Public Health Corner

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Hepatitis D double reflex testing of all hepatitis B carriers in low-HBV- and high-HBV/HDV-prevalence countries

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Summary

Hepatitis D virus (HDV) infection occurs as a coinfection with hepatitis B and increases the risk of hepatocellular carcinoma, decompensated cirrhosis, and mortality compared to hepatitis B virus (HBV) monoinfection. Reliable estimates of the prevalence of HDV infection and disease burden are essential to formulate strategies to find coinfected individuals more effectively and efficiently. The global prevalence of HBV infections was estimated to be 262,240,000 in 2021. Only 1,994,000 of the HBV infections were newly diagnosed in 2021, with more than half of the new diagnoses made in China. Our initial estimates indicated a much lower prevalence of HDV antibody (anti-HDV) and HDV RNA positivity than previously reported in published studies. Accurate estimates of HDV prevalence are needed. The most effective method to generate estimates of the prevalence of anti-HDV and HDV RNA positivity and to find undiagnosed individuals at the national level is to implement double reflex testing. This requires anti-HDV testing of all hepatitis B surface antigen-positive individuals and HDV RNA testing of all anti-HDV-positive individuals. This strategy is manageable for healthcare systems since the number of newly diagnosed HBV cases is low. At the global level, a comprehensive HDV screening strategy would require only 1,994,000 HDV antibody tests and less than 89,000 HDV PCR tests. Double reflex testing is the preferred strategy in countries with a low prevalence of HBV and those with a high prevalence of both HBV and HDV. For example, in the European Union and North America only 35,000 and 22,000 cases, respectively, will require anti-HDV testing annually.

Background

Hepatitis D virus (HDV) infection, which occurs as a coinfection with hepatitis B, increases the risk of hepatocellular carcinoma (HCC), decompensated cirrhosis, and mortality 3.2- (95% CI 1.0–10.0), 2.2- (95% CI 0.8–5.7), and 2.0- (95% CI 0.7–5.7) fold, respectively, compared to hepatitis B virus (HBV) monoinfections.[1–5] Therefore, reliable estimates of the prevalence of HDV infection and disease burden are essential to formulate strategies to find coinfected individuals more effectively and efficiently. Early diagnosis of HDV will also allow for more appropriate counselling (*e.g.*, reduce alcohol consumption, lose weight) to reduce the risk of disease progression and prevent HDV transmission, interventions including antiviral treatment, and follow-up (ultrasound and HCC surveillance). In

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Key points

- Accurate estimates of the prevalence of anti-HDV and HDV RNA positivity are needed to assess the national, regional and global disease burden.
- We recommend double reflex testing of all HBV-infected individuals for anti-HDV and HDV RNA.
- The burden of double reflex testing (anti-HDV and PCR) will be small as only newly diagnosed HBV cases will require testing.
- Globally, less than 2 million people will require anti-HDV testing and less than 90,000 will require PCR testing.
- This recommendation makes the most sense in countries with a low prevalence of HBV and those with a high prevalence of HBV and HDV (*i.e.* most countries).

addition, early detection of complications will save lives by enabling appropriate interventions (*e.g.*, liver transplantation or HCC treatment). Knowledge of HDV infection will raise awareness of the infection among healthcare professionals with potential access to therapy and may empower patients to take action.

Methods

The Polaris Observatory started the task of quantifying the global prevalence of HDV infection. A comprehensive literature review was conducted to determine the prevalence of anti-HDV and HDV-RNA positivity for individual countries/territories. Virtual meetings were held with experts from each setting to discuss the literature search findings and collect unpublished data/reports. The crude reported prevalence was adjusted for patient segments and regional heterogeneity to estimate the adjusted HDV prevalence in the HBV-infected population. The findings were then combined with the Polaris Observatory HBV data (6) to estimate the overall prevalence of anti-HDV and HDV-RNA positivity in each country/territory at the population level.

The number of newly diagnosed HBV infections in each country was updated annually using the following methodologies: In countries where HBV surface antigen (HBsAg) was a notifiable infection, the annual reported data was collected. In countries where the number of newly diagnosed cases was not available, expert panel input was used. Lastly, the secant method was used to solve for the proportion of diagnosed HBsAg-infected population to match the reported number of diagnosed cases to modelled in a given year.[7] This method assumed that at base, those in later stages of the disease are more likely to be diagnosed than those in earlier stages. Details of the data sources for each country were described previously in Table 6 of Appendix.[6]

For countries where no data was available, the weighted average of countries within the same region, as defined by the Global Burden of Diseases, was applied. The regional estimates (income group, continent, and the European Union) were calculated by summing data from countries in each region. The World Bank data list of all countries in each income group was used.[8]

