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# Multidisciplinary Approaches to Hospital Preparedness and Management of Infectious Disease Outbreaks in Saudi Arabia-Hepatitis as an Example

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## Abstract

**Background:** Viral hepatitis remains a major public health concern in Saudi Arabia, with varying epidemiology across hepatitis A, B, C, D, and E. Despite substantial progress achieved through nationwide vaccination, improved sanitation, surveillance, and treatment programs, challenges persist due to demographic shifts, behavioral risk factors, co-infections, and disparities in healthcare access.

**Aim:** This review aims to synthesize current evidence on the epidemiology, risk factors, prevention strategies, and management of viral hepatitis in Saudi Arabia, while highlighting the multidisciplinary roles essential to preparedness and outbreak control. In the same way, this review aims to evaluate the main role of physician, epidemiologists, internal specialists, nutritionists, health security professionals, medical information technologists, medical secretaries, medical managers, and physiotherapists in the management of hepatitis during outbreaks.

**Methods:** A narrative review approach was utilized, analyzing national surveillance reports, seroprevalence studies, Ministry of Health publications, and published regional data addressing HAV–HEV distribution, determinants, and clinical management strategies across healthcare sectors in Saudi Arabia.

**Results:** Findings demonstrate significant declines in HBV prevalence due to universal infant vaccination, fluctuating HAV and HEV incidence influenced by sanitation and seasonal patterns and marked reductions in HCV linked to the National Hepatitis Program and direct-acting antivirals. HDV remains underdiagnosed but clinically significant among HBV carriers. Risk factors include socioeconomic disparities, inadequate sanitation, unsafe medical practices, intravenous drug use, and limited adult vaccination uptake. Management strategies vary by viral type, with strong national programs supporting HBV and HCV control, though HDV and HEV treatment access remain limited.

**Conclusion:** Saudi Arabia has achieved substantial progress in hepatitis control through vaccination, surveillance, and treatment programs. However, persistent gaps—particularly in stigma reduction, adult vaccination, HDV surveillance, and access disparities—require strengthened integrated strategies and multidisciplinary collaboration.

**Keywords:** Viral hepatitis, Saudi Arabia, epidemiology, vaccination, surveillance, HBV, HCV, HAV, HDV, HEV, public health.

## Introduction

Viral hepatitis, defined by inflammation of the liver caused by distinct viral pathogens, continues to pose a significant public health challenge worldwide. Its burden is influenced by complex factors, including modes of transmission, population susceptibility, and effectiveness of public health interventions. In Saudi Arabia, viral hepatitis encompasses five primary types: hepatitis A (HAV), B (HBV), C (HCV), D (HDV), and E (HEV). The epidemiology of these infections reflects both notable successes and ongoing challenges. Universal infant vaccination has dramatically reduced HBV prevalence, demonstrating the potential of structured immunization programs. Nevertheless, persistent gaps in surveillance, shifting demographic patterns, and


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emerging risk factors such as intravenous drug use and migration complicate efforts toward elimination. Moreover, less studied co-infections, particularly HDV among HBV carriers, contribute to accelerated liver disease and heightened risk of cirrhosis and hepatocellular carcinoma, emphasizing the need for integrated screening and management strategies [1]. HAV historically exhibited high endemicity in Saudi Arabia, particularly in areas with inadequate sanitation. Most infections occurred in early childhood, often asymptomatically or with mild flu-like symptoms. However, improvements in hygiene and living conditions have shifted exposure patterns, reducing early-life immunity. Recent seroprevalence studies indicate that only 33.1% of the population possesses protective anti-HAV IgG antibodies, a notable decline from previous decades, when rates among adolescents and young adults approached 50%. This decreasing immunity highlights an expanding pool of susceptible adolescents and adults, who are more likely to experience symptomatic or severe disease, including fulminant hepatitis. Such demographic shifts necessitate targeted vaccination strategies for high-risk groups, including travelers and pilgrims, to prevent outbreaks and reduce morbidity [2][3]. Clinical presentation differs by age, with approximately 70% of adults developing overt symptoms such as jaundice, whereas most children under six presents with mild, nonspecific symptoms [4].

