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Research Article

Keywords: Guidelines for the Prevention and Treatment of Chronic Hepatitis B, Clinicians, Questionnaire Survey, Awareness, Follow-up

Posted Date: May 5th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-9541175/v1>

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Additional Declarations: No competing interests reported.

Cognitive Biases and Practical Barriers Among Chinese Clinicians

Regarding the *Guidelines for the Prevention and Treatment of Chronic Hepatitis B(version 2022)*: Results of a Multicenter Survey

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Abstract:

Background: Chronic hepatitis B virus (HBV) infection is a major global public health issue, and insufficient adherence to clinical guidelines has led to persistent preventable complications. By investigating clinicians' cognitive characteristics regarding the *Guidelines for the Prevention and Treatment of Chronic Hepatitis B (version 2022)* and their impact on patient follow-up management, this study aims to address key barriers to translating evidence into clinical practice. **Methods:** This study conducted a large-scale, multicenter cross-sectional survey among 1,586 physicians from 50 hospitals across 14 cities to assess clinicians' overall guideline awareness and patient follow-up practices. We collected data on guideline cognition, clinical management behaviors, and barriers to follow-up. Both traditional statistical methods and a machine-learning random forest model were applied to quantify feature significance. **Results:** Educational background, professional title, hospital tier, and departmental specialization have highly significant effects on physicians' guideline cognition ($P < 0.01$). Additionally, the top 3 features in the random forest model by significance were geographical region, educational background, and professional title. Patient follow-up rates declined stepwise at 1, 3, and 5 years, and this decline was closely associated with physician-related factors (insufficient time for follow-up communication, lack of efficient follow-up tools) and patient-related factors (poor disease awareness, tendency toward self-discontinuation of medication). Meanwhile, hospital tier, department type, and general hospital geographical region were identified as critical factors of follow-up management ratio. **Conclusions:** Cognitive biases and practical barriers hinder the clinical translation of guidelines. Accordingly, we suggest that targeted interventions should be adopted, including geographically tailored training modules, AI-driven follow-up platforms, and policy-guided resource reallocation, thereby collectively promoting guideline implementation.

Keywords: Guidelines for the Prevention and Treatment of Chronic Hepatitis B; Clinicians; Questionnaire Survey; Awareness; Follow-up.

Contributions to the literature:

1. This study fuses machine learning with conventional surveys to rigorously evaluate clinicians' guideline awareness, addressing key gaps in implementation research for chronic disease management.

2. We found variations in cognitive biases among clinicians. We identified that educational level and professional title influence the adoption of clinical practice guidelines in China, which can help optimize the targeting of training interventions.
3. The findings indicate that structural factors (hospital tier, regional resources) constrain patient follow-up management, providing a basis for optimizing resource allocation and digital health solutions in resource-constrained settings.

Main Text:

1. Background

Chronic hepatitis B virus (HBV) infection represents a major global public health challenge, which affects approximately 296 million individuals worldwide. As a country with a high burden of hepatitis B, China plays a pivotal role in achieving the World Health Organization's goal of global hepatitis elimination by 2030(1-4). Although widespread hepatitis B vaccination has led to a substantial decline in the incidence of new infections, the disease burden among individuals with chronic HBV infection remains considerable, posing long-term challenges to both socioeconomic development and healthcare systems⁽⁵⁾.

To provide more standardized guidance for the diagnosis, treatment, and management of patients with chronic hepatitis B in China, the Chinese Society of Hepatology and the Chinese Society of Infectious Diseases have regularly updated the *Guidelines for the Prevention and Treatment of Chronic Hepatitis B* since 2005 (hereinafter referred to as the "Guidelines")(6). Grounded in the latest evidence-based research, the *2022 Edition* of the Guidelines further expands the indications for antiviral therapy, recommends the use of high-sensitivity diagnostic assays, and emphasizes "clinical cure" as a higher therapeutic goal, thereby promoting early intervention and individualized management(7). These updates are intended to reduce the risk of disease progression and improve long-term patient outcomes. However, the effectiveness of clinical guideline implementation is highly dependent on physicians' levels of awareness and adherence. To date, the actual level of understanding of the updated Guidelines among physicians in highly relevant departments, such as hepatology and infectious diseases, as well as their real-world practices across screening, diagnosis, treatment, and long-term management, remains unclear.

