Original Article

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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

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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 masks, 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 the patient was probably infected 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.

Table 2. Positive test results for anti-HEV IgG and IgM according to sex, age, and working duration among slaughterhouse workers and residual products handlers

Characteristics	Slaughter workers (n=1434)				Residual products handlers (n=414)			
	No. of examinees	No. of positive	%	*p*-value	No. of examinees	No. of positive	%	*p*-value
Anti-HEV IgG								
Sex								
Male	1343	456	34.0	<0.001[1]	205	83	40.5	0.07[1]
Female	91	14	15.4		209	67	32.1	
Age (y)								
<40	257	19	7.4	<0.001[2]	40	7	17.5	<0.001[2]
40–49	371	69	18.6		73	17	23.3	
50–59	585	248	42.4		193	70	36.3	
≥60	221	134	60.6		108	56	51.9	
Working duration (y)								
<10	683	166	24.3	<0.001[2]	247	84	34.0	0.20[2]
10–19	403	131	32.5	(n=1393)	111	41	36.9	(n=407)
20–29	222	106	47.7		38	18	47.4	
≥30	85	55	64.7		11	4	36.4	
Anti-HEV IgM								
Sex								
Male	1343	6	0.4	0.37[3]	205	3	1.5	0.12[3]
Female	91	1	1.1		209	0	0.0	
Age (y)								
<40	257	1	0.4	0.37[2]	40	1	2.5	0.09[2]
40–49	371	0	0.0		73	1	1.4	
50–59	585	5	0.9		193	1	0.5	
≥60	221	1	0.5		108	0	0.0	
Working duration (y)								
<10	683	3	0.4	0.31[2]	247	3	1.2	0.22[2]
10–19	403	0	0.0	(n=1393)	111	0	0.0	(n=407)
20–29	222	4	1.8		38	0	0.0	
≥30	85	0	0.0		11	0	0.0	

HEV, hepatitis E virus.
[1]Tested by chi squared test.
[2]Tested by chi squared for trend test.
[3]Tested by Fisher's exact test.