HBV transmission, predominantly via blood and bodily fluids, presents distinct epidemiological challenges. Nationwide infant vaccination programs introduced in 1989 have reduced HBV prevalence to around 1.3%. Despite this success, HDV co-infection complicates disease management, affecting 5–20% of HBV cases and significantly accelerating progression to cirrhosis and hepatocellular carcinoma. High-risk populations include healthcare workers, hemodialysis patients, and expatriates from regions of higher endemicity. These observations highlight the importance of integrating HDV screening and targeted interventions into HBV control programs to prevent severe outcomes [5][6]. HCV prevalence in Saudi Arabia remains low, estimated at 0.124%, with minimal perinatal transmission. Historically, unscreened blood transfusions before 1990 contributed to early infections, whereas contemporary concerns focus on intravenous drug use as a rising transmission route. HEV is primarily waterborne, with outbreaks linked to poor sanitation, high-density gatherings, and mass events such as the Hajj pilgrimage. The influx of pilgrims and a large expatriate workforce complicates disease dynamics, emphasizing the need for robust surveillance, public health planning, and preventive strategies [7].

Despite progress, critical gaps persist. Recent nationwide seroprevalence data for HCV, HDV, and HEV are limited, and the effects of migration, travel, and changing risk behaviors remain insufficiently studied. Emerging challenges, including drug-resistant viral strains and inadequate HDV monitoring, necessitate urgent attention [8]. Addressing these issues is essential to strengthen national hepatitis policies and advance elimination goals. This review aims to synthesize current evidence on the epidemiology, trends, and risk factors for HAV, HBV, HCV, HDV, and HEV in Saudi Arabia. It evaluates the effectiveness of existing prevention strategies, particularly the HBV vaccination program, identifies persistent challenges, and proposes evidence-based recommendations to enhance surveillance, prevention, and control. In the same way, this review aims to evaluate the main role of physician, epidemiologists, internal specialists, nutritionists, health security professionals, medical information technologists, medical secretaries, medical managers, and physiotherapists in the management of hepatitis during outbreaks.

**Epidemiology of Hepatitis in Saudi Arabia**

Viral hepatitis remains a significant public health concern in Saudi Arabia, though the burden of disease has substantially decreased over the past few decades due to comprehensive public health interventions, improved sanitation, vaccination programs, and enhanced screening and treatment strategies. The epidemiology of hepatitis in the country varies by type, age, region, and population subgroups, reflecting both historical exposure patterns and the impact of targeted interventions. This section provides a detailed overview of hepatitis A, B, C, D, and E, highlighting incidence trends, prevalence, risk factors, and regional differences.

**Hepatitis A**

Hepatitis A virus (HAV) infection occurs sporadically worldwide and often follows cyclical patterns, with approximately 1.5 million cases reported annually. The disease burden is higher in low- and middle-income countries due to historically limited sanitation and hygiene, while in high-income countries, HAV accounts for 20–25% of viral hepatitis cases. Socioeconomic improvements, access to clean water, and widespread vaccination programs have significantly influenced HAV epidemiology over the past two decades. In Saudi Arabia, HAV incidence has demonstrated notable fluctuations. Blood donor data reveal rates of 0.32% in 2016, rising to 0.74% in 2018, peaking sharply at 9% in 2020, and gradually declining to 7–8% in 2021–2022, indicating occasional rebounds despite an overall downward trend [10][11]. Similar patterns were observed in Ministry of Health (MOH) reports, with 157 cases of HAV reported in 2023 and fluctuating prevalence rates over recent years [9]. Seroprevalence studies further demonstrate age and regional variability. In Riyadh, 45% of children had protective anti-HAV IgG by age 11, while in Western Saudi Arabia (Jeddah), rates among schoolchildren were 28.7%. In the Eastern region (Dammam), seroprevalence was higher among school-aged children and increased with age,

reflecting historical exposure during periods of limited sanitation [12][13][14][15]. Seasonal peaks were observed in March and September, corresponding with indoor winter gatherings and post-summer school or workplace returns, facilitating fecal–oral transmission [16][17]. These trends underscore the importance of targeted vaccination strategies for high-risk groups, including adolescents, adults, travelers, and pilgrims, to prevent severe disease and outbreaks.