Through a multicenter cross-sectional survey, this study aims to assess the level of awareness and clinical practice patterns related to the *Guidelines for the Prevention and Treatment of Chronic Hepatitis B (version 2022)* among physicians in hepatology, infectious diseases, and other relevant departments in China, thereby providing scientific evidence and actionable recommendations to strengthen targeted training, promote standardized clinical application of the Guidelines, and enhance clinicians' capabilities in the diagnosis, treatment, and management of chronic hepatitis B.

2. Methods

2.1 Study design

Integrated traditional statistical analysis and a machine-learning random forest model, this study adopted a multicenter cross-sectional survey to quantify predictors of guideline awareness and adherence among clinical physicians in China, covering five regions: eastern, southern, western, northern, and central China from 19 July 2024 to 31 December 2025. A total of 1,586 physicians from departments of hepatology, infectious diseases, and related specialties across 50 hospitals were included in this study, with 1,586 questionnaires distributed and retrieved.

2.2 Research Hospitals and Populations

A multicenter study was conducted across 50 hospitals in 14 cities in China, including Beijing,

Shanghai, Qinghai, and other regions. Participating hospitals were categorized by type and administrative level, including provincial-, municipal-, and county/district-level general hospitals, as well as infectious disease and hepatology specialty hospitals. A census-based sampling approach was employed to recruit eligible clinicians from hepatology, infectious diseases, and related departments, regardless of professional title. Individuals undergoing standardized residency training, interns, and contract/outsourced staff were excluded. Given practical constraints, the final sample of 1,586 clinicians represents the maximum feasible size attainable within the study period and available resources. Although the sample size was not derived from a priori power calculations for a specific effect size, it exceeds the minimum requirements for our analytical models and effectively mitigates overfitting risks associated with high-dimensional predictors.

2.3 Questionnaire

A standardized electronic questionnaire was used to survey participating clinicians. The questionnaire covered the following domains: (1) clinicians' awareness of HBsAg screening among key populations, including referral-related departments, early warning systems, and referral pathways for HBsAg-positive patients; (2) awareness and implementation of the *Guidelines for the Prevention and Treatment of Chronic Hepatitis B (version 2022)* among physicians in hepatology, infectious diseases, and other relevant departments; (3) current practices, existing challenges, and potential solutions related to patient follow-up management as reported by physicians in hepatology, infectious diseases, and related departments. The questionnaire consisted of 4 sections comprising a total of 18 items. Detailed questionnaire content is provided in Appendix 1.

2.4 Model Construction and Optimization

In this study, a random forest prediction model was developed using the RandomForestClassifier from the Scikit-learn library. The outcome variables were defined as: all incorrect responses on the questionnaire, one correct response, and two or more correct responses (classified variable, encoded as *y_encoded* using a LabelEncoder). Seven categorical variables, including sex, geographic region, and hospital tier, were independently encoded using LabelEncoder and incorporated as model features. The dataset was randomly divided into a training set and a test set at a ratio of 7:3. Stratified sampling was applied, and a fixed random seed (*random_state* = 42) was used to ensure reproducibility. Then, hyperparameter optimization was performed using GridSearchCV(8). Five-fold cross-validation was applied, with classification accuracy used as the evaluation metric. A systematic search was conducted over an expanded hyperparameter grid (*n_estimators*: [50, 100, 200, 300, 500]; *max_depth*: [None, 5, 10, 15, 20, 30, 40, 50]; *min_samples_split*: [2, 5, 10]; *min_samples_leaf*: [1, 2, 4]; *max_features*: ["sqrt", "log2", None]) to identify the optimal parameter combination (*best_estimator*). The model was trained using the optimal hyperparameters (*n_estimators* = 200, *max_depth* = 20, *min_samples_split* = 5, *min_samples_leaf* = 2, *max_features* = 'sqrt', *random_state* = 42), integrating multiple decision trees through bootstrap sampling and random feature subspace selection. Finally, model performance was evaluated on the test set using accuracy, multiclass receiver operating characteristic (ROC) curves, and area under the curve (AUC) values. Feature importance was assessed using the *feature_importances_* attribute to balance predictive accuracy and generalizability.

