Artificial Intelligence and Digital Health Innovations in Hepatitis Care: Transforming Screening, Diagnosis, and Elimination Efforts

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Abstract

Viral hepatitis remains one of the leading causes of preventable death worldwide, with the World Health Organization estimating that 287 million people were living with chronic hepatitis B or C infection in 2024 and roughly 3,500 people dying each day from hepatitis-related complications, placing global elimination targets for 2030 off track. Artificial intelligence (AI) and digital health technologies are increasingly positioned as tools capable of narrowing the diagnosis-and-treatment gap that underlies this burden. This review synthesizes current literature on the application of AI and digital health innovations across the hepatitis care continuum, including machine learning-based screening and risk prediction, deep learning approaches for non-invasive liver fibrosis staging and hepatocellular carcinoma (HCC) detection on imaging, telemedicine and facilitated-telehealth models for linkage to care, mobile health applications for patient self-management, large language model (LLM)-based chatbots for patient education and clinical decision support, and AI-assisted drug discovery for antiviral and functional-cure strategies. Evidence indicates that AI models can match or exceed conventional diagnostic accuracy in several domains, that telemedicine markedly improves treatment access among underserved and rural populations, and that digital tools show promise in HCC risk stratification and drug repurposing. However, persistent challenges include algorithmic bias, data privacy concerns, the digital divide affecting marginalized populations, limited external validation of AI models, and an evolving regulatory landscape. This review concludes that AI and digital health tools, when implemented equitably and validated rigorously, offer a meaningful pathway toward accelerating global hepatitis elimination goals.

Keywords: artificial intelligence; digital health; viral hepatitis; machine learning; telemedicine; hepatocellular carcinoma; liver fibrosis; hepatitis elimination

1. Introduction

Viral hepatitis, caused predominantly by the hepatitis B (HBV) and hepatitis C (HCV) viruses, continues to represent a major global public health threat. According to the World Health Organization's Global Hepatitis Report, an estimated 240 million people were living with chronic HBV infection and 47 million with chronic HCV infection in

2024, together accounting for around 1.3 million deaths annually from hepatitis-related cirrhosis and liver cancer [1,2]. Despite the availability of effective HBV vaccines and curative direct-acting antiviral (DAA) regimens for HCV, testing and treatment coverage remain far below the targets set for 2030, and the world is currently off track to meet the World Health Assembly's elimination goals [1,3,4]. Low rates of diagnosis, fragmented linkage to care, workforce shortages, and geographic and socioeconomic barriers to specialist services are widely recognized as the principal obstacles standing between existing curative tools and the patients who need them [4,5].

Artificial intelligence and digital health technologies have emerged over the past decade as a potential means of closing this diagnosis-and-treatment gap. AI broadly refers to computational systems, including machine learning (ML) and deep learning (DL), that can learn patterns from data to support prediction, classification, and decision-making tasks. Digital health, in turn, encompasses a wider set of technologies, such as telemedicine, mobile health (mHealth) applications, electronic health records (EHRs), and remote monitoring platforms, that use digital tools to deliver or support care. In hepatitis medicine specifically, these technologies are being explored across nearly the entire care continuum, from population-level screening and risk prediction, through non-invasive staging of liver disease and imaging-based cancer surveillance, to telehealth-facilitated treatment delivery and AI-assisted drug discovery for functional cure strategies [6,12,14].

This review aims to provide a comprehensive, narrative synthesis of recent advances in AI and digital health applications relevant to hepatitis care. It examines machine learning and deep learning applications for hepatitis screening, diagnosis, and prognosis; AI-assisted non-invasive assessment of liver fibrosis and hepatocellular carcinoma; the role of telemedicine and mobile health platforms in expanding access to testing and treatment; the emerging use of large language models and AI chatbots in patient education and clinical support; and AI-driven approaches to antiviral drug discovery. The review also critically discusses the limitations and implementation challenges that must be addressed, including data bias, privacy, model generalizability, and digital health equity, before these innovations can be responsibly scaled to help meet global hepatitis elimination targets.

2. Main Review

2.1 Machine Learning for Hepatitis Screening, Diagnosis, and Risk Prediction

A substantial body of literature has evaluated machine learning models for predicting hepatitis B and C seropositivity and disease severity from routine clinical and laboratory data. Comparative studies have tested classifiers such as logistic regression, support vector machines, k-nearest neighbors, random forests, gradient boosting, and artificial neural networks on datasets derived from standard biochemistry panels, with some hyperparameter-optimized gradient boosting frameworks reporting diagnostic accuracies above 95% for HCV prediction [6,7,8,13]. Feature-selection techniques, including the Boruta algorithm and sequential forward selection, have been used to identify the laboratory markers most predictive of hepatitis status, improving both model interpretability and clinical applicability [6,37]. Beyond single-institution datasets, EHR-based diagnostic systems trained on hundreds of patient records have demonstrated the ability to distinguish blood donors, suspected carriers, and patients with fibrosis or cirrhosis, illustrating how routinely collected clinical data can be repurposed for early detection without additional testing burden [10,11].

