

Prevalence of hepatitis E in pediatrics and the population of Al-diwanayah city, Iraq

Shaima'A Dakhel Abdulhassan¹

Abstract

Background: Over the past decade, our understanding of HEV has evolved significantly. Previously thought to be prevalent in specific developing nations, HEV cases were primarily seen in travelers returning from highly endemic regions in Asia or Africa to high-income countries. **Aim of the study:** This study aims to determine the prevalence of Hepatitis E (HEV)-induced diseases in both rural and urban areas of Al-Diwaniyah and assess its potential societal impact in the future. **Patients and Methods:** Health laboratory workers collected sixteen thousand one hundred forty-one samples over three consecutive years from Al-Diwaniyah Teaching Hospital and Maternity and Children Teaching Hospital in Al-Diwaniyah. The results were obtained through the Department of Viruses at the Public Health Laboratory in Diwaniyah for 2016, 2017, and 2018. Most patients had simple disease with no more complications. **Results:** The study found an overall HEV infection with a rate of 58% occurred in July 2018, with 13 cases, followed by March 2016 with 5 cases (representing 33%) and July 2017 with 9 cases (representing 9%) these overall percentage of data collected in our study. **Conclusion:** We can conclude that HEV can occur at any time, in any environment and in any gender, as long as there is environmental pollution with the virus and lack of awareness of hygiene. Additionally, a significant increase in infection rates was observed during the warmer seasons.

Keywords: hepatitis E virus (HEV), hepatitis A virus (HAV), acute liver failure (ALF), world health organization (WHO), tetra methyl benzamine (TMB)

1 Introduction

In the early 1980s, the discovery of HEV coincided with unexplained hepatitis outbreaks among Soviet troops in Afghanistan. Despite testing negative for Hepatitis A Virus (HAV) and Hepatitis B Virus (HBV), these soldiers experienced widespread outbreaks. A Russian scientist ingested a pooled sample of stool from affected soldiers, leading to the identification of a new virus through electron microscopy, later named HEV [1, 2].

Over the past decade, our understanding of HEV has evolved significantly. Previously thought to be prevalent in specific developing nations, HEV cases were primarily seen in travelers returning from highly endemic regions in Asia or Africa to high-income countries [3, 4, 5]. HEV belongs to the Hepeviridae family, including viruses infecting birds, mammals, and fish [6].

¹ Department of Pediatrics, College of Medicine, Al-Qadisiyah University, Iraq

Shaima'A Dakhel Abdulhassan (shaimaa.dakhel@qu.edu.iq)

Received: 11/03/2025 – Approved: 30/04/2025 – Published 19/07/2025

Species A is responsible for causing hepatitis E in humans, with eight different genotypes. Genotypes 1 and 2 exclusively infect humans [7]. Genotype 3 exhibits considerable diversity at a molecular level, with closely related viruses found in rabbits, suggesting sporadic infections with similar viruses in humans [8].

By utilizing current seroprevalence statistics and the latest data from blood donors, it can be reasonably inferred that Europe witnesses an annual occurrence of no less than two million HEV infections acquired within the region [9, 10, 11]. The infections were primarily attributed to HEV genotype 3, with sporadic instances linked to HEV genotype 4 [7, 8]. After infection, pigs release a substantial quantity of HEV through their feces. Consequently, this has led to environmental pollution, affecting areas like slurry lagoons, rivers, and streams [4, 5, 12, 13].

During pregnancy, particularly in the third trimester, contracting hepatitis E infection, especially genotype 1, is linked to heightened infection severity. This scenario could potentially result in acute liver failure and maternal mortality [14]. As pregnancy advances, there is a gradual elevation in the levels of progesterone, estrogen, and human chorionic gonadotropin. These hormonal changes are pivotal in altering the immune system's regulation and augmenting virus replication [15]. Individuals with suppressed immune systems might not successfully eliminate HEV infection. This can lead to the development of chronic hepatitis, observed primarily in patients infected with HEV genotypes 3 or 4 thus far [16, 17, 18].

Among solid organ transplant recipients who contract HEV infection, approximately one-third experience hepatitis that are resolved, while the remaining patients undergo the development of chronic hepatitis [19, 20]. Smaller studies indicate chronic infection develops in fewer than 50% of patients [21].