2.5 Data Analysis

The questionnaire platform was developed using HTML5 technology(9), and data were imported via Microsoft SQL Server(10). The backend logic was primarily based on .NET technology, and data were exported in Excel format for subsequent statistical analysis using

SPSS version 26.0 and R version 4.4.2. Categorical data were summarized using descriptive statistics. Chi-square tests were applied to cognition-related questions (items 4, 5, and 8), supplemented by a random forest model to evaluate overall clinician awareness of the Guidelines. For follow-up practice items, data were grouped according to subgroup variables using the dplyr package. The quantile function was used to calculate medians and interquartile ranges, and chi-square tests were performed to compare follow-up outcomes across the overall sample and subgroups (e.g., sex, educational level). Follow-up forest plots were generated using the forest plot package. Statistical significance was defined as $P < 0.05$, highly significant as $P < 0.01$, and extremely significant as $P < 0.001$.

2.6 Ethics

The study protocol was approved by the Ethics Committee of Beijing Ditan Hospital, Capital Medical University, on November 21, 2024 (Approval No.: JDLZ[2024]No.(118)-01). All participants provided electronic informed consent before participation.

3. Results

3.1 Basic Demographic Characteristics of Clinicians

A total of 1,586 clinicians were surveyed, including 729 individuals with a master's degree or higher. Among them, 800 held senior professional titles (chief or associate chief physicians), and 786 held attending or lower-level positions. Demographic characteristics of the respondents are presented in Table 1.

Table 1. Demographic Characteristics of Study Participants

Variable	Clinician Demographics	Frequency	Percent (%)	Valid Percent (%)
Clinician's basic information				
Sex				
Female	901	56.8	56.8	56.8
Male	685	43.2	43.2	100
Education Level				
Master's degree or above	857	54	54	54
Bachelor's degree or below	729	46	46	100
Professional Title				
Chief / Associate Chief Physician	800	50.4	50.4	50.4
Attending Physician or below	786	49.6	49.6	100
Hospital Type and Tier				
General Hospital	903	56.9	56.9	56.9
Tertiary Hospital	803	50.6	50.6	50.6
Secondary Hospital or below	100	6.3	6.3	56.9
Infectious Disease / Hepatology Specialty Hospital	683	43.1	43.1	100
Tertiary Hospital	659	41.6	41.6	98.5
Secondary Hospital or below	24	1.5	1.5	100
Hospital Department				

Hepatology-related Departments (Hepatology, Infectious Disease, Gastroenterology)	1322	83.4	83.4	83.4
Other Departments (Medical Affairs, Infection Control, etc.)	264	16.6	16.6	100
Geographic Region				
North	516	32.5	32.5	32.5
East	265	16.7	16.7	49.2
South	223	14.1	14.1	63.3
West	363	22.9	22.9	86.2
Central	219	13.8	13.8	100

Note: Hospital tiers in this study were determined according to the *Hospital Classification and Management Measures* issued by the National Health Commission of China.

3.2 Clinicians' Awareness and Implementation of Treatment Updates in the 2022 Guidelines

Based on Chinese clinicians' awareness and implementation of treatment recommendations in the updated Guidelines, univariate analyses were conducted on the accuracy of cognition-related questions. Categories included "all correct", "one correct", "two correct", and "all incorrect", as well as chi-square frequencies for items 4, 5, and 8. The results were tabulated and summarized as shown (Figure 1; Supplementary Tables 1–4).

Overall, educational level, professional title, hospital tier (secondary \tertiary), and department type had a highly significant impact on question accuracy ($P < 0.01$). Specifically, clinicians with a master's degree or higher had higher accuracy than those with a bachelor's degree or lower (23.2% vs. 20.8%). Similarly, senior physicians (chief/associate chief) outperformed lower-ranking physicians (attending or below) (23.2% vs. 20.8%); tertiary hospitals outperformed secondary or lower-level hospitals (23.2% vs. 20.8%); and physicians in hepatology-related departments had higher accuracy than those in other departments (23.2% vs. 20.8%). The same pattern was observed for items 4, 5, and 8. No significant differences were observed by sex for any of the questions. The geographic region was not statistically significant for most items, except item 8 ($P < 0.005$), where the northern region had the highest accuracy rate at 21.7%, significantly higher than the central region at 11%.