At a population-health level, a large prospective evaluation of an XGBoost-based screening model, developed in accordance with U.S. Preventive Services Task Force recommendations, was used to identify previously unknown HCV carriers within a large health-maintenance organization, enabling a staged outreach program to the highest-risk members [9]. This work illustrates a shift from opportunistic, provider-initiated testing toward systematic, algorithm-driven case-finding embedded within existing health records, an approach that may be particularly valuable in health systems with large, under screened populations. Reviews synthesizing this literature conclude that AI-assisted diagnostic tools can reduce reliance on costly or invasive testing, accelerate case identification, and support personalized treatment planning, although reported model performance varies considerably depending on dataset composition, class balance, and the degree of external validation performed [12,14,15].

2.2 AI-Assisted Non-Invasive Assessment of Liver Fibrosis

Liver biopsy remains the historical reference standard for staging fibrosis but is invasive, costly, and prone to sampling error, driving sustained interest in non-invasive alternatives such as transient elastography (TE), serum biomarker indices (for example, FIB-4 and APRI), and, increasingly, AI-enhanced imaging [21,24]. Deep learning models applied to non-contrast MRI have achieved area-under-the-curve (AUC) values of approximately 0.81 to 0.93 for detecting significant fibrosis, advanced fibrosis, and cirrhosis, in several studies outperforming transient elastography, serum biomarkers, and junior radiologists, particularly when clinical, imaging, and radiomic features were fused into a single model [22]. Similarly, CT-based deep learning systems that combine automated liver and spleen segmentation with a human-in-the-loop decision framework have shown improved diagnostic consistency across multiple external validation cohorts after applying test-time adaptation to correct for scanner and population differences [23].

AI-based models are also being developed to overcome specific practical limitations of existing non-invasive tests. For example, platelet-independent AI models have been proposed for settings, such as certain national health check-up programs, where platelet counts are not routinely measured, thereby broadening the populations in which fibrosis risk can be screened at scale [22]. Taken together, this body of work suggests that AI-enhanced imaging and multimodal fusion models can approach or exceed the accuracy of existing non-invasive fibrosis tests, though the AASLD's own systematic review supporting current practice guidelines emphasizes that elastography and biomarker panels remain the most extensively validated tools, and that AI-based alternatives will require larger, more diverse validation cohorts before broad clinical adoption [24].

2.3 Deep Learning for Hepatocellular Carcinoma Detection and Surveillance

Hepatocellular carcinoma (HCC), the most common primary liver cancer and a major cause of hepatitis-related mortality, is frequently diagnosed late, when curative options are limited. Deep learning, particularly convolutional neural network (CNN)-based architectures, has been widely applied to CT and MRI imaging to improve early detection. Models using architectures such as You Only Look Once (YOLO) and U-Net-based segmentation networks have reported Dice similarity coefficients in the range of 0.75 to 0.83 for tumor segmentation, with some systems reducing radiologist segmentation time by nearly a third while maintaining diagnostic accuracy [16,19,20]. AI platforms have also been developed for opportunistic HCC screening using non-contrast CT scans originally obtained for unrelated indications, potentially identifying tumors in patients who would not otherwise have undergone dedicated liver imaging, with diagnostic accuracy comparable to radiologist interpretation during internal validation [17].

Externally validated deep learning algorithms integrated into routine CT workflows have similarly demonstrated high detection sensitivity for HCC, and comprehensive reviews of the field report that DL models frequently match or exceed the performance of experienced clinicians on standardized imaging benchmarks [16,18]. Beyond detection, AI approaches are being extended to hepatic vascular segmentation to support surgical planning and to risk-prediction models that combine imaging, laboratory, and clinical variables to identify patients who would benefit most from intensified HCC surveillance [15,18]. Nonetheless, published reviews caution that most HCC-focused AI models have been developed and validated on relatively homogeneous, single-center datasets, and that variability in imaging protocols and patient populations across institutions continues to limit generalizability [16,20].