A temperature of 80°C was necessary to halt HEV infection within one minute of heating. However, the extent to which these laboratory-based observations align with real-world food preparation practices remains uncertain [22]. Numerous case-control studies have explicitly linked the consumption of inadequately cooked meat from pigs, wild boar, and deer to the heightened risk of HEV infection in Europe. The extent to which HEV infection contributes to this heightened risk is yet to be established. The safety of other consumable items, such as strawberries, spinach, shellfish, and camel milk, remains subject to further scrutiny [23, 24].

The degree of risk regarding HEV transmission between patients remains inadequately characterized. Instances of sexual transmission of HEV have been documented among men engaged in sexual activity with other men [25, 26]. Given that stool carries a substantial load of infectious HEV particles, it is noteworthy that HEV obtained from stool has demonstrated higher infectivity than HEV sourced from plasma [27, 28].

In 2011, China authorized a vaccine against HEV. This vaccine exhibited a remarkable efficacy of 97% in preventing symptomatic acute hepatitis, and its continued effectiveness was validated through subsequent extended monitoring [29].

2 Patients and methods

The study was conducted at Ad-Diwaniyah Teaching Hospital and Maternity and Child Hospital. A prospective design was implemented in the current study to fulfil the objectives outlined earlier, covering the timeframe spanning from October 2018 to March 2019. Sixteen

thousand one hundred forty-one samples were collected over three consecutive years: 4,064 samples for 2016, 2,452 for 2017, and 9,625 for 2018. Health laboratory workers collected these samples at "Diwaniyah Teaching Hospital" and "Maternity and Child Hospital in Diwaniyah." Results were obtained through the Department of Viruses at the Public Health Laboratory in Diwaniyah for all 2016-2017 and 2018 months. Samples were collected from patients from the Diwaniyah Health Department for the past three years: 2016-2017 and 2018. Upon sampling, the statistics were analyzed using Excel and Word programs, including the name of the patient, Age of the patient, Sex of the patient, Patient housing (rural city), Period of admission to the hospital, Period of infection, Percentage of pregnant women out of the total infections. Blood samples were gathered from every healthcare worker using sterile containers with proper seals. These samples were then transported to the Public Health Laboratory situated in Diwaniyah Teaching Hospital. Before the microscopic examination, a visual inspection was conducted. The examination method involved the steps in reference [30].

2.1 Statistical analysis

Data was entered to do statistical analysis and description. Numbers and percentages were used to express categorical variables. The range, standard deviation, mean, median, and interquartile range were used to express quantitative data. Based on well-founded statistical hypotheses, proportions were compared using the Fischer exact test, the chi-square test, or the Yates correction. A significant threshold of $p < 0.05$ was established.

3 Results

Of the 16141 patients, 27 were positive for HEV infection. The highest rate of HEV infection was observed in the age group ≥ 10 years and ≤ 30 years (59%). The lowermost rate was witnessed within the age group from (41-60 years) Which denotes (19%) As shown in Figure 1.

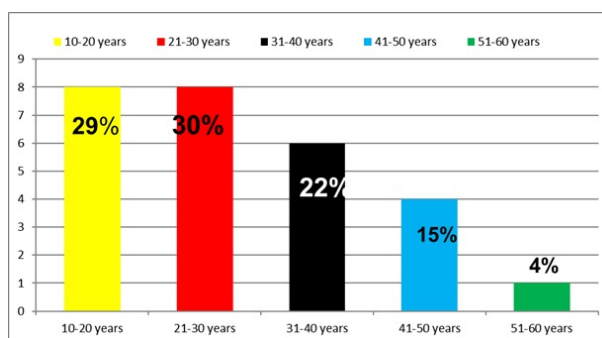


Figure 1: The age group most susceptible to infection. as depicted in the chart covering three consecutive years (2016, 2017, and 2018)

The statistical ratio between males and females for 2016, 2017, and 2018 was substantial, with 18 cases for females versus 9 for males, As shown in Figure 2.

