DOI: 10.4274/vhd.galenos.2023.2023-3-1
Viral Hepatitis Journal 2023;29(1):1-9

Changing Trends in the Epidemiology of Delta Virus Infection

Delta Virüsü Enfeksiyonunun Epidemiyolojisinde Değişen Eğilimler

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ABSTRACT

Hepatitis delta virus (HDV) infection is an important health and economic problem worldwide. There are approximately 15 million patients with HDV worldwide and effects of 5-10% of all hepatitis B virus (HBV) infections globally. Chronic HDV infection results in 3 times more hepatocellular carcinoma (HCC) and 2 times more hepatic decompensation in cirrhosis patients compared with chronic HBV infection. HDV is associated with a higher economic burden than both HBV and hepatitis C virus (HCV) infection alone. Unlike HBV, HDV infection progresses to liver cirrhosis in 5 years, to HCC in 10 years. Risk factors for HDV infection are hepatitis B surface antigen (HBsAg) positivity, intravenous drug use, multi-partner sexual behaviors, anti-human immunodeficiency virus positivity, anti-HCV positivity, men who have sex with men, healthcare workers, immigrant people moving from high HBV infection endemic areas, prisoners, hemophiliacs, poor hygienic conditions, and low economic income. From West to East, HDV prevalence increased in both patients with chronic active hepatitis (CAH) and cirrhosis. However, the prevalence of HDV infection decreased both CAH and cirrhosis after 1995 in Turkey. Amazon basin, Indian population living in Venezuela, and the Santa Marta region of Colombia are areas of the highest HDV prevalence. Due to immigration from high HBV infection endemic areas to industrialized countries, Delta infection continues stably 5-10 % in HBsAg carriers. Each HBsAg-positive patient should be checked for anti-delta antibody to prevent rapid progress of parenchymal liver diseases.

Keywords: HDV, anti-HDV, cirrhosis, hepatitis, liver

ÖZ

Hepatit delta virüs (HDV) enfeksiyonu tüm dünyada önemli bir sağlık ve ekonomik sorundur. Dünya çapında yaklaşık 15 milyon HDV hastası vardır ve küresel olarak tüm hepatit B virüs (HBV) enfeksiyonlarının %5-10'unu etkilemektedir. Kronik HDV enfeksiyonu, kronik HBV enfeksiyonuna kıyasla siroz hastalarında 3 kat daha fazla hepatosellüler kanser (HCC) ve 2 kat daha fazla karaciğer yetmezliğine neden olur. HDV hem HBV hem de HCV enfeksiyonundan daha fazla ekonomik yüke sahiptir. HDV enfeksiyonu HBV'nin aksine 5 yılda karaciğer sirozu, 10 yılda karaciğer kanserine ilerleyicidir. HDV enfeksiyonu için risk faktörleri; hepatit B yüzey antijeni (HBsAg) pozitifliği, damar içi ilaç kullanımı, çok eşli cinsel davranışlar, anti-insan bağışıklık eksikliği virüsü (anti-HIV) pozitifliği, anti-HCV pozitifliği, erkeklerle cinsel ilişkiye giren erkekler, sağlık çalışanları, yüksek HBV enfeksiyonu endemik bölgelerden taşınan göçmenler, mahkumlar, hemofili hastaları, kötü hijyen koşulları ve düşük ekonomik gelir düzeyidir. Batı'dan Doğu'ya, HDV prevalansı hem kronik aktif hepatit (KAH), hem de siroz hastalarında artmıştır. Ancak Türkiye'de 1995 yılından sonra HDV enfeksiyonu prevalansı hem KAH hem de siroz için düşüş göstermiştir. Amazon havzası, Venezuela'da yaşayan yerli yaşam alanları ve Kolombiya'nın Santa Marta bölgesi HDV prevalansının en yüksek olduğu bölgelerdir. Yüksek HBV enfeksiyonu endemik bölgelerinden sanayileşmiş ülkelere göç nedeniyle, HBsAg taşıyıcılarında delta enfeksiyonu %5-10 oranında stabil olarak devam etmektedir. Parankimal karaciğer hastalıklarının hızlı ilerlemesini önlemek için her HBsAg pozitif hasta anti-delta antikoru açısından kontrol edilmelidir.

Anahtar Kelimeler: HDV, anti-HDV, siroz, hepatit, karaciğer

Cite this article as: Örmeci N, Erdem H. Changing Trends in the Epidemiology of Delta Virus Infection. Viral Hepatitis Journal 2023;29(1):1-9

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Introduction

Hepatitis delta virus (HDV) infection is an important health and economic problem all over the world, particularly in endemic areas such as the Mediterranean, Southern and Eastern Europe, the Middle East regions and Turkey. It was reported in the United States of America (USA) that the annual cost of HDV infection was 23,605$, which was 1.32 times higher and significantly more expensive than the annual cost of hepatitis B virus (HBV) infection (1).

HDV: HDV is a small, 36 nm in diameter, defective, negative single-stranded RNA virus requiring hepatitis B surface antigen (HBsAg), which allows HDV to enter hepatocytes. The virus was discovered by Rizzetto (2) in 1977. HDV is wrapped in HBsAg. HBV outer surface antigens such as large (Pre S1), medium (Pre S2), and small antigens are peripherally located surface proteins. Small and large delta antigens and single-stranded HDV-RNA take part in the central portion. Small HD Ag is essential for initiating viral replication, while large HD Ag is necessary for the assembly of new viral particles. Unlike the other RNA viruses, HDV uses host HDV polymerases for viral replication.

Epidemiology of HDV

HDV genotypes: Up to now, eight genotypes of HDV have been reported. Genotype 1 is common in Turkey as well as in North America, Europe, North Africa, Mediterranean countries and the Middle East. Sequence analysis has shown 82-95% similarity in patients with genotype 1. However, high genetic diversity was observed among the isolates, with a mean full-length dissimilarity score of 13.05% (3,4,5). Genotype 3 causes fulminant hepatitis and epidemics in East and South American countries (6).

HDV infection: There are approximately 15 million patients with HDV worldwide. It consists of 5-10.6 % of all HBV infections globally (7,8). People of the Amazon basin and Indian population living in Venezuela and the Santa Marta region of Colombia have long been known to have the highest HDV prevalence in the world (9). Reservoirs and transmission patterns of HDV infection are by nature in accordance with HBV infection. Delta prevalence was initially less than 5% in adults under 30 years of age and when the patients were over 40, the prevalence was around 20-33% in 1993 (9). Değertekin et al. (10) reported in a meta-analysis that HDV prevalence was found to be 84.9% in inactive HBsAg carriers, 20% in patients with chronic active hepatitis (CAH) due to HBV, 32.5% in patients with liver cirrhosis (LC). However, these prevalence rates have decreased from 20% to 11% in CAH, from 32% to 24% in LC patients in the last two decades (10).