Results

We found a much lower prevalence of anti-HDV and HDV RNA positivity than that reported in published studies.[9–12] Key drivers of this discrepancy were the lack of nationally representative studies and the use of crude or pooled prevalence in meta-analyses, rather than adjusted prevalence (*i.e.*, HDV prevalence of a study adjusted for age, sex, population, or geography of the country). Most data on prevalence estimates relied on studies within smaller regions and subpopulations, which can lead to overestimation of the actual disease prevalence in the general population. As an example, most studies in Brazil report a high prevalence of anti-HDV positivity in the Amazon region. However, the Amazon region also has a small population. After adjusting for the population, HBV prevalence, and HDV infection prevalence in different regions of Brazil, the prevalence of anti-HDV positivity dropped by half, from 3.2% to 1.6%, among HBV-positive individuals in the same study.[13] Previous studies have also shown a 5- to 10-fold difference in the prevalence of anti-HDV positivity among blood donors and patients with cirrhosis in Italy, Turkey, and Uzbekistan.[14,15]

The total HBsAg-positive infections and the number of newly diagnosed HBsAg-positive infections from the Polaris Observatory are provided in Table 1.

Discussion

The most effective method to develop accurate estimates of the prevalence of anti-HDV and HDV RNA positivity and find undiagnosed individuals at the national level is to implement double reflex testing. This requires anti-HDV testing of all HBsAg-positive individuals and HDV RNA testing of all anti-HDV-positive individuals.

Table 1. Total HBsAg infections and newly diagnosed HBsAg infections.

Regions	Total HBsAg-positive infections, 2021	Newly diagnosed HBsAg infections, 2021
Global	262,240,000	1,994,000
Regions by income groups		
High income	11,375,000	114,000
Upper middle income	98,193,000	1,128,000
Lower middle income	116,585,000	631,000
Low income	35,636,000	119,000
Geographical regions		
Africa	69,512,000	187,000
Asia	178,978,000	1,694,000
Australia	316,000	6,000
Europe	7,502,000	66,000
North America	2,710,000	22,000
Oceania	788,000	1,000
South America	2,433,000	19,000
European Union	2,828,000	35,000
China, Mainland	80,952,000	1,000,000

A study in Spain showed that implementation of reflex anti-HDV testing resulted in an increased diagnosis of anti-HDV-positive individuals.[16] Without reflex testing, national registries will report a greater HDV prevalence because of selection bias; patients suspected of having hepatitis D, most of them with advanced liver disease, are referred for testing and recorded in the national registry.[17]

The current European Association for the Study of the Liver and the Asian Pacific Association for the Study of the Liver guidelines already recommend HDV screening of all HBsAg-positive individuals, whereas the American Association for the Study of Liver Diseases guidelines only recommend screening populations at greater risk for this infection.[18–20] HDV reflex testing is already performed at specific hospitals or in specific regions within a limited set of countries (*e.g.*, Spain, France, Brazil, Sweden, Canada), but not at the national level.[21–23] In most cases, only individuals suspected of HDV infection (elevated alanine transaminase level, early-age cirrhosis, or HCC) are screened, leading to high prevalence estimates as a result of selection bias. This screening strategy also has the limitation that it is often too late to implement any preventive measures in individuals suspected of having advanced liver disease.

On the surface, double reflex testing may appear to put an undue burden on healthcare systems, but analysis of the hepatitis B cascade of care provides a different story, because only individuals diagnosed with HBsAg will have to be tested for anti-HDV.[24]

As shown in Table 1, an estimated 2 million HBsAg-positive people worldwide are diagnosed annually, with half of them residing in mainland China. In all of Europe, an estimated 65,800 patients with HBV would require reflex testing for anti-HDV (only 34,500 in the European Union). Therefore, at the national level, the numbers that require anti-HDV testing will be even fewer. The estimated number of patients requiring testing would be less in North America, South America, and Australia. The total annual number that should be tested for anti-HDV in all of Africa is also less than 180,000. The overall cost could be managed further by not testing for HDV if patients have the same diagnosis already noted in their medical record.