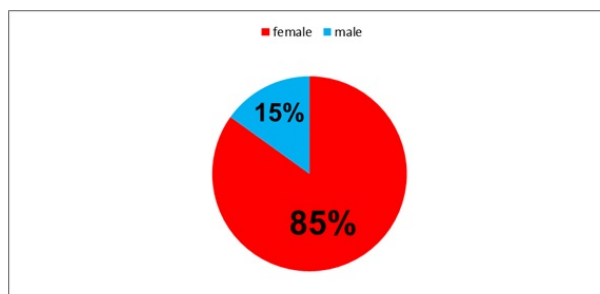


Figure 2: Showing the proportion of females and males positive for HEV for three consecutive years(2016-2017 and 2018), where the percentage of females (85%) is higher than males (15%)

High rates of HEV infection were reported in 2018, With 13 cases out of 9625 total patients tested. During three consecutive years, No substantial statistical dissimilarity was perceived in HEV infection between urban and rural (52% and 48%). It was ranked second in terms of severity of infection in 2017 with 9 cases out of 2452 total patients tested followed by 2016 with 5 cases out of 4064 total patients tested, as shown in Figure 3. Table 1 presents the age, sex, and residence details of patients diagnosed with HEV infection during the years 2016, 2017, and 2018.

Table 1: The age, sex, residence of the patients diagnosed with HEV infection for the years 2016, 2017 and 2018

a	Patient age Year	Number	Sex			Residence	
			Male	Female		Rural	Urban
				Number	Pregnant		
2016	20 -30	3	2	1	-	1	2
	41 - 50	1	1	-	-	1	-
	51 - 60	1	-	1	-	1	-
2017	10 - 20	3	-	3	1	-	3
	21 -30	2	-	2	-	2	-
	31 - 40	3	1	2	1	2	1
	41 - 50	1	-	1	-	-	1
2018	10 - 20	5	1	4	1	1	4
	21 -30	3	1	2	2	1	2
	31 - 40	3	1	2	-	1	2
	41 - 50	2	2	-	-	2	-

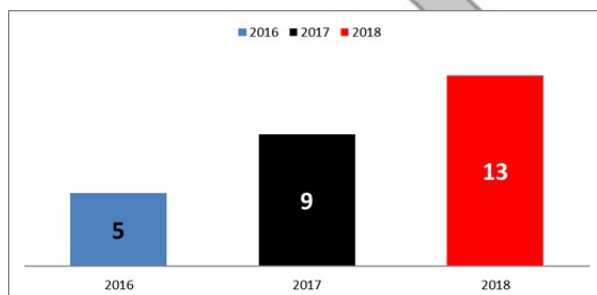


Figure 3: Showing the proportion of cases within three consecutive years of patients who positive for HEV, Where the highest infection rate was in 2018 with 13 cases, followed by 2017 with 9 cases of illness, while in 2016 had 5 cases only

The 21-30-year-olds group, They exhibit the highest susceptibility, followed by those aged 10-20 years. Subsequently, the group aged 31-40 years also shows vulnerability. The age category displaying the next level of susceptibility is 41-50 years. The least susceptible group, according to statistics, falls within the age range of 51-60 years. Figure 4 shows the proportion of males and females infected with the HEV virus in urban and rural areas for the years 2016, 2017, and 2018. Among the 27 total reported cases, 52% were from urban areas and 48% from rural areas. Figure 5 presents the monthly distribution of HEV infections across the three years, highlighting July as the month with the highest incidence, accounting for 9 cases.

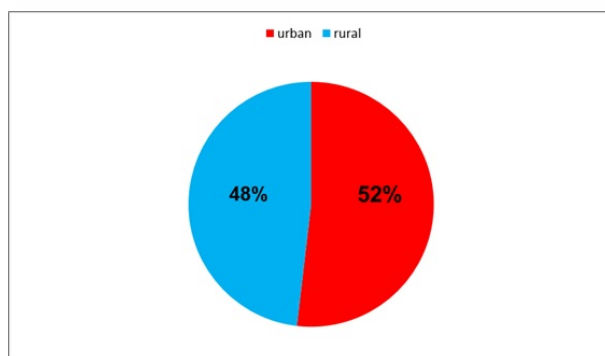


Figure 4: The proportion of males and females infected with the HEV virus according to the cities and rural areas for 2016,2017 and 2018, where the proportion of rural (48%) and the city (52%), the total number of cases was 27