Course of HDV infection: Chronic HDV infection is seen mostly during the 5th decade. It is associated with acute simultaneous co-infection of HBV and HDV, which results in mostly resolution of HBV infection but rarely causes severe or fulminant hepatitis; or superinfection, which is accelerated progressive replication of HDV and finally causes CAH, LC, hepatocellular carcinoma (HCC), and death (9). High HDV-RNA levels are commonly associated with high fibrosis scores, high necro-inflammations, high aspartate transaminase (AST) and alanine transaminase (ALT) levels, and lower albumin levels (11). When patients with chronic HBV are infected with HDV, approximately 76% of those patients may have chronic HDV infection within three years. Chronic HDV infection results in three-fold more HCC. In addition, it results in LC in a shorter period, which was observed 10-15% of patients within two years, in 30% of patients within 3 years. Moreover, hepatic decompensation was observed 2 times more compared with chronic HBV infection (1,7,12,13). Overall, HDV infection progresses to LC in 5 years, to HCC in 10 years (14).

Overall HDV prevalence: HDV prevalence of patients with acute, chronic, or fulminant hepatitis are 3-10 times more common compared with HBV seroprevalence (9). In a meta-analysis assessing 182 studies in 61 countries; the overall HDV prevalence was found to be 0.98% in HBsAg positives, where the pooled prevalence was found to be 14.6%. It was 37.6% in patients using intravenous drugs and 17% in patients with high-risk sexual behaviors (15). In a recent and large meta-analysis containing 120,293 patients in 282 studies, HDV prevalence was found to be 0.16 in the general population, 4.5% in HBsAg positive patients, 16.4% in patients who were followed by the outpatient liver clinics, 18% in patients with LC, 20% in patients with HCC (16).

Acute HBV infection and HDV

During acute HBV infection, HDV positivity rates were found to be 8.1% out of 766 patients in Turkey; 4% in Turin, and 91% in Naples out of 687 patients in Italy, and 0% out of 342 patients in Japan (10,17,18). In a meta-analysis in Turkey, the overall HDV positivity rate was 8.8% in 833 patients with acute hepatitis B (10).

Seroprevalence studies

Seropositivity of HBsAg and anti-delta immunoglobulin G (IgG) was checked in 29,960 volunteer persons from east to west parts of Turkey. Seropositivity of HBsAg and anti-delta IgG was found to be 1,805 (6.02%) and 43 (2.39%) out of 1,805 HBsAg positives; respectively (19). Accordingly, seroprevalence of HBsAg, anti-hepatitis C virus (anti-HCV), and anti-HDV was searched in volunteers; 19,250 persons during the years 2004-2006 in Urfa; and in 2012 individuals between 2007 and 2009 in Bolu. HDV seroprevalence was found 2.5% in Urfa but 0% in Bolu (20).

Chronic HBV-related liver disease and HDV

1. Data from Turkey

Viral hepatitis is one of the significant public health concerns in Turkey (21). Chronic HDV infection is endemically seen in countries where HBsAg positivity is common. It was reported that the positivity of HBsAg is 4% in a pivotal study in Turkey (22). In several studies, HDV rates were found between 1.76-6.8% of patients with HBsAg positive status in İzmir and this rate decreased from 5.2% in 2018 to 3.4% in 2019 (10). Similarly, HDV rates varied between 1.8% and 4.1% in İstanbul during the years between 2012 and 2019 (22,23,24,25,26,27,28,29,30) (Table 1). In East and Southeast provinces of Turkey, which have lower economic status, HDV prevalence rates in HBsAg positives were found to be 4-18.7% between 2002 and 2017 (31,32,33,34,35,36,37,38,39,40) (Table 2). In the central part of Anatolia, the HDV prevalence rate was reported as 23.9 % in 1986 (41). However, this rate became stable between 1.9% and 4.2% during the years 2000 and 2013 in Ankara and Konya (42,43,44,45) (Table 3).

Table 1. Prevalence of HDV between 2000 and 2018 in the western part of Turkey

References	Area	Date	Patients' types and numbers	HDV prevalence
İnci et al. (25)	İstanbul	2002-2012	HBsAg carriers (n=1,339)	3.4%
Gül Yurtsever et al. (28)	İzmir	2008-2010	HBsAg carriers (n=913)	6.3%
Özgenç et al. (29)	İzmir	2010	HBsAg carriers (n=170)	1.76%
Uzun et al. (30)	İzmir	2010-2011	HBsAg carriers (n=88)	3.4%
Eren (48)	İzmir	2013-2018	HBsAg carriers (n=968)	6.8%
Tozun et al. (22)	İstanbul	2015	HBsAg carriers (n=5,460)	2.8%
Yolcu et al. (24)	İstanbul	2015-2017	HBsAg carriers (n=2,089)	4.1%
Kaya et al. (27)	İzmir	2018	HBsAg carriers (n=8,250)	5.2%
Serin and Vatansever (23)	İstanbul	2019	CAH (n=587)	1.8%
			LC (n=84)	20%

HDV: Hepatitis delta virus, HBsAg: Hepatitis B surface antigen, CAH: Chronic active hepatitis, LC: Liver cirrhosis

Table 2. Prevalence of HDV in HBsAg carriers and chronic active hepatitis in East and South-East regions of Anatolia between 2002-2017

Authors	Location	Years	Number of patients	Prevalence of HDV
Celen et al. (31)	Diyarbakır	2002-2004	HBsAg carriers (n=889)	6%
			CAH (n=120)	27.5%
Güdücüoğlu et al. (32)	Van	2003-2004	HBsAg carriers (n=184)	19.5%
Bahcecioglu et al. (33)	Elazığ	2006-2009	CAH (n=282)	45.5%
Parlak et al. (34)	Erzurum	2008-2013	HBsAg carriers (n=2,540)	4.05%
Doğan et al. (35)	Ağrı	2009-2012	HBsAg carriers (n=787)	7% anti-HDV (+); 2.4% HDVAg (+)
Dulger et al. (36)	Van	2012-2014	HBsAg carriers (n=3,352)	18.4% in urban area; 12.5% in rural area
Ayaz and Sarı (37)	Gaziantep	2012-2017	HBsAg carriers (n=5,471)	4.44%
Mese et al. (38)	Diyarbakır	2014	HBsAg carriers in blood donors (n=186/6200)	6.98%
Sahin et al. (39)	Elazığ	2016-2017	HBsAg carriers (n=554)	9.6%
Eser-Karlidag (40)	Elazığ	2017-2019	CAH (n=455)	8.8%