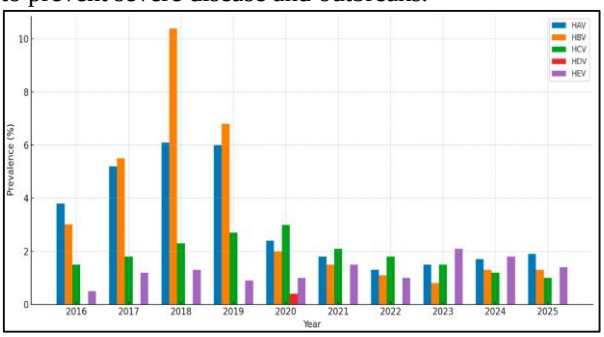


**Fig. 1:** Prevalence of Hepatitis in KSA (2016-2025).

**Hepatitis B**

Hepatitis B virus (HBV) represents a major global health issue, with an estimated 254 million individuals living with chronic infection in 2022, and approximately 1.2 million new chronic cases occurring annually [18]. The Eastern Mediterranean region, including Saudi Arabia, has an estimated prevalence of 3.3%, with 18 million individuals affected by 2024 [19]. Blood donor studies indicate variable HBV prevalence, with Saudi Arabia historically reporting higher rates (3.02%) compared to neighboring countries such as Iraq (0.67%) and Iran (0.58%) [16]. Universal infant vaccination, introduced in 1990, has dramatically reduced HBV prevalence, from approximately 8% in the 1980s to 1.3% in vaccinated cohorts in Riyadh, highlighting the success of immunization campaigns [20]. Recent surveillance continues to demonstrate fluctuating trends. In 2016, HBV prevalence among blood donors was 3.02%, rising to 10.4% in 2018, followed by a progressive decline to 0.8% in 2024 and a minor rise to 1.3% in 2025, suggesting persistent low-level transmission [21][22][23][24][25]. Geographic variability remains significant, with higher crude incidence rates observed in Qunfudah, Jeddah, Tabuk, and Taif (25–29 per 100,000) compared to Hail, Qurayyat, Jouf, and Hafr Al Baten (1–4 per 100,000) [27]. Age- and gender-specific data indicate lower incidence among children (0.3–0.8 per 100,000 for ages 0–14) and higher rates among adults aged 15–44 (~14 per 100,000) and 45+ (~30 per 100,000). Saudi males generally have a 1.4-fold higher incidence than females, and among expatriates, males exhibit a 2.2-fold higher rate, reflecting greater occupational and behavioral exposure [28][29]. Public awareness remains limited, underscoring the need for ongoing education alongside vaccination and screening programs.

**Hepatitis C**

Hepatitis C virus (HCV) infection represents a persistent public health concern in the Eastern Mediterranean, with approximately 12 million individuals infected [30]. The Saudi MOH has launched a national elimination program targeting a 90% reduction in new HCV cases and a 65% reduction in related deaths by 2030 [31]. HCV prevalence in Saudi Arabia has fluctuated significantly. National reports show 12733 cases in 2023 [9], with prevalence peaking at 22.63% in 2020 and declining to 0.09% by 2025, reflecting the impact of screening programs, public health interventions, and effective treatment strategies [32][33]. High-risk groups, including individuals who inject drugs, remain disproportionately affected, with prevalence as high as 38–69%, predominantly genotype 1b. Age-stratified data indicate increasing seroprevalence with age, from 4.49% in those under 15 years to 15% in the 45–54-year age group. Hospital-based and mixed datasets may overestimate prevalence due to inclusion of previously treated or cleared infections [34][35][36].

**Hepatitis D and E**

Hepatitis D virus (HDV), a defective virus requiring HBV co-infection, affects approximately 7.7% of chronic HBV patients in Saudi Arabia as of 2020, with incidence reported at 30.7% in 2025 [6][37]. HDV infection accelerates progression to cirrhosis and hepatocellular carcinoma, yet remains understudied. Surveillance and targeted management in HBV-infected individuals are critical to mitigating adverse outcomes. Hepatitis E virus (HEV) is primarily waterborne and often causes self-limiting infection; however, pregnant women are at high risk of severe complications, including fulminant hepatitis, miscarriage, and maternal mortality, with case fatality rates of 20–30% during outbreaks. HEV incidence in Saudi Arabia fluctuates, with 15 cases reported in 2023 [9], prevalence ranging from 4.3% in 2022 to 23.8% in 2023 [38][39][40], and sporadic detection in most study years. Population movement, environmental conditions, and mass gatherings such as the Hajj contribute to outbreak dynamics, highlighting the need for enhanced surveillance, targeted vaccination strategies, and improved sanitation [41][42].Overall, the epidemiology of viral hepatitis in Saudi Arabia reflects the interplay of historical exposure, improved public health infrastructure, vaccination programs, and emerging risk factors. While significant progress has been achieved in reducing the burden of HAV, HBV, and HCV, challenges remain, including geographic and demographic variability, co-infections such as HDV, and gaps in surveillance for HEV. Continued efforts in vaccination, public awareness, screening, and targeted interventions are essential to consolidate gains, prevent outbreaks, and achieve the national elimination goals for viral hepatitis.

**Risk Factors of Hepatitis in Saudi Arabia**

The epidemiology of hepatitis in Saudi Arabia is shaped by multiple interrelated risk factors, including socioeconomic conditions, behavioral patterns, healthcare access, and regional disparities. The modes of transmission vary by hepatitis type: HAV and HEV are primarily spread via the fecal–oral route, while HBV, HCV, and HDV are bloodborne or sexually transmitted. These distinctions necessitate targeted prevention strategies addressing both environmental and individual-level determinants [43].

