be underestimated, as we analyzed anti-HEV IgM only in anti-HEV IgG-positive samples. However, our study population is similar to those of a previous study in 2007, which, like the present study, comprised a majority of male subjects aged between 40 and 49 years [5]. This fact suggests that our study subjects are not selected by specific factors.

HEV seropositivity was not significantly different between slaughter workers and residual products handlers. However, there were significant differences in seropositivity according to sex and working duration. Differences due to sex in slaughter workers might be due to male, rather than female, workers being primarily in charge of physically demanding work. This work may in turn be associated with a lower likelihood of wearing PPE due to its burdensome nature. In addition, the risk of infection might increase for male workers, who are more likely to be in contact with blood or bodily secretions from livestock. In contrast, residual products handlers have fewer requirements for heavy physical work and this may explain why there was no difference in the seropositivity of anti-HEV IgG by sex in this group of workers.

In South Korea, research focusing on zoonoses in high-risk groups is increasing, but there are few investigations into HEV. The present study is significant in that it provides an investigative survey of a high-risk group for zoonotic HEV, which is rare in the general Korean population.

In developed countries, HEV is known to be associated with domestic animals such as livestock, as well as with raw meat and pork products, and so it is more closely monitored [18-20]. Generally, North America and Europe are regarded as non-endemic areas of HEV infection, as the HEV seropositivity range is typically 1% to 5% [21]. However, even in non-endemic areas, some animals, such as swine, are known to be carriers of HEV [22]. Samples from two-month old pigs have shown positive test results for HEV RNA in Japan (2.7%), Korea (1.6%), and Taiwan (4.5%), as have samples from slaughtered pigs in Canada (32.6%) [23-26]. Among the main dairy production countries of Europe, seropositivity for anti-HEV IgG has been confirmed in pigs from Belgium (6.1% to 7.2%), France (31% to 65%), Germany (49.8%), Netherlands (68%), and northern Italy (87%) [27]. Regarding domestic Korean HEV infection, the seropositivity of anti-HEV IgG on Jeju Island was found to be 55% in swine, compared to the 15.0% to 40.7% seropositivity between 2003 and 2007 and the HEV RNA detected in 17.5% of swine in 2008 [28-30].

Another study reported that anti-HEV IgG was detected in 100% of swine breeders and 55% of adult blood donors in some Chinese provinces [31]. In Taiwan, seropositivity for anti-HEV IgG was 8% in the general population, but 27% in people in contact with swine [31]. In the American state of North Carolina, pig farmers showed a high level of seropositivity for anti-HEV IgG (11.0%), which was 4.5 times higher than among other workers (2.4%) [22]. In the present study, the seropositivity for anti-HEV IgG was higher than in Taiwan and North Carolina but less than in Chinese provinces.

### Table 5. Risk factors associated with hepatitis E virus infection in the multivariate analysis

| Factor                     | OR (95% CI) | Lower  | Upper  |
|----------------------------|-------------|--------|--------|
| Slaughter workers          |             |        |        |
| Sex: Male                  | 4.195       | 2.154  | 8.189  |
| Sex: Female                | Reference   |        |        |
| Age (y): <40               |             |        |        |
| Sex: Male                  | 2.913       | 1.651  | 5.141  |
| Sex: Female                | Reference   |        |        |
| Age (y): 40–49             | 9.882       | 5.831  | 16.747 |
| Age (y): ≥60               | 20.697      | 11.657 | 36.747 |
| Wearing protective apron   |             |        |        |
| Yes: Wearing apron         | 2.000       | 1.304  | 3.068  |
| No: Wearing apron          | Reference   |        |        |
| Eating raw beef            |             |        |        |
| Yes: Eating raw beef       | 2.466       | 1.222  | 4.976  |
| No: Eating raw beef        | Reference   |        |        |
| Residual products handlers |             |        |        |
| Sex: Male                  | 1.855       | 1.188  | 2.896  |
| Sex: Female                | Reference   |        |        |
| Age (y): <40               |             |        |        |
| Sex: Male                  | 2.310       | 0.768  | 6.946  |
| Sex: Female                | Reference   |        |        |
| Age (y): 40–49             | 5.107       | 1.837  | 14.199 |
| Age (y): ≥60               | 9.400       | 3.311  | 26.691 |

OR, odds ratio; CI, confidence interval.

1In the last year.

### DISCUSSION

In this study, we examined HEV seropositivity and seroprevalence in slaughterhouse workers in South Korea. Compared to previous studies [9-11,14], seropositivity for anti-HEV IgG among slaughterhouse workers in South Korea is relatively high. Furthermore, in our analyses, the seroprevalence of anti-HEV IgM might be underestimated, as we analyzed anti-HEV IgM only in anti-HEV IgG-positive samples. However, our study population is similar to those of a previous study in 2007, which, like the present study, comprised a majority of male subjects aged between 40 and 49 years [5]. This fact suggests that our study subjects are not selected by specific factors.
Wearing PPE such as gloves and masks is important in the prevention of zoonotic infection [32]. Among the work-related risk factors investigated in this study, the use of protective vinyl gloves, aprons, boots, and disposable protective suits was higher among slaughter workers with seropositivity for anti-HEV IgG compared to other workers. This suggests that a high usage of PPE does not prevent against zoonotic HEV infection, or that people identified as HEV seropositive may be more likely to wear PPE. It has previously been suggested that some operators may not be properly using PPE, or that PPE is ineffective [33]. Therefore, the correct use of PPE must be encouraged, and guidelines for usage may be necessary for workers. The discomfort and increased burden of wearing PPE (14.7% in slaughter workers and 11.4% among residual product handlers) may contribute to the avoidance of this equipment, which may contribute to the difficulty in preventing zoonoses. Contact with livestock blood and bodily secretions more than once a week was more frequent among the slaughter workers testing negative for anti-HEV IgG compared to others; however, this association is inconsequential. Further study will assist in confirming the association of work-related risk factors with zoonotic infection. The association of some risk factors with HEV-IgG seropositivity may lead to controversial interpretation, highlighting the limitations of the cross-sectional nature of the present study. Subsequent case-control and cohort studies may be needed to address these limitations.

When investigating lifestyle-related risk factors, the proportion of slaughter workers who eat raw pork and beef was found to be significantly higher in the anti-HEV IgG seropositive group than in the control group. Since swine are an important vector for HEV, public relations and education campaigns regarding the risks of HEV infection associated with consumption of raw pork and beef products need to be intensified. Given the recent increase in the number of restaurants, the frequency with which people may come into contact with zoonoses by ingesting meat products such as beef and pork, as well as potentially contaminated wild game, is greatly enhanced. In the stages of slaughter and processing of meat, workers come into contact with body tissue and fluids, increasing the likelihood of contamination with pathogens. HEV is primarily transmitted via the fecal-oral route [34]. At this stage, the surveillance and management of slaughterhouse workers is needed to limit contact with zoonoses. Further studies extending the present findings will confirm and improve the identification of work- and lifestyle-related risk factors for HEV infections associated with working in slaughterhouses. Future research will also facilitate the prevention of this infection in high-risk groups, such as slaughterhouse workers and administrative staff.

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CONFLICT OF INTEREST

The authors have no conflicts of interest with the material presented in this paper.

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