HDV: Hepatitis delta virus, HBsAg: Hepatitis B surface antigen, CAH: Chronic active hepatitis

Table 3. Prevalence of HDV in central part of the Anatolia

Authors	Location	Years	Number of patients	Prevalence of HDV
Balik et al. (41)	Ankara	1986-1988	Acute HBV (n=237)	13.1%
			CAH (n=165)	32.7%
			Hemodialysis (n=12)	41.7%
			Poly-transfusion (n=45)	46.7%
Korkmaz et al. (44)	Eskisehir	2012-2013	HBsAg carriers (n=547)	1%
Türk-Arıbaş and Tekin (43)	Konya	2000-2002	Overall (n=107)	1.9%
			HBsAg carriers (n=30)	3.3%
			CAH (n=45)	2.2%
			Acute HBV (n=32)	0%
Gürkan et al. (42)	Ankara	2010-2013	HBsAg carriers (n=2,119)	4.2%
Altınbaş et al. (45)	Ankara	2009-2011	HBsAg carriers (n=348)	2%

HDV: Hepatitis delta virus, HBV: Hepatitis B virus, CAH: Chronic active hepatitis, HBsAg: Hepatitis B surface antigen

In a meta-analysis, 6,734 patients with CAH and 1,503 patients with LC were investigated in terms of HDV prevalence. From Western to Eastern Turkey, HDV prevalence increased in patients with CAH (from 5% to 19.6%) and LC (from 32.1% to 46.3%). However, both CAH (to 12%) and LC decreased to 27% after 1995 in Turkey (46). The reasons for the decrease in delta prevalence are the augmented hygienic measures, such as the use of disposable syringes, the decrease in sexual activity with multi-partners, the increase in awareness of HDV infection, improving education and socio-economic levels, and the vaccination of HBV.

In another study, HDV prevalence was found to be 1.56% of 2,314 patients with HBsAg positive status in Samsun, the Northern part of Anatolia, between 2005 and 2010 (47). In İzmir, located at the western tip of the country, it was found to be 6.8% among HBsAg carriers (48).

In a meta-analysis, anti-HDV positivity rates varied widely between 0.5-16.2% (mean was 4.9%) in 6,613 inactive HBsAg carriers. It decreased from 5.4% to 2.9%, years from 1991 to 2005. In the same paper, it was reported that HDV positivity in 5,961 patients with CAH-B and in 1,421 patients with LC was 20% and 32%, respectively. These rates increased from west to east. However, these ratios decreased in the West, Central, and East Anatolia years between 1980 and 2005. Anti-HDV positivity in patients with HCC was found 23% of 748 patients, but it varied widely from east to the west of Anatolia (10).

In another meta-analysis comprising 30 original studies, 6,734 patients with chronic liver diseases (n=5231) and LC (n=1503) were analyzed in terms of HDV seropositivity. When it was compared to anti-HDV seropositivity between east and west parts of Turkey, it was found that the prevalence of HDV was the lowest (5% and 20%; $p<0.0001$) in the west and the highest (27% and 46%; $p<0.0001$) in the southeast part of Turkey for chronic liver diseases and LC. However, when it was compared to HDV prevalence; both west and east, before and after the year of 1995; for chronic liver diseases and LC, it was reported that HDV prevalence decreased in both diseases after the year 1995. In conclusion, chronic delta infection is the most common of Turkey and is responsible for 1/4th of patients with CAH and 1/2nd of patients with LC in that area (46).

In a study from Elazığ located in the eastern part of Turkey, including the 2006-2009 period, 282 patients with CAH-B were investigated in terms of anti-delta seropositivity and HDV-RNA, and liver biopsy was performed. Anti-delta was positive in 128 (45.5%) patients. HDV-RNA was detected in 56.9% of patients. There was a close relationship between liver fibrosis stage, ALT levels, and serum albumin levels. HDV-RNA levels were higher in patients with high fibrotic stage and elevated ALT levels but low albumin levels. In patients with chronic HBV, chronic HDV infection and LC were 23.4% and 29.4%, respectively (11).

2. Global Data

In a meta-analysis analyzing 182 articles from 61 countries, it was reported that the global prevalence of HDV was 0.98. HDV prevalence was 14.57% in patients with HBsAg positive status; 37.57% in patients with intravenous drug users; 17.01% in patients with high-risk sexual behavior (15). In another meta-analysis, which included 282 studies from 95 countries, it was reported that the estimated global HDV prevalence among HBsAg-positives was 4.5%. In the general population, it was 0.16%, and in patients with LC and HCC were 18% and 20%, respectively (16).

In a meta-analysis including 332,155 people from 83 countries, it was reported that pooled HDV prevalence was 0.80 in the general population. HDV prevalence in HBsAg carriers was 13% out of 27,1,629 people in 83 countries. It was 26.75% in acute fulminant hepatitis and 25.77% in LC. HDV infection, which is highly prevalent in Central Asia, East and South Europe, Central Latin America, and Central and West Sub-Saharan Africa, was the leading cause of 19.8% of HCC. First in Asia, primarily in China (44.41%) and India (56.55%), then in Africa (22.30%) particularly in Nigeria (38.37%), HDV prevalence were predominant (14).

HDV prevalence was found to be higher than 20% in patients with HBsAg positivity between 1980 and 1990, and it decreased to 5-10% after 1990, most particularly due to HBV vaccination (49).

Buti et al. (50) reported from Spain that HDV prevalence was 1% until 1995. However, it increased to 28% between 1996 and 2008. Recently, HDV prevalence seems stable in West European countries; 8.5% in England, 8.1% in Italy, 11% in Germany (50).

HDV infection rates vary according to endemic areas, such as countries with limited resources in Africa, South America, throughout the Western Pacific (27.7%), Kiribati and Nauru Islands (84%) as high endemic areas; Mediterranean Basin, Italy (25%), Taiwan (24.7%) as intermediate endemic areas; North America, Korea; and cold areas with a low prevalence of HCV, HBV infection (0.85%) (51,52,53,54,55,56,57,58,59,60,61,62) (Table 4). The reason for wide differences the prevalence of HDV infection among all countries is associated with local socio-economic differences, genotype and virulence differences of HDV, and genetic differences of ethnic groups (63).