**Socioeconomic Factors**

Socioeconomic status is a major determinant of hepatitis prevalence. Populations in low-income or rural areas face higher rates of HAV and HEV due to limited access to clean water, inadequate sanitation, and overcrowded living conditions. Alshwailem et al. reported that children from low-income households had an HAV seroprevalence of 50%, compared with 30% among high-income peers, highlighting disparities in early-life exposure and immunity [44]. Similarly, HCV prevalence is unevenly distributed, with economically disadvantaged regions such as Jazan reporting rates of 1.5%, compared to 0.5% in more affluent areas like Riyadh [3]. Gender differences also reflect socioeconomic influences. Men demonstrate higher HCV prevalence (0.4% vs. 0.2% in women), likely due to occupational exposures, higher engagement in high-risk behaviors, and less frequent healthcare utilization. Marital status further contributes: widowed and divorced individuals exhibit elevated risk, with adjusted odds ratios of 7.8 and 2.07, respectively, potentially linked to psychosocial stress, reduced access to preventive care, and increased likelihood of high-risk behaviors following marital separation [12]. Comorbidities amplify susceptibility. Individuals with chronic conditions—such as diabetes (34.9%), hypertension (35%), or chronic kidney disease (11.8%)—require repeated healthcare interventions, including injections or dialysis, increasing exposure risk. Compromised immune function in these populations further exacerbates vulnerability. HDV infection, which requires concurrent HBV infection, is a particularly aggressive co-infection, with transmission linked to unsafe injections, contaminated medical equipment, and high-risk sexual practices. Migrants from endemic regions and individuals who inject drugs remain key populations requiring focused surveillance [3].

**Behavioral Factors**

Behavioral and systemic factors play a critical role in hepatitis transmission. Intravenous drug (IVD) use is a major contributor to HCV infection, accounting for 30–50% of cases. Although these figures are lower than in some developed countries, underreporting due to stigma and limited surveillance likely underestimates the true burden. The increasing opioid use across Gulf Cooperation Council (GCC) countries, combined with the absence of comprehensive harm reduction programs, such as needle exchange initiatives, exacerbates transmission risk [45]. Vaccination gaps represent another behavioral risk factor. Despite high national coverage of infant HBV vaccination, adult immunization rates are suboptimal. In one study, only 79.9% of adults reported receiving the HBV vaccine [46]. Gaps are particularly pronounced among migrants, rural populations, and older adults. Regional disparities include needle reuse in Jazan at 40% above the national average and unsafe Hijama (wet cupping) practices during Hajj contributing to approximately 8% of HCV cases in Makkah. Rural regions such as Al-Baha report adult vaccination coverage 15–20% lower than urban centers, and migrant populations in Dammam face logistical and financial barriers, leaving up to 30% unvaccinated [47]. Comparisons with neighboring countries illustrate potential strategies for Saudi Arabia. Kuwait reduced Hijama-related HCV cases by 60% through clinic licensing, Iran achieved a 45% decline in HCV via practitioner certification, and Egypt employed mosque-based campaigns to counter sterilization myths. Vaccine hesitancy remains a barrier within Saudi Arabia: 25% of refusals cite infertility concerns, while others invoke religious beliefs, such as “Allah protects the pious.” Structural limitations, including the kafala system, restrict healthcare access for migrant populations, contributing to unregulated care and higher HCV risk.

**Combined Implications for HDV and Other Hepatitis Types**

Chronic HBV carriers and high-risk populations, including migrants and those with poor sanitation, are particularly vulnerable to HDV co-infection. HDV’s aggressive disease course accelerates liver damage and increases the risk of cirrhosis and hepatocellular carcinoma, yet underdiagnosis remains widespread. HEV risk is similarly influenced by socioeconomic and behavioral factors, with outbreaks occurring in areas of poor sanitation or mass gatherings, such as the Hajj, highlighting the intersection of environmental, behavioral, and population-level determinants. Overall, hepatitis risk factors in Saudi Arabia reflect a complex interplay of socioeconomic, behavioral, and systemic influences. Low-income and rural populations, men, widowed or divorced individuals, those with comorbidities, migrants, and high-risk behavioral groups such as IVD users experience disproportionately higher risk. Persistent gaps in vaccination, unsafe medical practices, and limited harm reduction programs exacerbate transmission, particularly for HCV and HDV. Addressing these factors requires comprehensive, multi-layered interventions, including targeted adult vaccination, public health education, improved sanitation, harm reduction initiatives, and robust surveillance, particularly among high-risk populations. Strategic lessons from regional peers can inform evidence-based policies aimed at mitigating disparities, preventing outbreaks, and progressing toward the national and global hepatitis elimination goals [48].