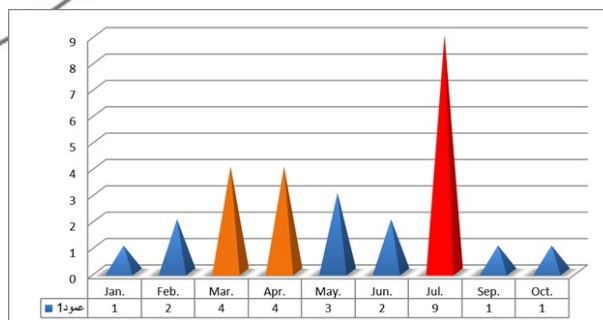


Figure 5: Statistical shows for all the months in which the infection occurred for HEV for three consecutive years, showing where the diagram, July is the highest rate for 9 cases

4 Discussion

Infection rates were often associated with the degree of water contamination and consumption of meat containing HEV or through unacceptable hygiene. HEV cases have been reported in Diwaniyah province in the last three years, with HEV in cities and the countryside. The prevalence rate of the virus in the city is gradually increasing. As shown in Figure 1, the second highest percentage was in the age group 10-20 years, involving the pediatric age group; most of these cases had a history of traveling with family or with a member of their families, the risk of spreading disease in these groups because most are in school-age groups or higher education levels, where these places are crowded with students. Also, 12 cases were reported in the rural areas, while the city center recorded 14 positive cases of the virus, Figure 4. It is suggested that its activity in summer is due to the low water level in streams and rivers, adding to unsatisfactorily little chlorination stages. The poor discharge of human waste into the rivers exacerbates the virus in the rivers. There were also cases in Western countries with the infection of fresh fruits [4, 5, 12, 13] by the virus, and most of the fruits are abundant in the summer. In addition to importing them mostly from countries infected with the virus, in the rural, it is suggested that the reason for the spread of the virus is due to insufficient personal hygiene and lack of access to sterile water as well as the consumption of meat and camel milk (gt7,8), which may be a container with a virus, As well as frequent swimming in summer for citizens in streams and small shallow rivers.

In cities and rural areas, the proportion of people exposed to the virus in the city is 52% higher than those in the rural areas of the virus, according to the statistics available for three consecutive years. It is proposed that this lack of statistics in rural areas is the need for health centers. In addition, most patients do not go to the existing health centers due to their lack of health awareness.

Alternatively, the passage of waste contaminated with the virus to the pipes equipped with drinking water; we also suggest that one of the causes of the infection is the travel of some citizens of countries with a solid basis to the spread of the virus, such as Southern France, Korea, India, Japan, China, and Sudan. There were multiple cases of the virus in those high-income countries. A study was conducted in Korea in 2007 for hospitalized

patients, and the number of patients was 55 (9%) with five positive cases of the virus [30].

A similar study was conducted in Japan in 2005-2006 with a group of patients with acute hepatitis, and when tested, 128 (3) (2.4%) had HEV [31]. The virus was also observed in blood donors. In 2007, China recorded 3701 blood donors, of whom 1,107 (29%) had a positive HEV infection. A study in New Zealand in 2007 recorded 265 blood donors, 11 of whom were positive for the virus (4%) [32, 33, 34, 35].

A study was also conducted in Baghdad in 2010. The Sadr City Medical recorded that 268 patients had been examined, and 40% had positive for the virus [33] and compared the results between the province of Baghdad and Diwaniyah based on the census, we found Baghdad is five times the population of Diwaniyah, so Al-Diwaniyah Higher severity of the virus from the province of Baghdad, being recorded in three consecutive years 27 cases out of 16141 patients. If we consider the age groups most susceptible to infection in Diwaniyah, the age group (10-30) years is the highest risk of infection at 59% of the total age groups (Figure 1). Nevertheless, Baghdad recorded the highest age group exposed to the virus, the largest ≥ 40 years in 2010 [33].

We suggest that the infection in the age group ≥ 40 was caused by their weakness of immunity, a previous acute liver infection, or dysfunction of the liver or hormones. The age group of 10-30 years suggests that the infection resulted from some of the reasons, including drinking contaminated water, swimming in contaminated tables, Or consuming amounts of infected meat. The categories 10-20 years may cause infection or change their immunity. During the Study of the virus, we found that the virus is spreading in low-income countries, as opposed to what has been found in previous studies. The virus is spread only in high-income countries [3, 4].