Immigrants and HDV Infection

In a study reported from USA, the overall estimated prevalence of HBsAg was found to be 0.36% and 3.4% in non-Hispanic Asian population between 2011 and 2016. However, the prevalence of HDV was found 42% in HBsAg carriers. HDV prevalence was 45% in Asian HBsAg-positive adults, while it was found 39% in HBsAg-positive adults of all other races (64). This study indicated that HDV seroprevalence was significantly higher in the United States than previously acknowledged, and it was disproportionately higher among Asians and persons born outside the United States.

HDV prevalence increased from 4.1% to 6.2% ($p<0.06$) among 1,307 HBsAg carriers in Dusseldorf between 1989 and 2008. Similarly, HDV prevalence increased from 32.1% to 46.2% in the former Soviet Union and from 0 to 17.2% in Africa. Seemingly, the reason for this increase is immigrants from high endemic areas of HBsAg carriers (49).

HDV prevalence in Italy was found to be 6.4% in native Italian and 26.4% in non-native Italian population in 2019 (58). Manesis et al. (62) reported that HDV prevalence was found 4.7% among 4,673 persons in Greece. However, this ratio was 2.8% in Greek people compared to 7.5% non-Greek immigrants (62). Hence, immigration seems to be a great facilitator for HDV spread in the community.

Use of Blood and Blood Products and HDV

Delta prevalence in patients with hemophilia and poly-transfused carriers was found to be significantly higher than in non-poly-transfused HBsAg carriers. In a multicentric study, HDV prevalence was found 50% in Italy, 48% of 273 patients with hemophilia in Maryland (65). HDV prevalence was found 6.98% of 6200 blood donors in Diyarbakır (38). This rate was found 3.8% in America (7).

HIV and HDV Co-infection

There was a close relationship among HDV, human immunodeficiency virus (HIV), and intravenous drug users (66). HDV infection predisposes co-infections such as HDV/HBV/HCV or HBV/HDV/HIV or HBV/HDV/hepatitis E virus (HEV) infections compared to HBV infection alone (25,61,67). HDV/HIV co-infection varies from 5% to 10.6% in the world, from 6% to 14% in North America and Europe, and from 10% to 20% in Asia and Africa (7). Soriano et al. (68) reported that HBsAg was positive in

Table 4. HDV prevalence of different geographic areas in the world

Name of Author	Country	Year	Number of patients	Prevalence of HDV
Ordieres et al. (51)	Spain	1983-1997	Chronic hepatitis B (n=786)	9.4%
		1998-2012	Chronic hepatitis B (n=429)	6.1%
Wu et al. (52)	China	2010-2013	HBsAg carriers (n=225)	4.9%
Genné and Rossi (53)	Switzerland	2008	HBsAg carriers (n=1,699) (76% had >F_2 fibrosis)	5.9%
Heidrich et al. (54)	Germany	1992-2006	HBsAg (+) (n=2,349)	11%
Aberra et al. (55)	Ethiopia	2017	CAH, HIV negative (n=1,267)	1.5%
Lago et al. (56)	Brazil	2013-2015	HBsAg carriers (n=1,240)	3.2%
Rizzetto (57)	Italy	1983	Asymptomatic carriers	7.1%
			Parenchymal liver disease	24.6%
		1987	HBsAg positives	23%
			Cirrhosis	40%
		1992	HBsAg carriers	14%
		1997	HBsAg carriers	8.3%
			Cirrhosis	11.7%
		2008	HBsAg carriers	9.7%
Mitamura et al. (17)	Japan	1991	HBsAg carriers (n=1,668)	0.59%
		1979-1985	CAH (n=690)	0.43%
		1986-1992	Cirrhosis (n=338)	1.47%
		-	Acute hepatitis (n=342)	0%
Stroffolini et al. (85)	Italy	2019	HBsAg carriers (n=894)	9.9% overall
			Italian native	4%
			Non-native	26.4%
Besombes et al. (59)	France	2019	HBsAg carriers (n=1,621)	10.6%
Cross et al. (60)	United Kingdom	2000-2006	HBsAg carriers (n=962)	8.52%
Coghill et al. (61)	Australia	1997-2016	HBsAg carriers (n=4,497)	4.1%
Manesis et al. (62)	Greece	1997-2010	HBsAg carriers (n=4,673)	4.7%
Değertekin et al. (10)	Turkey	1980-2005	HBsAg carriers (n=6,613)	4.9%
			Acute viral hepatitis (n=1,416)	3%
			CAH (n=5,961)	20%
			Acute hepatitis B (n=766)	8.1%
			Cirrhosis (n=1,421)	32.5%
Smedile et al. (18)	Italy	1978-1981	HBsAg carriers (n=492)	4.7%
			CAH (n=822)	4-51%
			Acute hepatitis B (n=687)	4-91%

HDV: Hepatitis delta virus, HBsAg: Hepatitis B surface antigen, CAH: Chronic active hepatitis

1,319 (7.9%) out of 16,597 patients with HIV (EuroSIDA study) in European countries. HDV prevalence was found in 422 (14.5%) patients with CAH B and HIV carriers (68). The combination of HBV and HIV infection progresses fast to chronic liver diseases. HCV is also a major cause of chronic liver diseases in patients with HIV (69). The most common cause of HIV, HBV, and HDV co-infection is intravenous drug use due to the similar transmission of those hepatotropic infections (70). Four hundred and eighty-four patients with HIV were assessed for hepatotropic virus in Buenos Aires. The prevalence of hepatitis B core antibody (58.5%), anti-HCV (14.5%), and anti-HEV (6.6%); were found to be higher than the control cases (p=0.001). Delta prevalence was 1.9% in those populations (71).

Sexual Associations

In an U.S. study, the prevalence of anti-delta in patients with men having sex with men varied from city to city. It was 0% in Chicago, 9.4% in San Francisco, 1.3% in Pittsburg, and 15.1% in Los Angeles. In addition, HDV prevalence was found to be 14.3% in 40 homosexual men in France and 21.73% in 154 homosexual men in Italy (72,73).