**Hepatitis Treatment and Management in Saudi Arabia**

Hepatitis management in Saudi Arabia is stratified by viral type, reflecting differences in transmission, clinical course, and therapeutic options. The Saudi Ministry of Health (MOH), in alignment with global guidelines, has developed evidence-based strategies for each hepatitis type, integrating public health interventions, vaccination, and antiviral therapy while addressing regional and population-specific challenges.

**Hepatitis A (HAV)**

Management of HAV in Saudi Arabia is primarily supportive, as no specific antiviral therapy exists. Mild cases are treated with oral rehydration solutions (WHO-ORS), whereas intravenous fluids (0.9% saline with dextrose) are indicated for moderate to severe dehydration. High-risk patients require close monitoring of liver function (ALT, AST, bilirubin) for 48 hours, with dietary measures emphasizing low-fat, high-carbohydrate meals to reduce hepatic strain [49]. Preventive strategies have significantly reduced HAV incidence. The Municipal Water Safety Initiative (2018–2025) expanded water treatment infrastructure from 120 to 185 plants, resulting in a 58% reduction in contamination-related cases and a 45% decline in HAV incidence, representing an economic saving of $2.1 billion. Complementing this, the National School Vaccination Program achieved 98% coverage, preventing over 1,200 annual HAV cases [50]. These initiatives highlight the importance of integrating environmental improvements with vaccination in disease control.

**Hepatitis B (HBV)**

HBV management in Saudi Arabia targets both chronic and acute infections. Most chronic HBV cases are identified in primary care, with active disease cases referred to specialists for antiviral therapy. Public healthcare delivers 89% of HBV treatments, predominantly nucleotide analogs such as tenofovir and entecavir, while private care remains concentrated in urban centers. Despite an estimated 260,000 chronic HBV cases, only 14% were diagnosed in the past decade, and just 14% of those received treatment, emphasizing gaps in detection and linkage to care [51]. Treatment guidelines, aligned with SASLT, WHO, EASL, and AASLD standards, recommend therapy for patients with HBV DNA >2000 IU/mL and elevated ALT, significant fibrosis, cirrhosis, or high-risk comorbidities, including immunocompromised or co-infected patients. Acute HBV generally requires supportive care, with antivirals reserved for severe cases (INR >1.5, bilirubin >10 mg/dL, or prolonged illness) [52]. Geographic and demographic disparities persist, with higher incidence rates among men and older adults, highlighting the need for targeted screening and ongoing vaccination coverage to maintain low prevalence.

**Hepatitis C (HCV)**

HCV management has transformed with the widespread adoption of pan-genotypic direct-acting antivirals (DAAs), offering cure rates exceeding 95% (SVR12). The Saudi National Hepatitis Program (SNHP), launched in 2018, provides free access to DAAs such as glecaprevir/pibrentasvir (8 weeks) and sofosbuvir/velpatasvir (12 weeks), with ribavirin added for complex cases. Between 2018 and 2020, the SNHP screened 5 million individuals, identifying 12,000 HCV-positive cases, achieving a 92% linkage-to-care rate, and by 2023, over 50,000 patients had been treated, maintaining 95% SVR12 [30]. Micro-elimination strategies are central to HCV control, including point-of-care RNA testing in rural areas and task-shifting to expand treatment delivery through primary care. Research by institutions like KAIMRC supports optimization of therapy through resistance monitoring [24]. These initiatives have significantly reduced HCV prevalence, with adult rates declining from 0.4% to 0.1% among children, demonstrating the impact of comprehensive national strategies.

**Hepatitis D (HDV)**

HDV management remains challenging due to limited therapeutic options. Pegylated interferon-alpha (PEG-IFNα) has been the standard, achieving only 29% sustained virologic response and relapse rates approaching 50%. Newer agents, such as bulevirtide, show virologic response rates of 71–76% in clinical trials, but access in Saudi Arabia is limited [53]. MOH guidelines recommend HDV RNA testing in HBV patients, emphasizing early detection. The national HBV vaccination program indirectly reduces HDV prevalence by preventing HBV infection, while specialized hepatology clinics provide care for co-infected patients [54,55].