The prevalence of HDV among HBsAg-positive individuals was estimated to be between 4.5% and 14.6%.[10–12] This is likely an overestimate; but, if we use it as a placeholder, only an estimated 89,000 people will need annual HDV PCR tests globally. Table 1 suggests that double reflex testing for HDV will not overburden healthcare systems and may result in cost savings by reducing costly end-stage disease.[25]

The only exception to this recommendation is for countries and regions with a high prevalence of HBV but a low prevalence of HDV infection (*e.g.*, mainland China, Taiwan, Korea, Japan), for which a cost-effectiveness study is needed to assess the benefit of reflex testing; serum pooling techniques could be considered in this setting.[26] Nonetheless, in regions and at-risk groups with a high HDV prevalence, such as persons who inject drugs and prisoners,[26] reflex testing remains beneficial. In addition, reflex testing may be warranted in individuals previously diagnosed with HBV who engage in high-risk behaviours. Our recommendation still applies to countries with a low prevalence of HBV infection (Europe and North America), where fewer HBV-positive individuals will be diagnosed, and thus fewer reflex tests will be needed. The recommendation does not apply to quantitative HBsAg testing, which is used repeatedly for reasons other than diagnosis.

Today, there is limited availability and standardisation of HDV RNA PCR tests in anti-HDV tests used in different countries and there are no World Health Organization prequalified tests. However, this limitation is mainly a result of the low demand for these tests, given current practices. With the implementation of double reflex testing, there will be an incentive for diagnostics companies to register their tests and compete based on quality and price, as well as to commercialise rapid anti-HDV diagnostic tests with high sensitivity and specificity that can be used in resource-limited settings as well as other countries.[27]

The double reflex test is manageable for healthcare systems. In addition, it will provide more accurate estimates of the prevalence of HDV infection as well as help develop more reasonable strategies to identify HDV-infected individuals early in the disease course and offer appropriate linkage to care, counselling, follow-up, and interventions, with the ultimate goals of reducing morbidity and mortality.

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Abbreviations

HBsAg, HBV surface antigen; HBV, hepatitis B virus; HCC, hepatocellular carcinoma; HDV, hepatitis D virus.

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Conflict of interest

SB, IG, HAR, DRS, KRS, AV – CDA Foundation received an investigator sponsored research grant to study HDV prevalence. NAM reports personal fees from AbbVie. HC reports a grant from Gilead Sciences. CF reports grant and personal fees from Gilead Sciences. ASD has received honorary for lectures from Gilead, MSD and AbbVie, and has participated in an expert meeting for Gilead. GF reports personal fees from Gilead. CS reports personal fees from Gilead & AbbVie. RG – consult for Gilead, Quest, LabCorp and Diasorin. NT reports grants from NIH, GSK, Genentech-Roche, Helio Health, Gilead Sciences and Durect Corp, and consulting with Eiger Biopharmaceuticals.

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Authors' contributions

Conceptualization – All authors, Data curation - All authors; Formal Analysis – HR, SB, DRS, IG, AV, and KRS; Methodology - HR; Project administration - HR; Supervision - HR; Validation - All authors; Visualization - HR; Writing – original draft - HR; Writing – review & editing - All authors.

Data availability statement

The data reported in this publication is available through Center for Disease Analysis Foundation's website https://cdafound.org/polaris-observ-access/for a period of 12 months and is refreshed quarterly.

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Supplementary data

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References

[1] Brancaccio G, Nardi A, Madonia S, Fasano M, Verucchi G, Massari M, et al. The present profile of chronic hepatitis B virus infection highlights future challenges: an analysis of the Multicenter Italian MASTER-B cohort. Dig Liver Dis 2019;51(3):438–442.

[2] Romeo R, Del Ninno E, Rumi M, Russo A, Sangiovanni A, de Franchis R, et al. A 28-year study of the course of hepatitis Delta infection: a risk factor for cirrhosis and hepatocellular carcinoma. Gastroenterology 2009;136(5):1629–1638.

[3] Beguelin C, Moradpour D, Sahli R, Suter-Riniker F, Luthi A, Cavassini M, et al. Hepatitis delta-associated mortality in HIV/HBV-coinfected patients. J Hepatol 2017;66(2):297–303.

[4] Roulot D, Brichler S, Layese R, BenAbdesselam Z, Zoulim F, Thibault V, et al. Origin, HDV genotype and persistent viremia determine outcome and treatment response in patients with chronic hepatitis delta. J Hepatol 2020;73(5):1046–1062.