We found a statistical study in Sudan in 2006. There were 2621 positive for HEV, and the mortality rate was 45%; 61 pregnant women were of 19 dead. A similar study was conducted in Egypt in 2006 with a group of patients with acute viral hepatitis and found 64 cases, of whom about 23% had a positive for HEV. In a study in low-income Pakistan, the patients were hospitalized with severe hepatitis 148, of whom 21 (14%) were positive for HEV [34, 36]. We suggest that the spread of the virus in low-income countries is due to the lack of adequate health education in addition to malnutrition, contamination of food and drinking water, and the lack of periodic screening of citizens. If we studied the virus in pregnant women and exposed to the virus. We found a statistic for two consecutive years (2017,2018) in Diwaniyah that there were 5 cases of HEV for pregnant women, most of them in July. Most pregnant women who have HEV lose their child or their life.

A study was conducted in India on 62 pregnant women who had jaundice in the last period of pregnancy, and, after the necessary tests, found that 45% of women had positive HEV and 9 cases of liver failure. However, the rate of mortality was about 27%. 31 While in Sudan, 39 pregnant women were recorded and ended up with intrauterine death and the early birth of some.

In our study of causes, we suggest that the cause of the infection is due to hormonal changes occurring during pregnancy, causing an evident immune change in the pregnant woman. In addition, most women lack the necessary health education as well as food and water contaminated with the virus.

5 Conclusion

The primary hosts of the virus are pigs and wild boar, as well as the meat of camels and milk, spinners, and rabbits. The most common methods of spreading the virus are water and food contamination with HEV, as well as contamination of meat and the infected of passengers to areas infected with HEV. The spread of the virus among people is more often due to contamination of drinking and food via the virus. The highest infection rate is in July, i.e., in the summer or the end of the summer. The highest infection rate among age groups is (10-30 years). People in cities recorded the highest rate of HEV exposure from rural areas.

References

- [1] Balayan MS, Andjaparidze AG, Savinskaya SS, Ketiladze ES, Braginsky DM, Savinov AP, Poleschuk VF. Evidence for a virus in non-A, non-B hepatitis transmitted via the fecal-oral route. *Intervirology*. 1983 Jul 24;20(1):23-31.
- [2] Reyes GR, Purdy MA, Kim J, Luk KC, Young LM, Fry KE, Bradley DW. Isolation of a cDNA from the virus responsible for enterically transmitted non-A, non-B hepatitis. *Science*. 1990 Mar 16;247(4948):1335-9.
- [3] Dalton HR, Bendall R, Ijaz S, Banks M. Hepatitis E: an emerging infection in developed countries. *The Lancet Infectious Diseases*. 2008 Nov 1;8(11):698-709.
- [4] Kamar N, Bendall R, Legrand-Abravanel F, Xia NS, Ijaz S, Izopet J, Dalton HR. Hepatitis e. *The Lancet*. 2012 Jun 30;379(9835):2477-88.
- [5] Kamar N, Dalton HR, Abravanel F, Izopet J. Hepatitis E virus infection. *Clinical Microbiology Reviews*. 2014 Jan;27(1):116-38.
- [6] Adlhoch C, Avellon A, Baylis SA, Ciccaglione AR, Couturier E, de Sousa R, Epstein J, Ethelberg S, Faber M, Fehér Á, Ijaz S. Hepatitis E virus: Assessment of the epidemiological situation in humans in Europe, 2014/15. *Journal of Clinical Virology*. 2016 Sep 1;82:9-16.
- [7] Smith DB, Simmonds P, International Committee on the Taxonomy of Viruses Hep-
eviridae Study Group, Jameel S, Emerson SU, Harrison TJ, Meng XJ, Okamoto H,
Van der Poel WH, Purdy MA. Consensus proposals for classification of the family
Hepeviridae. *Journal of General Virology*. 2014 Oct;95(10):2223-32.
- [8] Purdy MA, Harrison TJ, Jameel S, Meng XJ, Okamoto H, Van der Poel WH, Smith
DB, ICTV Report Consortium. ICTV virus taxonomy profile: Hepeviridae. *Journal of
General Virology*. 2017 Nov;98(11):2645-6.
- [9] Abravanel F, Lhomme S, El Costa H, Schvartz B, Peron JM, Kamar N, Izopet J.
Rabbit hepatitis E virus infections in humans, France. *Emerging Infectious Diseases*.
2017 Jul;23(7):1191.