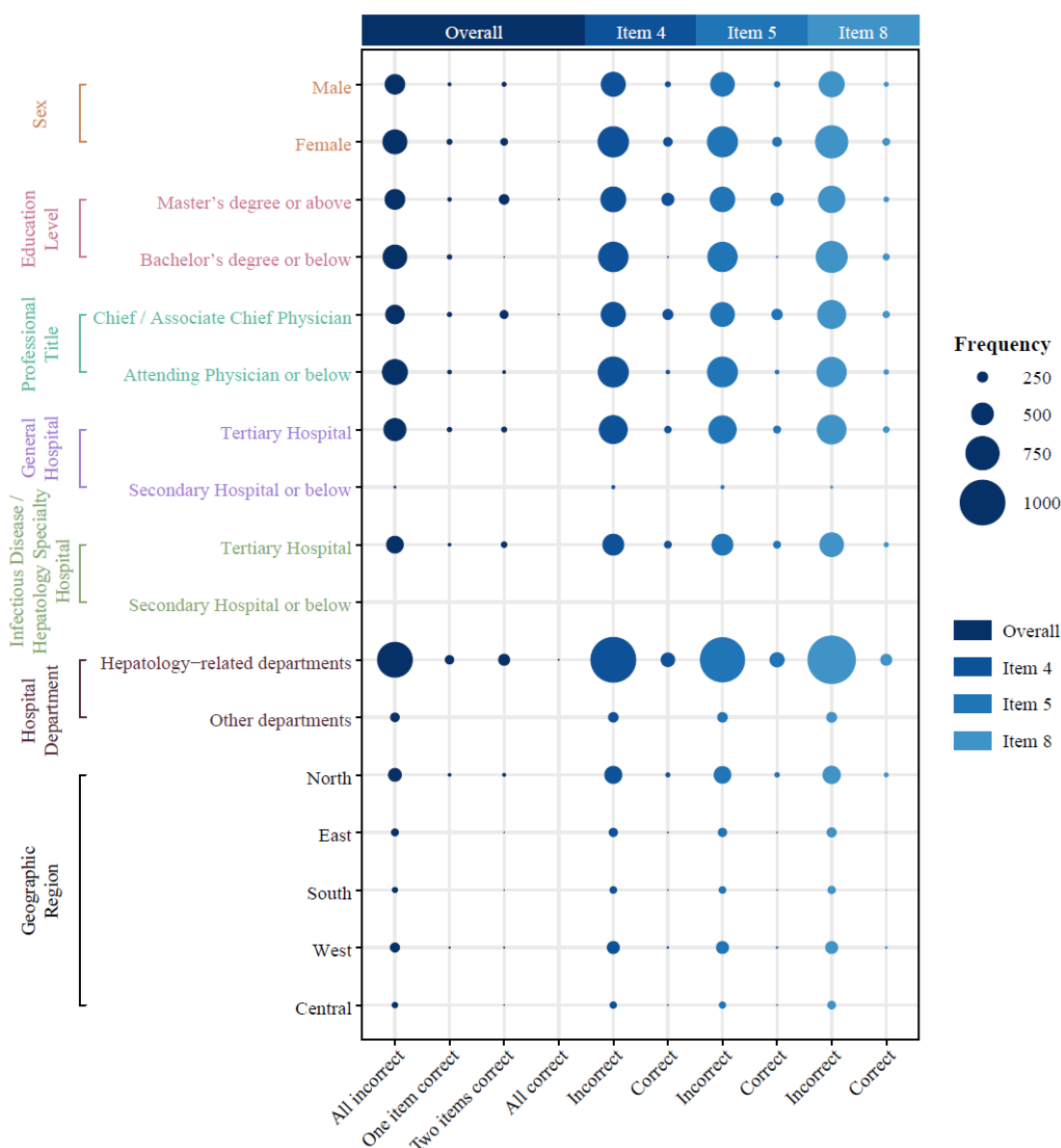


Figure 1. Bubble plot of univariate analysis of guideline awareness. Chi-square frequency distributions were stratified by total and individual items (item 4, 5, 8). Circles represent frequency counts, and different square colors indicate different question groupings.

Meanwhile, a random forest model was constructed using various predictor variables to evaluate responses to guideline-related cognition questions. The overall accuracy was 0.70 on the training set and 0.69 on the test set, indicating high consistency in data distribution with no evidence of overfitting or underfitting. Feature importance rankings and values were identical between the training and test sets (region: 0.35 > educational level: 0.22 > professional title: 0.16 > general/specialty hospital: 0.10 > department: 0.08 > sex: 0.06 > hospital tier: 0.03), demonstrating strong stability of the model's dependence on predictor variables (see Figure 2 A–F).