[5] Fattovich G, Giustina G, Christensen E, Pantalena M, Zagni I, Realdi G, et al. Influence of hepatitis delta virus infection on morbidity and mortality in compensated cirrhosis type B. The European Concerted Action on Viral Hepatitis (Eurohep). Gut 2000;46(3):420–426.
[6] Razavi-Shearer D, Gamkrelidze I, Nguyen MH, Chen DS, Van Damme P, Abbas Z, et al. Global prevalence, treatment, and prevention of hepatitis B virus infection in 2016: a modelling study. Lancet Gastroenterol Hepatol 2018;3(6):383–403.
[7] Weisstein EW. Secant Method: Wolfram Research, Inc.; [cited 2017 September 7]. Available from: http://mathworld.wolfram.com/SecantMethod.html.
[8] The World Bank. DataBank, World development indicators. The World Bank; 2022. Available from: https://databank.worldbank.org.
[9] Razavi-Shearer D, Dhindsa K, Razavi H. Population adjusted prevalence of hepatitis Delta virus in 16 countries. Hepatology 2022;76:S211.
[10] Chen HY, Shen DT, Ji DZ, Han PC, Zhang WM, Ma JF, et al. Prevalence and burden of hepatitis D virus infection in the global population: a systematic review and meta-analysis. Gut 2019;68(3):512–521.
[11] Miao Z, Zhang S, Ou X, Li S, Ma Z, Wang W, et al. Estimating the global prevalence, disease progression, and clinical outcome of hepatitis delta virus infection. J Infect Dis 2020;221(10):1677–1687.
[12] Stockdale AJ, Kreuels B, Henrion MYR, Giorgi E, Kyomuhangi I, de Martel C, et al. The global prevalence of hepatitis D virus infection: systematic review and meta-analysis. J Hepatol 2020;73(3):523–532.
[13] Lago BV, Mello FCA, Barros TM, Mello VM, Villar LM, Lewis-Ximenez LL, et al. Hepatitis D infection in Brazil: prevalence and geographical distribution of anti-Delta antibody. J Med Virol 2018;90(8):1358–1363.
[14] Rizzetto M, Hamid S. The medical impact of hepatitis D virus infection in Asia and Africa; time for a reappraisal. Liver Int 2021;41(1):16–19.
[15] Rizzetto M, Hamid S, Negro F. The changing context of hepatitis D. J Hepatol 2021;74(5):1200–1211.
[16] Palom AR-SA, Vico J, Pacín B, Vargas E, Barreira-Díaz A, Rodríguez-Frías F, Riveiro-Barciela M, Esteban R, Buti M. Implementation of anti-HDV reflex testing among HBsAg-positive individuals increases testing for hepatitis D. JHEP Rep 2022;4(10):1–4.
[17] Osiowy C, Swidinsky K, Haylock-Jacobs S, Sadler MD, Fung S, Wong D, et al. Molecular epidemiology and clinical characteristics of hepatitis D virus infection in Canada. JHEP Rep 2022;4(5):100461.
[18] European Association for the Study of the Liver. Electronic address eee, European association for the study of the L. EASL 2017 clinical practice guidelines on the management of hepatitis B virus infection. J Hepatol 2017;67(2):370–398.
[19] Sarin SK, Kumar M, Lau GK, Abbas Z, Chan HLY, Chen CJ, et al. Asian-Pacific clinical practice guidelines on the management of hepatitis B: a 2015 update. Hepatol Int 2016;10(1):1–98.
[20] Terrault NA, Lok ASF, McMahon BJ, Chang KM, Hwang JP, Jonas MM, et al. Update on prevention, diagnosis, and treatment of chronic hepatitis B: AASLD 2018 hepatitis B guidance. Hepatology 2018;67(4):1560–1599.
[21] Crespo J, Cabezas J, Aguilera A, Berenguer M, Buti M, Forns X, et al. Recommendations for the integral diagnosis of chronic viral hepatitis in a single analytical extraction. Gastroenterol Hepatol 2022 (In Press).
[22] Ministry of Health Brazil. Clinical Protocol and therapeutic guidelines for hepatitis B and coinfections. Brasil: Ministério da Saúde; 2017.
[23] Brichler SRD, et al. Hepatitis delta virus reflex testing in patients with hepatitis B improves the HDV screening cascade: 10 years of real-word experience from Avicenne University hospital, France. J Hepatol 2022;77:S271.
[24] Center for Disease Analysis Foundation. HBV Cascade of Care 2022 [Available from: https://cdafound.org/polaris-observ-access/.
[25] 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(2):399–411.
[26] Lu MY, Chen CT, Shih YL, Tsai PC, Hsieh MH, Huang CF, et al. Changing epidemiology and viral interplay of hepatitis B, C and D among injecting drug user-dominant prisoners in Taiwan. Scientific Rep 2021;11(1):8554.
[27] Lempp FA, Roggenbach I, Nkongolo S, Sakin V, Schlund F, Schnitzler P, et al. A rapid point-of-care test for the serodiagnosis of hepatitis delta virus infection. Viruses 2021;13(12).