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			Total			*p*-value[1]	OR (95% CI)	Anti-HEV IgG (+) group			Anti-HEV IgG (-) group			Total			*p*-value	OR (95% CI)
	n	Yes	%	n	Yes	%	n	Yes	%			n	Yes	%	n	Yes	%	n	Yes	%		
Always wearing protective eyeglasses	459	70	15.3	956	156	16.3	1415	226	16.0	0.61	0.922(0.679, 1.254)	142	26	18.3	251	46	18.3	393	72	18.3	1.00[1]	0.999 (0.587, 1.701)
Always wearing protective mask	459	171	37.3	953	352	36.9	1412	523	37.0	0.91	1.014 (0.805, 1.277)	144	44	30.6	253	77	30.4	397	121	30.5	0.98[1]	1.006 (0.645, 1.568)
Always wearing long protective gloves	463	346	74.7	951	645	67.8	1414	991	70.1	0.008	1.403 (1.093, 1.801)	147	127	86.4	257	225	87.5	404	352	87.1	0.74[1]	0.903 (0.496, 1.645)
Always wearing protective apron	468	429	91.7	959	817	85.2	1427	1246	87.3	0.001	1.912 (1.317, 2.777)	148	138	93.2	261	249	95.4	409	387	94.6	0.35[1]	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)	149	145	97.3	263	258	98.1	412	403	97.8	0.60[2]	0.703 (0.186, 2.658)
Always wearing disposable protective clothes	456	214	46.9	948	366	38.6	1404	580	41.3	0.003	1.406 (1.122, 1.762)	143	76	53.1	254	133	52.4	397	209	52.6	0.88[1]	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)	146	124	84.9	255	205	80.4	401	329	82.0	0.25[1]	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)	148	135	91.2	260	245	94.2	408	380	93.1	0.25[1]	0.636 (0.294, 1.376)
Being in contact with blood around the mouth (more than once a week)	468	72	15.4	961	149	15.5	1429	221	15.5	0.95	0.991 (0.730, 1.345)	148	19	12.8	257	38	14.8	405	57	14.1	0.59[1]	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)	149	28	18.8	259	56	21.6	408	84	20.6	0.50[1]	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)	147	32	21.8	262	89	34.0	409	121	29.6	0.009[1]	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	Slaughter workers											Residual products handlers										
	Anti-HEV IgG (+) group			Anti-HEV IgG (-) group			Total			*p*-value	OR (95% CI)	Anti-HEV IgG (+) group			Anti-HEV IgG (-) group			Total			*p*-value	OR (95% CI)
	n	Yes	%	n	Yes	%	n	Yes	%			n	Yes	%	n	Yes	%	n	Yes	%		
Eating raw beef[1]	468	20	4.3	963	20	2.1	1431	40	2.8	0.018[2]	2.105 (1.121, 3.952)	148	5	3.4	259	4	1.5	407	9	2.2	0.30[3]	2.229 (0.589, 8.434)
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)	148	1	0.7	261	2	0.8	409	3	0.7	1.00[3]	0.881 (0.079, 9.799)
Eating raw pork[1]	467	4	0.9	961	0	0.0	1428	4	0.3	0.011[3]	-	148	1	0.7	260	0	0.0	408	1	0.2	0.36[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)	147	1	0.7	259	0	0.0	406	1	0.2	0.36[3]	-
Eating raw milk of cow or goat[1]	469	8	1.7	956	21	2.2	1425	29	2.0	0.54[2]	0.773 (0.340, 1.758)	148	8	5.4	262	7	2.7	410	15	3.7	0.16[2]	2.082 (0.739, 5.861)
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)	148	3	2.0	262	12	4.6	410	15	3.7	0.27[3]	0.431 (0.120, 1.553)
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)	148	10	6.8	261	20	7.7	409	30	7.3	0.74[2]	0.873 (0.397, 1.919)
Breeding cattle	457	19	4.2	940	36	3.8	1397	55	3.9	0.77[2]	1.089 (0.618, 1.921)	146	5	3.4	259	8	3.1	405	13	3.2	1.00[3]	1.113 (0.357, 3.466)
Breeding goats	458	4	0.9	949	2	0.2	1407	6	0.4	0.09[3]	4.172 (0.761, 22.861)	148	0	0.0	260	0	0.0	408	0	0.0	-	-
Breeding pigs	456	3	0.7	940	5	0.5	1396	8	0.6	0.72[3]	1.238 (0.295, 5.205)	147	0	0.0	257	0	0.0	404	0	0.0	-	-
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)	147	11	7.5	260	22	8.5	407	33	8.1	0.73[2]	0.875 (0.412, 1.860)
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)	146	26	17.8	256	39	15.2	402	65	16.2	0.50[2]	1.206 (0.700, 2.077)
Breeding cats	465	6	1.3	951	10	1.1	1416	16	1.1	0.69[2]	1.230 (0.444, 3.405)	146	1	0.7	256	7	2.7	402	8	2.0	0.27[3]	0.245 (0.030, 2.014)

HEV, hepatitis E virus; OR, odds ratio; CI, confidence interval.
[1]In the last year.
[2]Tested by chi squared test.
[3]Tested by Fisher's exact test.

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

Factor	OR	OR (95% CI)	
		Lower	Upper
Slaughter workers			
Sex			
Male	4.195	2.154	8.169
Female	Reference		
Age (y)			
<40	Reference		
40–49	2.913	1.651	5.141
50–59	9.882	5.831	16.747
≥60	20.697	11.657	36.747
Wearing protective apron			
Yes	2.000	1.304	3.068
No	Reference		
Eating raw beef[1]			
Yes	2.466	1.222	4.976
No	Reference		
Residual products handlers			
Sex			
Male	1.855	1.188	2.896
Female	Reference		
Age (y)			
<40	Reference		
40–49	2.310	0.768	6.946
50–59	5.107	1.837	14.199
≥60	9.400	3.311	26.691

OR, odds ratio; CI, confidence interval.
[1]In 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.

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.

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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