Intravenous Drug Use and HDV Infection

It is assumed that the number of persons who are using intravenous drugs is 10.6 million worldwide in 2016. Half of this population has been living in China, Russia, and U.S (7). In a study from U.S, 1,368 female prostitutes were checked for HBV and HDV viral markers and intravenous drug use. Fifty-six percent of them were HBsAg positives, 74% were intravenous drug users, and 38% were non-intravenous drug users. The HDV prevalence of patients who had HBsAg positive and intravenous drug users was 21%, while it was 6% in patients with non-intravenous drug users (74). Hence, intravenous drug use, even by inhalation, increases the risk of HBV, HCV, HIV, and HDV infections (75). Moreover, in Worcester, Massachusetts 135 patients with acute hepatitis were diagnosed due to intravenous drug use between 1983 and 1985. Eleven patients out of 13 with fulminant acute hepatitis died, and acute delta co-infection was found to be 54% among parenteral drug users (76).

HDV prevalence was checked in 194 intravenous drug users in 1988-1989 period and in 258 patients between 2005 and 2006 in Baltimore. HDV prevalence decreased from 15% to 11% between these two periods (77). Ninety-nine intravenous drug users were checked for anti-delta serology during 1972-1975 period in Washington, D.C., Miami, and New Jersey. Anti-delta was found to be positive in 10.1% of 99 patients and in 42.1% of intravenous drug users (78).

Eighty-eight HBsAg positive patients with intravenous drug users were searched in terms of anti-HDV and anti-HIV in New York city from 1985 to 1986. Anti-delta and anti-HIV were found positive in 67% and 58%, respectively. The presence of anti-delta and intravenous drug use were significantly associated with older age, longer duration of drug abuse, and presence of liver disease. The presence of anti-HIV and intravenous drug use are associated with younger age and increased serum globulin levels (79). Consequently, intravenous drug use is a noteworthy factor to facilitate the transmission of HDV infection.

Prisoners

In Taiwan, 1,137 prisoners were checked for HBsAg, anti-HCV, and anti-delta. Eighty-nine and 2% of these patients were intravenous drug users, and none were anti-HIV positive. HDV prevalence was 3.4% and triple infection (HBV, HDV and HCV) rate was 2.8% (80). In addition, inmates at Boston Municipal House were assessed for HBV and HDV in 1985. HBV markers were detected in 173 (43%) out of 406 inmates, whereas HBV markers were found in 10 (8%) out of 129 staff. Fourteen inmates (8%) had anti-HDV positivity among 173 inmates who had positive HBV markers, but no one had anti-delta (0%) among the staff. Intravenous drug use was found to be the strongest risk factor for the detection of HBV and HDV markers (81).

Mental Disorders and HDV Infection

Four thousand six hundred and seventy-one patients with mental retardation were searched in terms of HBsAg and anti-HDV in Illinois, USA in 1984. HBsAg was found in 238 of 4,671 patients. Seventy-one (29.8%) out of 238 patients had anti HDV (82). Hence, mentally disabled populations may impose significant risks for HDV infection.

Conclusion

Delta infection still causes health and economic problems, particularly in endemic countries. HDV infection is associated with HBV epidemiology and is significantly more common with intravenous drug use, multi-partner sexual behaviors, anti-HIV positivity, anti-HCV positivity, men who have sex with men, healthcare workers, immigrant people moving from high endemic areas, prisoners, hemophiliacs, poor hygienic conditions, and in those living in low economic income countries (14,15,16,51,83,84,85). Hence, delta infection continues stably 5-10% in patients with HBsAg carriers. Every patient with HBsAg positivity should be checked for delta infection to protect against the rapid progression of parenchymal liver diseases.

Ethics

Peer-review: Internally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: N.Ö., H.E., Concept: N.Ö., H.E., Design: N.Ö., H.E., Data Collection or Processing: N.Ö., H.E., Analysis or Interpretation: N.Ö., H.E., Literature Search: N.Ö., H.E., Writing: N.Ö., H.E.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

References

1. Elsaid MI, Li Y, John T, Narayanan N, Catalano C, Rustgi VK. Economic and Health Care Burdens of Hepatitis Delta: A Study of Commercially Insured Adults in the United States. Hepatology. 2020;72:399-411.
2. Rizzetto M. Hepatitis D Virus: Introduction and Epidemiology. Cold Spring Harb Perspect Med. 2015;5:a021576.