- [10] Hewitt PE, Ijaz S, Brailsford SR, Brett R, Dicks S, Haywood B, Kennedy IT, Kitchen A, Patel P, Poh J, Russell K. Hepatitis E virus in blood components: a prevalence and transmission study in southeast England. *The Lancet*. 2014 Nov 15;384(9956):1766-73.
- [11] Bura M, Lagiedo M, Michalak M, Sikora J, Mozer-Lisewska I. Hepatitis E virus IgG seroprevalence in HIV patients and blood donors, west-central Poland. *International Journal of Infectious Diseases*. 2017 Aug 1;61:20-2.
- [12] Maunula L, Kaupke A, Vasickova P, Söderberg K, Kozyra I, Lazic S, van der Poel WH, Bouwknecht M, Rutjes S, Willems KA, Moloney R. Tracing enteric viruses in the European berry fruit supply chain. *International Journal of Food Microbiology*. 2013 Oct 15;167(2):177-85.
- [13] Terio V, Bottaro M, Pavoni E, Losio MN, Serraino A, Giacometti F, Martella V, Motola A, Di Pinto A, Tantillo G. Occurrence of hepatitis A and E and norovirus GI and GII in ready-to-eat vegetables in Italy. *International Journal of Food Microbiology*. 2017 May 16;249:61-5.
- [14] Devi SG, Kumar A, Kar P, Husain SA, Sharma S. Association of pregnancy outcome with cytokine gene polymorphisms in HEV infection during pregnancy. *Journal of Medical Virology*. 2014 Aug;86(8):1366-76.
- [15] Fiore S, Savasi V. Treatment of viral hepatitis in pregnancy. *Expert Opinion on Pharmacotherapy*. 2009 Dec 1;10(17):2801-9.
- [16] Kamar N, Selves J, Mansuy JM, Ouezani L, Péron JM, Guitard J, Cointault O, Esposito L, Abravanel F, Danjoux M, Durand D. Hepatitis E virus and chronic hepatitis in organ-transplant recipients. *New England Journal of Medicine*. 2008 Feb 21;358(8):811-7.
- [17] Kamar N, Mansuy JM, Cointault O, Selves J, Abravanel F, Danjoux M, Otal P, Esposito L, Durand D, Izopet J, Rostaing L. Hepatitis E virus-related cirrhosis in kidney and kidney-pancreas-transplant recipients. *American Journal of Transplantation*. 2008 Aug 1;8(8):1744-8.
- [18] Gérolami R, Moal V, Colson P. Chronic hepatitis E with cirrhosis in a kidney-transplant recipient. *New England Journal of Medicine*. 2008 Feb 21;358(8):859-60.
- [19] Kamar N, Garrouste C, Haagsma EB, Garrigue V, Pischke S, Chauvet C, Dumortier J, Cannesson A, Cassuto-Viguier E, Thervet E, Conti F. Factors associated with chronic hepatitis in patients with hepatitis E virus infection who have received solid organ transplants. *Gastroenterology*. 2011 May 1;140(5):1481-9.
- [20] Kamar N, Abravanel F, Selves J, Garrouste C, Esposito L, Lavayssière L, Cointault O, Ribes D, Cardeau I, Nogier MB, Mansuy JM. Influence of immunosuppressive therapy on the natural history of genotype 3 hepatitis-E virus infection after organ transplantation. *Transplantation*. 2010 Feb 15;89(3):353-60.