**Hepatitis E (HEV)**

Acute HEV management is supportive, similar to HAV, focusing on hydration, rest, and avoidance of hepatotoxic medications. Chronic HEV, particularly in immunocompromised patients, is treated with ribavirin (600–1000 mg/day for three months), achieving 78–83% SVR, though with risk of hemolytic anemia in 18% of patients. Pegylated interferon is an alternative but limited by adverse effects [56]. HEV control in Saudi Arabia includes improved water sanitation, surveillance in high-risk groups, and ribavirin access in tertiary hospitals, though underdiagnosis remains a significant barrier due to limited PCR testing and absence of a national HEV registry [40].

**Government and NGO Initiatives**

The SNHP has played a central role in national hepatitis control, screening approximately 20% of the population between 2018 and 2023. Complementary initiatives by the Saudi CDC ("Know Hepatitis") and King Faisal Specialist Hospital targeted high-risk populations, including dialysis patients, with large-scale screening and treatment campaigns, achieving cure rates exceeding 95% and

aligning with WHO 2030 elimination targets [57]. Integrated strategies combining vaccination, early detection, DAA therapy, and public health campaigns have driven HCV cure rates above 95% and reduced HBV prevalence to 1.3%. While HAV, HDV, and HEV receive less national focus due to lower prevalence, ongoing surveillance, improved diagnostic capacity, and access to targeted treatment remain critical for high-risk populations, including migrants, immunocompromised patients, and rural residents [58]. Saudi Arabia's hepatitis management demonstrates a comprehensive, evidence-based approach, integrating clinical care, vaccination, and public health interventions. Challenges persist in equitable access, particularly for rural populations and migrants, as well as in HDV and HEV treatment availability. Continued investment in surveillance, education, and innovative delivery models will be essential to achieving national and global hepatitis elimination goals by 2030.

**Successful Policies and Interventions to Prevent and Control Hepatitis in Saudi Arabia**

Saudi Arabia has implemented a multi-layered approach to hepatitis prevention and control, integrating vaccination, screening, public awareness, and targeted interventions for high-risk populations. These policies reflect evidence-based strategies aligned with global health recommendations while addressing the country's specific demographic, cultural, and epidemiological context.

**Vaccination Programs**

Since 1990, the national Expanded Program on Immunization (EPI) has included universal HBV vaccination for infants, beginning with the first dose administered within 24 hours of birth. This early prophylaxis is critical for preventing mother-to-child transmission (MTCT), particularly for infants born to mothers positive for both hepatitis B surface antigen (HBsAg) and hepatitis B e-antigen (HBeAg), who face a 70–90% risk of infection without intervention [59]. Long-term studies support the efficacy of this strategy. Al-Faleh et al. reported a 77% overall seroconversion rate among 4,087 children aged up to 12 years, with higher rates for those vaccinated at birth (77%) compared to school-entry vaccination (71%). Immunity persisted for years, with 65% retaining anti-HB titers above 10 IU/L and 28% above 100 IU/L eight years post-vaccination [36]. The HBV program has achieved near-universal newborn coverage of 98% and a 90% reduction in childhood HBV incidence since its introduction. By 2015, national HBsAg prevalence fell below 1%, illustrating the effectiveness of sustained, targeted vaccination [60]. For HAV, vaccination was incorporated into the National Immunization Program in 2008, targeting children. Coverage has exceeded 90% in many regions, reducing both outbreak frequency and hospitalization rates. School-based campaigns (95% coverage) and vaccination mandates for healthcare workers (97% coverage) further minimized occupational transmission by 85% [61]. These programs underscore the synergy of early-life vaccination, institutional mandates, and public health education.

**Screening and Early Diagnosis Programs**

Beyond vaccination, Saudi Arabia has prioritized screening to enable early diagnosis and treatment. A nationwide prenatal screening program, launched in 2014, ensures 99% of pregnant women are tested for HBV, allowing timely antiviral therapy to prevent MTCT. Premarital screening programs have also contributed to early detection, with HBsAg positivity rates reported between 1.3% and 1.7%, though these figures may underestimate prevalence due to sample bias [62]. Historical data illustrate the impact of these interventions. Earlier regional studies reported HBsAg prevalence ranging from 4.1% to 17.3% before universal screening and vaccination. Longitudinal analysis of couples attending fertility clinics showed a decline from 4.7% prevalence in 2002–2005 to 1.7% in 2023, demonstrating the sustained effect of targeted screening, vaccination, and public health policies [62]. Such programs allow early intervention, reduce chronic infection rates, and support national elimination goals.