2.4 Telemedicine and Facilitated Telehealth Models for Linkage to Care

Digital health has had perhaps its most immediately measurable impact on hepatitis care through telemedicine-facilitated treatment delivery, particularly for populations facing geographic, logistical, or stigma-related barriers to specialist care. The Transporting Hep C Viral Elimination Services via Telemedicine (TRAVEL) program in rural Maryland linked 76% of referred HCV-antibody-positive individuals to care between 2018 and 2024 through a model combining local nurse case management with facilitated telemedicine, despite a study population in which the majority had a co-occurring substance use disorder [25,28]. Comparable programs using syringe service programs as telehealth hubs in rural Kentucky, and randomized evaluations of facilitated telemedicine integrated into opioid treatment programs in New York, have reported cure rates as high as 90% among participants completing facilitated telemedicine pathways, substantially higher than off-site referral alone [25,26].

These sociotechnical models typically combine bidirectional videoconferencing between a remote specialist and the patient with an on-site case manager or peer navigator who supports trust-building, logistics, and adherence, addressing both the technological and human barriers that purely virtual care can otherwise overlook [25,26]. A nationwide survey of U.S. HCV treatment providers found that most respondents using telemedicine reported it had become embedded in standard clinical practice following its expansion during the COVID-19 pandemic, though screening and linkage-to-care volumes had also shown measurable declines during pandemic disruptions, underscoring that digital tools can both mitigate and, in some circumstances, be constrained by broader health-system stressors [27,29]. Programs explicitly designed to address digital exclusion, such as initiatives distributing mobile phones and pairing patients with peer health mentors, have also shown improved engagement with HIV and HCV care among criminalized and structurally marginalized populations, highlighting that the benefits of telehealth are not automatically distributed equitably unless deliberately designed to be [29].

2.5 Mobile Health Applications and Patient Self-Management

Mobile health applications are being trialled as tools to support long-term self-management of chronic hepatitis B and post-treatment surveillance for cirrhosis and HCC. A large prospective cohort study is currently evaluating an app-based intelligent management platform for patients with compensated HBV-related cirrhosis, in which the application sends automated follow-up reminders, medication reminders, and health education content, with an intelligent-management arm designed to further personalize this support [33]. Such platforms are intended to improve adherence to antiviral therapy and surveillance imaging schedules, both of which are strongly linked to reduced rates of decompensation and improved early cancer detection. Reviews of AI applications in chronic hepatitis B management similarly emphasize that AI-enabled mobile platforms can support patient engagement through personalized reminders and educational content, potentially reducing the loss-to-follow-up that undermines long-term disease control in real-world settings [34].

2.6 Large Language Models and AI Chatbots in Patient Education and Clinical Support

The emergence of large language models (LLMs) has introduced a new category of digital health tool capable of generating conversational, context-aware responses to patient and clinician queries. A systematic review of 137 studies evaluating LLM-based chatbots for health advice found that the large majority assessed closed-source models and that fewer than a third of studies adequately addressed the ethical, regulatory, and patient-safety implications of clinical integration, underscoring that this field remains early in its maturation [30]. LLMs are increasingly used in patient-facing roles such as symptom checking and health information delivery, and in clinician-facing roles including documentation support and diagnostic decision assistance, with early evidence suggesting these systems can explain complex medical information at a level accessible to patients with limited health literacy [31,40]. Large-scale analyses of public chatbot usage have shown that health-related queries constitute a substantial and growing proportion of everyday conversational AI use, suggesting patients are already turning to these tools for hepatitis- and liver-related questions whether or not clinicians have formally incorporated them into care pathways [32].

Within hepatology specifically, LLM-based tools have been proposed for tasks such as summarizing patient-provider dialogue, generating individualized education materials about antiviral regimens and lifestyle modification, and supporting remote patient monitoring after gastrointestinal procedures [30,31]. However, reviewers consistently caution that LLM outputs require rigorous, disease-specific validation before clinical deployment, given documented risks of factual inaccuracy, inconsistent reasoning, and the potential to encode biases present in training data, particularly for a disease area such as viral hepatitis where treatment guidance is time-sensitive and stigma around routes of transmission can affect the quality of publicly available training text [30,31].

2.7 AI-Assisted Drug Discovery and Progress Toward Functional Cure

Beyond diagnosis and care delivery, AI and machine learning are being applied to accelerate antiviral drug discovery for hepatitis B, for which current nucleos(t)ide analogue therapy suppresses viral replication but rarely achieves the functional cure defined by hepatitis B surface antigen loss [58]. Machine learning-guided drug-repurposing pipelines use molecular docking simulations combined with pattern recognition across patient outcome data to prioritize existing approved compounds most likely to inhibit HBV replication or destabilize the covalently closed circular DNA (cccDNA) reservoir that underlies chronic infection, a strategy intended to shorten development timelines relative to de novo drug design [57]. Related deep reinforcement learning-based molecular design platforms have been used to generate large virtual libraries of candidate antiviral compounds, which are then filtered computationally before a small number are advanced to in vitro and in vivo testing, illustrating how generative AI methods are beginning to reshape early-stage antiviral discovery pipelines more broadly [56].