3. Bulut Y, Bahcecioglu IH, Aygun C, Oner PD, Ozercan I, Demirdag K. High genetic diversity of hepatitis delta virus in eastern Turkey. J Infect Dev Ctries. 2014;8:74-78.
4. Altuğlu I, Ozacar T, Sertoz RY, Erensoy S. Hepatitis delta virus (HDV) genotypes in patients with chronic hepatitis: molecular epidemiology of HDV in Turkey. Int J Infect Dis. 2007;11:58-62.
5. Le Gal F, Badur S, Hawajri NA, Akyüz F, Kaymakoglu S, Brichler S, Zoulim F, Gordien E, Gault E, Dény P. Current hepatitis delta virus type 1 (HDV1) infections in central and eastern Turkey indicate a wide genetic diversity that is probably linked to different HDV1 origins. Arch Virol. 2012;157:647-659.
6. Botelho-Souza LF, Vasconcelos MPA, Dos Santos AO, Salcedo JMV, Vieira DS. Hepatitis delta: virological and clinical aspects. Virol J. 2017;14:1-15.
7. Ferrante ND, Lo Re V 3rd. Epidemiology, Natural History, and Treatment of Hepatitis Delta Virus Infection in HIV/Hepatitis B Virus Coinfection. Curr HIV/AIDS Rep. 2020;17:405-414.
8. Wranke A, Pinheiro Borzacov LM, Parana R, Lobato C, Hamid S, Ceausu E, Dalekos GN, Rizzetto M, Turcanu A, Niro GA, Lubna F, Abbas M, Ingiliz P, Buti M, Ferenci P, Vanwolleghem T, Hayden T, Dashdorj N, Motoc A, Cornberg M, Abbas Z, Yurdaydin C, Manns MP, Wedemeyer H, Hardtke S; Hepatitis Delta International Network. Clinical and virological heterogeneity of hepatitis delta in different regions worldwide: The Hepatitis Delta International Network (HDIN). Liver Int. 2018;38:842-850.
9. Polish LB, Gallagher M, Fields HA, Hadler SC. Delta hepatitis: molecular biology and clinical and epidemiological features. Clin Microbiol Rev. 1993;6:211-229.
10. Değertekin H, Yalçin K, Yakut M. The prevalence of hepatitis delta virus infection in acute and chronic liver diseases in Turkey: an analysis of clinical studies. Turk J Gastroenterol. 2006;17:25-34.
11. Yalçın MS, Yalçın K. Analysis of Virological, Histological and Clinical Features of Hepatitis Delta Virus Infection in Southeastern Turkey. Viral Hepatitis Journal. 2018;24:47-52.
12. Farci P, Niro G. Clinical features of hepatitis D. Semin Liver Dis. 2012;32:228-236.
13. Noureddin M, Gish R. Hepatitis delta: Epidemiology, diagnosis and management 36 years after discovery. Curr Gastroenterol Rep. 2014;16:365.
14. Miao Z, Miao Z, Zhang S, Ou X, Li S, Ma Z, Wang W, Peppelenbosch MP, Liu J, Pan Q. Estimating the Global Prevalence, Disease Progression, and Clinical Outcome of Hepatitis Delta Virus Infection. J Infect Dis. 2020;221:1677-1687.
15. Chen HY, Shen DT, Ji DZ, Han PC, Zhang WM, Ma JF, Chen WS, Goyal H, Pan S, Xu HG. Prevalence and burden of hepatitis D virus infection in the global population: a systematic review and meta-analysis. Gut. 2019;68:512-521.
16. Stockdale AJ, Kreuels B, Henrion MYR, Giorgi E, Kyomuhangi I, de Martel C, Hutin Y, Geretti AM. The global prevalence of hepatitis D virus infection: Systematic review and meta-analysis. J Hepatol. 2020;73:523-532.
17. Mitamura K. Epidemiology of HDV infection in Japan. Prog Clin Biol Res. 1991;364:81-87.
18. Smedile A, Lavarini C, Farci P, Aricò S, Marinucci G, Dentico P, Giuliani G, Cargnel A, Del Vecchio Blanco C, Rizzetto M. Epidemiologic patterns of infection with the hepatitis B virus-associated delta agent in Italy. Am J Epidemiol. 1983;117:223-229.
19. Örmeci N, Balık İ, Tabak F, Saltoğlu N, Tosun S, Şencan İ. Anti-Delta positivity in Patients with HBsAg positive. X. In: National Viral Hepatitis Congress Antalya; 2010, p. 173.
20. Sırmatel F, Yetkin G, Eriş F, Koruk S, Duygu F, Karaağaç L. Seroprevalance of Hepatitis B Virus, Hepatitis C Virus and Hepatitis D Virus in Healthy Blood Donors. Viral Hepatitis Journal. 2012;18:19-22.
21. Erdem H, Akova M. Leading infectious diseases problems in Turkey. Clin Microbiol Infect. 2012;18:1056-1067.
22. Tozun N, Ozdogan O, Cakaloglu Y, Idilman R, Karasu Z, Akarca U, Kaymakoglu S, Ergonul O. Seroprevalence of hepatitis B and C virus infections and risk factors in Turkey: a fieldwork TURHEP study. Clin Microbiol Infect. 2015;21:1020-1026.
23. Serin A, Vatansever S. Seroprevalence of Delta Hepatitis in Chronic Hepatitis B Patients: Single Center Study. FU Med J Health Sci. 2019;33:137-141.
24. Yolcu A, Karabulut N, Alaçam S, Önel M, Büyük M, Güllüoğlu M, Ağaçfidan A. Frequency of Hepatitis Delta Virus in Hepatitis B Surfaceantigen-positive Patients. Viral Hepatitis Journal. 2019;25:14-18.
25. İnci A, Fincancı M, Müderrisoğlu C. Investigation of Anti-Hepatitis Delta Virus and Anti-Hepatitis C Virus in Patients with Hepatitis B Virus Infection. Istanbul Medical Journal. 2013;14:109-111.
26. Kose S, Ece G, Gozaydin A, Turken M. Study on seroprevalence of hepatitis delta in a regional hospital in western Turkey. J Infect Dev Ctries. 2012;6:782-785.
27. Kaya S, Karabey M, Güngör S, Baran N, Şener AG, Afşar İ. Evaluation of Hepatitis D Virus serology results of İzmir Katip Çelebi University Atatürk Training and Research Hospital. J Immunol Clin Microbiol. 2019;4:91-96.
28. Gül Yurtsever S, Er HH, Güngör S, Uzun B. The Prevalence and Clinical Significance of Delta Antibody in Hepatitis B Virus Infection. Viral Hepatitis Journal. 2011;17:69-73.
29. Özgenç F, Ecevit ÇÖ, Erdemir G, Sertöz R, Yağcı RV. Prevelance of hepatitis D co-enfection in children with hepatitis B infection: cross-sectional analyses from Western Turkey. Turk J Gastroenterol. 2013;24:345-348.
30. Uzun B, Şener AG, Güngör S, Afşar I, Demirci M. Evaluation of hepatitis delta virus (HDV) infection in blood donors in western Turkey. Transfus Apher Sci. 2014;50:388-391.
31. Celen MK, Ayaz C, Hosoglu S, Geyik MF, Ulug M. Anti-hepatitis delta virus seroprevalence and risk factors in patients with hepatitis B in Southeast Turkey. Saudi Med J. 2006;27:617-620.
32. Güdücüoğlu H, Altunbaş S, Bozkurt H, Baykal S, Berktaş M. Invaestigation of Delta Anribody in HBsAg Positive Soldiers in Van AMilitary Hospital. Van Medical Journal. 2006;13:118-120.
33. Bahcecioglu IH, Aygun C, Gozel N, Poyrazoglu OK, Bulut Y, Yalniz M. Prevalence of hepatitis delta virus (HDV) infection in chronic hepatitis B patients in eastern Turkey: still a serious problem to consider. J Viral Hepat. 2011;18:518-524.
34. Parlak E, Ertürk A, Parlak M, Koşan Z, Albayrak A, Özkurt Z, Özden K, Erol. Assessment of Patients with Hepatitis D. Viral Hepatit Dergisi. 2015;21:80-84.
35. Doğan M, Güneş H, Mete R, Taş T, Mengeloğlu FZ, Küçükbayrak A. Prevalence of anti-HDV and HDAg in patients with chronic hepatitis B. Dicle Medical Journal. 2013;40:50-53.
36. Dulger AC, Suvak B, Gonullu H, Gonullu E, Gultepe B, Aydın İ, Batur A, Karadas S, Olmez Ş. High prevalence of chronic hepatitis D virus infection in Eastern Turkey: urbanization of the disease. Arch Med Sci. 2016;12:415-420.
37. Ayaz C, Sarı T. Treatment results of chronic delta hepatitis patients. Middle-East Medical Journal. 2019;11:73-77 (Turkish).
38. Mese S, Nergiz S, Tekes S, Gul K. Seroprevalence of serum HBsAg positivity and hepatitis delta virus infection among blood donors in Southeastern Turkey. Clin Ter. 2014;165:95-98.
39. Sahin A, Gurocak S, Tunc N, Demirel U, Poyrazoglu OK, Akbulut H, Yalniz M, Toraman ZA, Bahcecioglu IH. Anti-HDV seroprevalance among patients with previous HBV infection. North Clin Istanb. 2018;5:132-138.
40. Eser-Karlidag G. Prevalence of hepatitis delta in chronic hepatitis B patients. KLIMIK Derg. 2019;32:281-284.