**Knowledge and Awareness Gaps**

Public awareness remains a central component of hepatitis prevention. A 2017 nationwide survey found that while 91% of participants had heard of hepatitis, only 54% had a solid understanding of HBV, and just 64.5% correctly identified it as a viral infection. Regional studies, such as in Taif, revealed similar gaps: 80.4% had heard of HBV, but detailed knowledge was limited. Factors such as higher education, medical sector employment, and monthly income above SAR 5,000 were predictive of better HBV knowledge [63,64]. Misunderstanding transmission routes and vaccination schedules persists. Many incorrectly believe HCV is transmitted via casual contact or that an HCV vaccine exists. High-risk groups, including people who inject drugs (PWID), migrants, and incarcerated individuals, often have inadequate knowledge of HCV and limited access to curative direct-acting antivirals (DAAs), compounded by stigma and structural barriers [65,70,71]. Pregnant women and healthcare providers sometimes lack clarity on MTCT prevention, neonatal vaccination timing, and immunoglobulin administration [74]. Physicians and healthcare workers also show knowledge gaps. Some incorrectly assume HCV vaccination exists or underestimate non-parenteral transmission risks. Screening practices vary due to guideline unfamiliarity or systemic barriers, and paramedical staff often have lower awareness and vaccination coverage, limiting their capacity to educate patients [69,74–77]. Socioeconomic disparities further affect awareness and vaccine uptake. Individuals with secondary education (19.1% of surveyed populations) may require simplified educational resources using visual aids. Outreach to self-employed populations (35.3%) and provision of

free or subsidized vaccines for lower-income groups (SAR 0–10,000) can improve coverage. Public health campaigns leveraging diverse communication platforms and culturally tailored educational materials are essential, particularly in high-density urban areas such as Makkah [78].

**Integration of Policies**

Saudi Arabia's approach combines preventive vaccination, widespread screening, and public education with targeted interventions for high-risk groups. Infant HBV vaccination, HAV childhood programs, and healthcare worker mandates provide foundational protection. Prenatal and premarital screening ensure early detection, while educational initiatives address knowledge gaps. These coordinated measures have effectively reduced HBV and HAV incidence, improved public understanding, and minimized occupational transmission. However, challenges remain. Knowledge deficits among healthcare providers, high-risk populations, and underserved communities persist. Continued investment in education, culturally tailored campaigns, and access to vaccines for marginalized groups is necessary. Integrating screening, vaccination, and awareness initiatives across healthcare settings and community platforms can further enhance the prevention and control of hepatitis nationwide.

**Challenges and Barriers in Hepatitis Control in Saudi Arabia**

Despite significant progress in reducing hepatitis incidence, Saudi Arabia continues to face social, economic, and structural challenges that impede effective prevention, diagnosis, and treatment. These barriers are multifactorial, encompassing stigma, financial burdens, healthcare infrastructure gaps, and population-specific vulnerabilities. Stigma represents a major obstacle to early diagnosis and treatment adherence, particularly for HBV. Patients often fear social rejection, discrimination, and economic consequences such as job insecurity. National surveys indicate that 62% of patients delayed testing due to fear of discrimination, and 45% concealed their infection even from family members. Women are disproportionately affected. Men are 3.2 times more likely to seek care than women, and 58% of female patients reported discouragement by physicians because of pregnancy-related concerns. These social pressures lead to reduced treatment adherence—stigmatized patients show 40% lower adherence—and a higher risk of disease progression. Statistically, such patients are 2.5 times more likely to develop cirrhosis (OR = 2.48; 95% CI: 1.67–3.69) [65]. Cultural beliefs exacerbate these effects. Around 34% of patients perceive HBV infection as divine punishment, resulting in delayed medical consultation. Combating stigma requires comprehensive interventions: public education campaigns to normalize testing and treatment, training healthcare providers to reduce bias, and community engagement programs to foster supportive environments for infected individuals. Reducing stigma directly correlates with improved early detection, adherence to therapy, and long-term health outcomes.

While antiviral therapies such as entecavir (ETV) and tenofovir alafenamide (TAF) are highly effective, they impose a substantial economic burden. In Saudi Arabia, ETV is provided free to citizens under government-funded healthcare programs, ensuring equitable access. However, the overall healthcare expenditure in 2022 reached SAR 147 billion (USD 39 billion), exceeding 15% of total government spending, with a significant portion directed toward lifelong antiviral therapy for chronic HBV patients. Vision 2030 reforms aim to mitigate these costs by enhancing healthcare efficiency. Measures include prioritizing cost-effective treatment regimens, streamlining clinical protocols, promoting private sector involvement, and emphasizing early detection and vaccination to prevent long-term complications. These strategies seek to sustain high-quality HBV care while maintaining fiscal responsibility for the healthcare system [79]. Geographic disparities affect access to hepatitis care. Urban centers such as Riyadh and Jeddah benefit from specialized hepatology clinics and comprehensive screening programs. In contrast, rural regions face reduced access to diagnostics and treatment, with rural patients experiencing up to 35% lower availability of antiviral therapy. Migrant populations encounter structural barriers, including the kafala system, which limits healthcare access and contributes to a 30% lower treatment uptake. These inequities underscore the need for decentralized treatment centers, mobile screening units, and culturally sensitive outreach programs.