AI-based approaches are also being integrated into the broader precision-medicine agenda for chronic liver disease, using high-throughput genomic and clinical data to identify patient subgroups most likely to benefit from particular antiviral or immune-modulatory strategies, and to flag patients at elevated risk of treatment failure or HCC development despite viral suppression [36,61]. While no AI-discovered anti-HBV compound has yet reached regulatory approval, proponents argue that the combination of molecular docking, generative chemistry, and clinical outcome modeling represents a meaningful complement to traditional pharmacology in the pursuit of a scalable functional cure [57,60].

2.8 Big Data, Electronic Health Records, and Epidemiological Surveillance

Electronic health record systems and large administrative datasets increasingly underpin AI-based hepatitis surveillance, enabling health systems to identify undiagnosed carriers, track treatment cascade attrition, and model the population-level impact of elimination interventions. The WHO's 2024 and 2026 Global Hepatitis Reports themselves rely on aggregated country-level surveillance data from 187 countries to track progress toward diagnosis and treatment coverage targets, revealing that hepatitis B diagnosis rates rose only from 10% to 13% and treatment from 2% to 3% between 2019 and 2022, underscoring how far surveillance-informed digital tools still need to move the needle [3,5,48]. National elimination profiling exercises, drawing on similarly structured country-level data, have identified a small number of countries, including Canada, Japan, and Rwanda, that have already met WHO's 90% diagnosis target, offering data-driven benchmarks for the digital and programmatic strategies associated with faster progress [50]. Machine learning-based epidemiological models are additionally being used to forecast disease burden and cost-effectiveness of elimination strategies at national and regional levels, providing policymakers with simulation tools to prioritize resource allocation toward screening, vaccination, and treatment scale-up [54].

2.9 Challenges and Implementation Barriers

Despite this promise, several substantial barriers constrain the translation of AI and digital health tools into routine hepatitis care. First, most AI diagnostic and imaging models remain validated on relatively narrow, single-centre, or single-population datasets, raising concerns about generalizability, algorithmic bias, and performance degradation when deployed in populations that differ demographically or clinically from the original training data [16,20,23]. Second, the digital divide, unequal access to smartphones, reliable internet connectivity, and digital literacy, risks widening rather than narrowing existing disparities in hepatitis care, particularly among people who inject drugs, incarcerated populations, and those experiencing homelessness, unless digital interventions are explicitly designed with equity safeguards such as device provision and peer navigation support [29]. Third, data privacy and security concerns are heightened in hepatitis care given the historical stigma associated with viral hepatitis and its transmission routes, making robust governance frameworks essential wherever AI tools draw on sensitive EHR or genomic data [29,30].

Fourth, the regulatory and evidentiary landscape for clinical AI, particularly LLM-based tools, remains immature; systematic reviews note that most published evaluations of health-advice chatbots do not adequately report which underlying model was tested or address safety and accountability questions, complicating efforts by clinicians and regulators to assess real-world reliability [30,31]. Finally, meaningful clinical adoption requires that AI tools be integrated into existing workflows in ways that augment rather than replace clinical judgment, with human-in-the-loop decision frameworks, such as those pairing deep learning fibrosis staging with radiologist oversight, offered as one practical model for responsible deployment [23]. Addressing these barriers through rigorous external validation, equity-centred design, and transparent reporting standards will be essential if AI and digital health tools are to make a durable contribution to global hepatitis elimination efforts.

3. Conclusion

Artificial intelligence and digital health technologies are reshaping multiple stages of the hepatitis care continuum, from machine learning-based screening and non-invasive fibrosis and cancer detection to telemedicine-facilitated treatment delivery, mobile health self-management platforms, and AI-assisted antiviral drug discovery. The evidence reviewed here suggests that these tools can improve diagnostic accuracy, expand access to care for underserved and rural populations, and accelerate the search for functional cure strategies, directly addressing the diagnosis and treatment gaps that currently place global hepatitis elimination targets off track. At the same time, the literature consistently highlights that these benefits are neither automatic nor evenly distributed: model generalizability, data privacy, algorithmic bias, and the digital divide remain significant obstacles that require deliberate, equity-centred solutions. Future research should prioritize large-scale, multi-centre external validation of AI diagnostic models, prospective trials of digital health interventions embedded within elimination programs in high-burden, low-resource settings, and the development of transparent regulatory frameworks for clinical AI, particularly LLM-based tools. With these safeguards in place, AI and digital health innovation hold genuine potential to help translate the biomedical advances of the past decade, effective vaccines and curative antivirals, into measurable reductions in hepatitis-related morbidity and mortality worldwide.

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