41. Balik I, Onul M, Tekeli E, Caredda F. Epidemiology and clinical outcome of hepatitis D virus infection in Turkey. Eur J Epidemiol. 1991;7:48-54.
42. Gürkan Y, Toyran A, Aksoy A, Coşkun FA, Çetin F. Evaluation of HBsAg and Anti-HDV Seroprevalance of Patients who Admitted to Ankara Numune Training and Research Hospital Between 2010 - 2013. Viral Hepatitis Journal. 2013;19:148-151.
43. Türk-Arıbaş E, Tekin B. Investigation of hepatitis delta virus antibody in patients with hepatitis B virus infection. General Medicine Journal. 2002;12:133-135 (Turkish).
44. Korkmaz P, Aykın N, Çağlan-Çevik F, Güldüren HM, Alpay Y. Seropositivity of Delta Hepatitis in HBsAg Positive Patients in Eskişehir Province. Viral Hepatitis Journal. 2014;20:72-74.
45. Altınbaş A, Yılmaz B, Ekiz F, Aktaş B, Çoban Ş, Başar Ö, Yüksel O. The incidence of delta hepatitis seropositivity in HBsAg positive patients. Cumhuriyet Med J. 2012;34:56-59.
46. Değertekin H, Yalçin K, Yakut M, Yurdaydin C. Seropositivity for delta hepatitis in patients with chronic hepatitis B and liver cirrhosis in Turkey: A meta-analysis. Liver Inter. 2008;28:494-498.
47. Karadağ A, Yılmaz H, Gören İ, Acuner İ, Eroğlu C, Günaydın M. Defining the Delta Virus Positivity in Hepatitis B Virus Infections. Viral Hepatitis Journal. 2014;202:64-66.
48. Eren O. Retrospective evaluation of the characteristics of delta positive and negative patients with HBsAg positive status in the blood samples detected in Ege University Hospital Microbiology Laboratory between 2013-2018. Ege University, School of Medicine; 2021.
49. Wedemeyer H, Manns MP. Epidemiology, pathogenesis and management of hepatitis D: Update and challenges ahead. Nat Rev Gastroenterol Hepatol. 2010;7:31-40.
50. Buti M, Homs M, Rodriguez-Frias F, Funalleras G, Jardí R, Sauleda S, Tabernero D, Schaper M, Esteban R. Clinical outcome of acute and chronic hepatitis delta over time: a long-term follow-up study. J Viral Hepat. 2011;18:434-442.
51. Ordieres C, Navascués CA, González-Diéguez ML, Rodríguez M, Cadahía V, Varela M, Rodrigo L, Rodríguez M. Prevalence and epidemiology of hepatitis D among patients with chronic hepatitis B virus infection: a report from Northern Spain. Eur J Gastroenterol Hepatol. 2017;29:277-283.
52. Wu S, Zhang Y, Tang Y, Yao T, Lv M, Tang Z, Zang G, Yu Y, Chen X. Molecular epidemiology and clinical characteristics of hepatitis delta virus (HDV) infected patients with elevated transaminases in Shanghai, China. BMC Infect Dis. 2020;20:565.
53. Genné D, Rossi I. Hepatitis delta in Switzerland: A silent epidemic. Swiss Med Wkly. 2011;141:1-4.
54. Heidrich B, Deterding K, Tillmann HL, Raupach R, Manns MP, Wedemeyer H. Virological and clinical characteristics of delta hepatitis in Central Europe. J Viral Hepat. 2009;16:883-894.
55. Aberra H, Gordien E, Desalegn H, Berhe N, Medhin G, Mekasha B, Gundersen SG, Gerber A, Stene-Johansen K, Øverbø J, Johannessen A. Hepatitis delta virus infection in a large cohort of chronic hepatitis B patients in Ethiopia. Liver Int. 2018;38:1000-1009.
56. Lago BV, Mello FCA, Barros TM, Mello VM, Villar LM, Lewis-Ximenez LL, Pardini MIMC, Lampe E; Brazilian Hepatitis B Research Group. Hepatitis D infection in Brazil: Prevalence and geographical distribution of anti-Delta antibody. J Med Virol. 2018;90:1358-1363.
57. Rizzetto M. Hepatitis D: the comeback? Liver International. 2009;29:140-142.
58. Mitamura K. Epidemiology of HDV infection in Japan. Prog Clin Biol Res. 1991;364:81-87.
59. Besombes C, Njouom R, Paireau J, Lachenal G, Texier G, Tejiokem M, Cauchemez S, Pépin J, Fontanet A. The epidemiology of hepatitis delta virus infection in Cameroon. Gut. 2020;69:1294-1300.
60. Cross TJ, Rizzi P, Horner M, Jolly A, Hussain MJ, Smith HM, Vergani D, Harrison PM. The increasing prevalence of hepatitis delta virus (HDV) infection in South London. J Med Virol. 2008;80:277-282.
61. Coghill S, McNamara J, Woods M, Hajkowicz K. Epidemiology and clinical outcomes of hepatitis delta (D) virus infection in Queensland, Australia. Int J Infect Dis. 2018;74:123-127.
62. Manesis EK, Vourli G, Dalekos G, Vasiliadis T, Manolaki N, Hounta A, Koutsounas S, Vafiadis I, Nikolopoulou G, Giannoulis G, Germanidis G, Papatheodoridis G, Touloumi G. Prevalence and clinical course of hepatitis delta infection in Greece: a 13-year prospective study. J Hepatol. 2013;59:949-956.
63. Rizzetto M, Ciancio A. Epidemiology of hepatitis D. Semin Liver Dis. 2012;32:211-219.
64. Patel EU, Thio CL, Boon D, Thomas DL, Tobian AAR. Prevalence of Hepatitis B and Hepatitis D Virus Infections in the United States, 2011-2016. Clin Infect Dis. 2019;69:709-712.
65. Rizzetto M, Purcell RH, Gerin JL. Epidemiology of HBV-associated delta agent: geographical distribution of anti-delta and prevalence in polytransfused HBsAg carriers. Lancet. 1980;7:1215-1218.
66. Solomon RE, Kaslow RA, Phair JP, Lyter D, Visscher B, Lyman D, VanRaden MT, Gerin J. Human immunodeficiency virus and hepatitis delta virus in homosexual men. A study of four cohorts. Ann Intern Med. 1988;108:51-54.
67. Özel-Yeşilyurt A, Ayraler A, Turfan S, Dülger AC, Ayvaz MA. Hepatitis E Virus Seroprevalence in Patients with Hepatitis Delta Virus Infection. Online Turkish Journal of Health Sciences. 2020;5:1-7.
68. Soriano V, Grint D, d'Arminio Monforte A, Horban A, Leen C, Poveda E, Antunes F, de Wit S, Lundgren J, Rockstroh J, Peters L. Hepatitis delta in HIV-infected individuals in Europe. AIDS. 2011;25:1987-1992.
69. Soriano V, Martin-Carbonero L, Vispo E, Labarga P, Barreiro P. Human immunodeficiency virus infection and viral hepatitis. Enferm Infecc Microbiol Clin. 2011;29:691-701.
70. Calle Serrano BC, Manns M, Wedemeyer H. Hepatitis delta and HIV infection. Semin Liver Dis. 2012;32:120-129.
71. Fainboim H, González J, Fassio E, Martínez A, Otegui L, Eposto M, Cahn P, Marino R, Landeira G, Suaya G, Gancedo E, Castro R, Brajterman L, Laplumé H. Prevalence of hepatitis viruses in an anti-human immunodeficiency virus-positive population from Argentina. A multicentre study. J Viral Hepat. 1999;6:53-57.
72. Pol S, Dubois F, Roingeard P, Zignego L, Housset C, Brechot C, Goudeau A, Berthelot P. Hepatitis delta virus infection in French male HBsAg-positive homosexuals. 1989;10:342-345.
73. Mele A, Franco E, Caprilli F, Gentili G, Stazi MA, Zaratti L, Capitanio B, Crescimbeni E, Corona R, Panà A, et al. Hepatitis B and Delta virus infection among heterosexuals, homosexuals and bisexual men. 1988;4:488-491.
74. Rosenblum L, Darrow W, Witte J, Cohen J, French J, Gill PS, Potterat J, Sikes K, Reich R, Hadler S. Sexual practices in the transmission of hepatitis B virus and prevalence of hepatitis delta virus infection in female prostitutes in the United States. JAMA. 1992;267:2477-2481.
75. Santana Rodríguez OE, Malé Gil ML, HernándezSantana JF, Limiñana Cañal JM, Martín Sánchez AM. Prevalence of serologic markers of HBV, HDV, HCV and HIV in non-injection drug users compared to injection drug users in Gran Canaria, Spain. Eur J Epidemiol. 1998;14:555-561.
76. Lettau LA, McCarthy JG, Smith MH, Hadler SC, Morse LJ, Ukena T, Bessette R, Gurwitz A, Irvine WG, Fields HA, et al. Outbreak of severe hepatitis due to delta and hepatitis B viruses in parenteral drug abusers and their contacts. N Engl J Med. 1987;317:1256-1262.
77. Kucirka LM, Farzadegan H, Feld JJ, Mehta SH, Winters M, Glenn JS, Kirk GD, Segev DL, Nelson KE, Marks M, Heller T, Golub ET. Prevalence, correlates, and viral dynamics of hepatitis delta among injection drug users. J Infect Dis. 2010;202:845-852.
78. Ponzetto A, Seeff LB, Buskell-Bales Z, Ishak KG, Hoofnagle JH, Zimmerman HJ, Purcell RH, Gerin JL. Hepatitis B markers in United States drug addicts with special emphasis on the delta hepatitis virus. Hepatology. 1984;4:1111-1115.
79. Novick DM, Farci P, Croxson TS, Taylor MB, Schneebaum CW, Lai ME, Bach N, Senie RT, Gelb AM, Kreek MJ. Hepatitis D virus and human