**Future Directions for Hepatitis Control**

Saudi Arabia must continue to expand vaccination programs, ensuring universal HBV coverage, including catch-up campaigns for high-risk populations such as healthcare workers, migrants, and incarcerated individuals. Routine HCV screening for pregnant women and other high-risk groups could significantly reduce vertical and horizontal transmission. Public awareness campaigns should focus on reducing stigma, promoting testing, and integrating hepatitis education into school health curricula. Blood and injection safety protocols require strict enforcement. Sterile medical practices and safe transfusion policies must be reinforced. Treatment access should be scaled up, ensuring the availability of DAAs for HCV and effective antivirals for HBV. Establishing specialized hepatitis treatment centers in underserved areas will improve care equity. Real-time electronic surveillance systems and periodic seroprevalence studies can monitor disease trends, inform policy, and identify emerging outbreaks [80].

Future research must focus on three domains. First, epidemiological studies targeting high-risk

groups—intravenous drug users, expatriate workers, and populations with limited healthcare access—will provide accurate prevalence data and clarify the role of migration in transmission. Second, clinical studies should explore HBV functional cure strategies, evaluate reinfection rates post-HCV therapy, and assess the cost-effectiveness of decentralized testing models. Third, innovation in prevention and treatment remains critical, including the development of an HCV vaccine and advanced HBV immunotherapies [44]. HDV and HEV represent understudied areas. HDV co-infection accelerates liver disease progression in 7.7% of chronic HBV patients, yet surveillance and treatment are limited. HEV poses outbreak risks during mass gatherings, including Hajj, but lacks comprehensive national monitoring. Expanding epidemiological research and integrated surveillance for these viruses is essential to close knowledge gaps [70]. Comparative studies with neighboring countries can inform best practices, particularly regarding vaccination coverage and morbidity patterns. Monitoring viral hepatitis prevalence across genders and population subgroups is necessary to identify disparities, guide tailored interventions, and track progress toward elimination goals [73].

International collaboration enhances elimination efforts. Partnerships with the WHO, the Global Hepatitis Network, and GCC countries facilitate data sharing, harmonized regional strategies, and capacity building. Professional exchanges with leading hepatology centers in the U.S., EU, and Egypt can strengthen local expertise. Evidence from collaborative initiatives shows that countries with robust international partnerships achieved a 50% faster reduction in HCV incidence, and Saudi Arabia's collaboration with Egypt increased local HCV testing rates by 25% in 2022 [71,81]. Saudi Arabia's progress in hepatitis prevention and control is substantial, yet challenges remain. Social stigma, economic burdens, healthcare access disparities, and knowledge gaps limit the effectiveness of existing programs. Addressing these barriers through public education, expanded vaccination, enhanced surveillance, equitable treatment access, and international collaboration will strengthen national hepatitis control. Future efforts must prioritize high-risk populations, research innovation, and data-driven policy to sustain reductions in hepatitis incidence and move toward the WHO's 2030 elimination targets.

**Conclusion:**

Viral hepatitis in Saudi Arabia reflects a dynamic interplay of epidemiologic transitions, strengthened public health systems, and emerging challenges requiring sustained national commitment. Significant progress has been achieved—most notably the dramatic reduction of hepatitis B prevalence following universal infant vaccination and the remarkable success of direct-acting antiviral therapies for hepatitis C, which enabled high cure rates and substantial declines in national prevalence. Improvements in water sanitation, childhood vaccination, and school-based initiatives have also reduced HAV incidence, demonstrating the effectiveness of integrated preventive approaches. Despite these achievements, multiple challenges persist. HDV co-infection continues to accelerate disease burden but remains underdiagnosed, while HEV outbreaks are complicated by mass gatherings and sanitation variability. Socioeconomic disparities, healthcare access limitations, and gaps in adult vaccination contribute to uneven disease distribution, particularly among migrants, rural populations, and high-risk groups such as intravenous drug users. Social stigma, misinformation, and inconsistent screening further delay diagnosis and reduce treatment adherence, worsening long-term outcomes. Moving forward, Saudi Arabia's national elimination efforts must prioritize expanded adult vaccination, decentralized care, real-time surveillance, and targeted education campaigns. Strengthening multidisciplinary collaboration—spanning physicians, public health professionals, epidemiologists, and community organizations—will be essential to achieving WHO's hepatitis elimination goals and sustaining the country's significant progress.

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