- [21] Pischke S, Stiefel P, Franz B, Bremer B, Suneetha PV, Heim A, Ganzenmueller T, Schlue J, Horn-Wichmann R, Raupach R, Darnedde M. Chronic hepatitis E in heart transplant recipients. *American Journal of Transplantation*. 2012 Nov 1;12(11):3128-33.
- [22] Kamar N, Weclawiak H, Guilbeau-Frugier C, Legrand-Abravanel F, Cointault O, Ribes D, Esposito L, Cardeau-Desangles I, Guitard J, Sallusto F, Muscari F. Hepatitis E virus and the kidney in solid-organ transplant patients. *Transplantation*. 2012 Mar 27;93(6):617-23.
- [23] Legrand-Abravanel F, Kamar N, Sandres-Saune K, Garrouste C, Dubois M, Mansuy JM, Muscari F, Sallusto F, Rostaing L, Izopet J. Characteristics of autochthonous hepatitis E virus infection in solid-organ transplant recipients in France. *The Journal of Infectious Diseases*. 2010 Sep 15;202(6):835-44.
- [24] Dalton HR, Bendall RP, Pritchard C, Henley W, Melzer D. National mortality rates from chronic liver disease and consumption of alcohol and pig meat. *Epidemiology & Infection*. 2010 Feb;138(2):174-82.
- [25] Montella F, Rezza G, Di Sora F, Pezzotti P, Recchia O. Association between hepatitis E virus and HIV infection in homosexual men.
- [26] Payne BA, Medhi M, Ijaz S, Valappil M, Savage EJ, Gill ON, Tedder R, Schwab U. Hepatitis E virus seroprevalence among men who have sex with men, United Kingdom. *Emerging Infectious Diseases*. 2013 Feb;19(2):333.
- [27] Sayed IM, Verhoye L, Cocquerel L, Abravanel F, Foquet L, Montpellier C, Debing Y, Farhoudi A, Wychowski C, Dubuisson J, Leroux-Roels G. Study of hepatitis E virus infection of genotype 1 and 3 in mice with humanised liver. *Gut*. 2017 May 1;66(5):920-9.
- [28] Allweiss L, Gass S, Giersch K, Groth A, Kah J, Volz T, Rapp G, Schöbel A, Lohse AW, Polywka S, Pischke S. Human liver chimeric mice as a new model of chronic hepatitis E virus infection and preclinical drug evaluation. *Journal of hepatology*. 2016 May 1;64(5):1033-40.
- [29] Zhang J, Zhang XF, Huang SJ, Wu T, Hu YM, Wang ZZ, Wang H, Jiang HM, Wang YJ, Yan Q, Guo M. Long-term efficacy of a hepatitis E vaccine. *New England Journal of Medicine*. 2015 Mar 5;372(10):914-22.
- [30] Aikawa T, Kojima M, Takahashi M, Nishizawa T, Okamoto H. Identification of indigenous hepatitis E virus from a Japanese patient who contracted sporadic acute hepatitis in 1982. *The Journal of Infectious Diseases*. 2002 Nov 15;186(10):1535-6.
- [31] Sainokami S, Abe K, Kumagai I, Miyasaka A, Endo R, Takikawa Y, Suzuki K, Mizuo H, Sugai Y, Akahane Y, Koizumi Y. Epidemiological and clinical study of sporadic acute hepatitis E caused by indigenous strains of hepatitis E virus in Japan compared with acute hepatitis A. *Journal of Gastroenterology*. 2004 Jul;39:640-8.

- [32] Dong C, Dai X, Shao JS, Hu K, Meng JH. Identification of genetic diversity of hepatitis E virus (HEV) and determination of the seroprevalence of HEV in eastern China. *Archives of Virology*. 2007 Apr;152:739-46.
- [33] Hasan A, Al-Dulaimy A, Jabar F. Clinical patterns and sero-10. logical markers of acute viral hepatitis in Diyala. *Iraqi Journal of Community Medicine*. 2005;18:355-60.
- [34] Guthmann JP, Klovstad H, Boccia D, Hamid N, Pinoges L, Nizou JY, Tatay M, Diaz F, Moren A, Grais RF, Ciglenecki I. A large outbreak of hepatitis E among a displaced population in Darfur, Sudan, 2004: the role of water treatment methods. *Clinical Infectious Diseases*. 2006 Jun 15;42(12):1685-91.
- [35] Dalton HR, Fellows HJ, Gane EJ, Wong P, Gerred S, Schroeder B, Croxson MC, Garkavenko O. Hepatitis E in new zealand. *Journal of Gastroenterology and Hepatology*. 2007 Aug;22(8):1236-40.
- [36] Stoszek SK, Abdel-Hamid M, Saleh DA, Kafrawy SE, Narooz S, Hawash Y, Shebl FM, El Daly M, Said A, Kassem E, Mikhail N. High prevalence of hepatitis E antibodies in pregnant Egyptian women. *Transactions of the Royal Society of Tropical Medicine and Hygiene*. 2006 Feb 1;100(2):95-101.