immunodeficiency virus antibodies in parenteral drug abusers who are hepatitis B surface antigen positive. J Infect Dis. 1988;158:795-803.

80. Lu MY, Chen CT, Shih YL, Tsai PC, Hsieh MH, Huang CF, Yeh ML, Huang CI, Wang SC, Tsai YS, Ko YM, Lin CC, Chen KY, Wei YJ, Hsu PY, Hsu CT, Jang TY, Liu TW, Liang PC, Hsieh MY, Lin ZY, Chen SC, Huang JF, Dai CY, Chuang WL, Yu ML, Chang WY. Changing epidemiology and viral interplay of hepatitis B, C and D among injecting drug user-dominant prisoners in Taiwan. Sci Rep. 2021;11:8554.
81. Barry MA, Gleavy D, Herd K, Schwingl PJ, Werner BG. Prevalence of markers for hepatitis B and hepatitis D in a municipal house of correction. 1990;80:471-473.
82. Hershow RC, Hershow RC, Chomel BB, Graham DR, Schyve PM, Mandel EJ, Kane MA, Fields HA, Hadler SC. Hepatitis D virus infection in Illinois state facilities for the developmentally disabled. Epidemiology and clinical manifestations. Ann Intern Med. 1989;110:779-785.
83. Toy M, Ahishali E, Yurdaydın C. Hepatitis Delta Virus Epidemiology in the Industrialized World. AIDS Rev. 2020;22:203-212.
84. Gilman C, Heller T, Koh C. Chronic hepatitis delta: A state-of-the-art review and new therapies. World J Gastroenterol. 2019;25:4580-4597.
85. Stroffolini T, Ciancio A, Furlan C, Vinci M, Fontana R, Russello M, Colloredo G, Morisco F, Coppola N, Babudieri S, Ferrigno L, Sagnelli C, Sagnelli E. Migratory flow and hepatitis delta infection in Italy: A new challenge at the beginning of the third millennium. J Viral Hepat. 2020;27:941-947.