Among the three categories, the "all incorrect" class showed high accuracy, with an AUC of 0.78 on the training set and 0.71 on the test set. The model effectively discriminated this class, with region, educational level, and professional title identified as key contributing features. The "two or more correct" class demonstrated moderate accuracy, with an AUC of 0.86 on the training set and 0.83 on the test set, indicating good discriminative performance. This pattern appears strongly

associated with specialty resources (general/specialty hospital), clinical experience depth (professional title), and resource infrastructure (region). The "one correct" class exhibited very low accuracy, with an AUC of 0.78 on the training set and 0.59 on the test set, approaching random performance. Prediction for this class likely depends on conflicting feature interactions or low-importance features, possibly due to feature overlap or limited sample size.

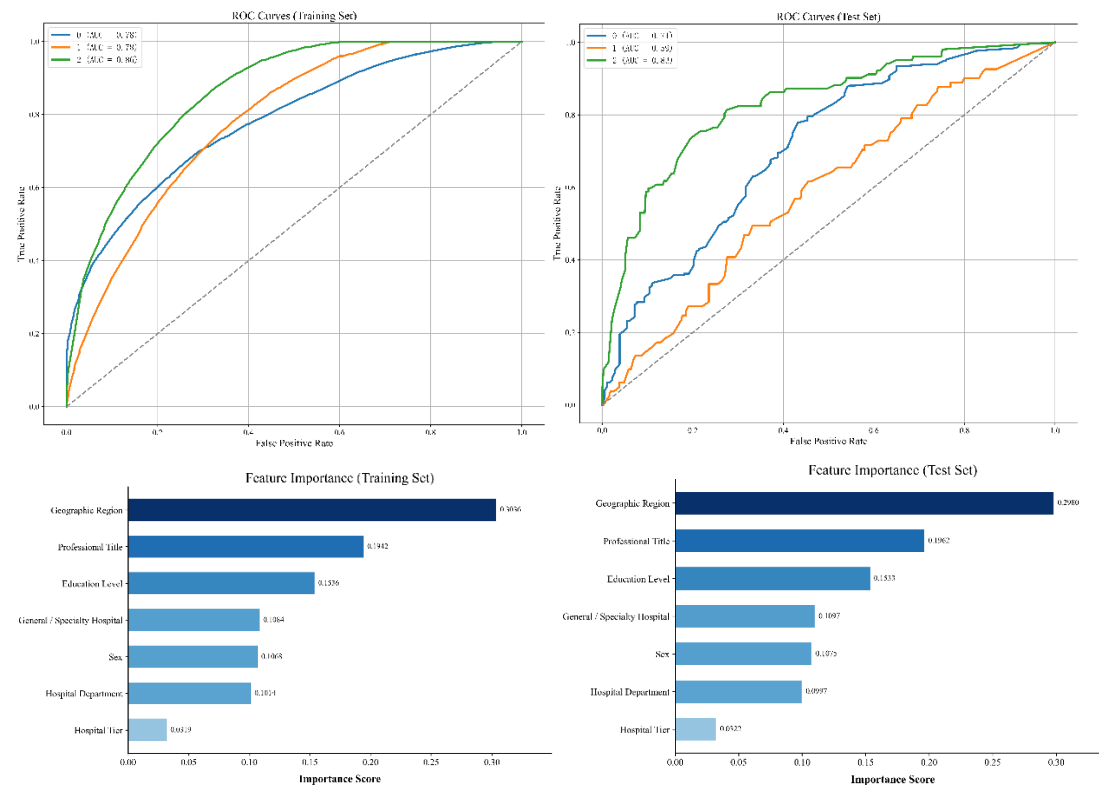


Figure 2 A–D. Random Forest model illustrating the impact of various clinician variables on guideline awareness. (A) ROC curve for the training set; (B) ROC curve for the test set; (C) Bar chart of feature importance scores in the training set; (D) Bar chart of feature importance scores in the test set.

3.3 Clinicians' Awareness and Implementation of Patient Follow-Up According to the 2022 Guidelines

Overall, patient follow-up rates at 1, 3, and 5 years ranged from 45% to 80%, 30% to 70%, and 25% to 65%, respectively. Hospital tier, department type, and geographic region were identified as key factors influencing patient follow-up rates. Although professional title, educational level, sex, hospital tier, and infectious disease/hepatology specialty hospitals were not statistically significant at the first, third, and fifth follow-up rates, they still appeared to have varying degrees of influence. The results are illustrated in the forest plots in Figure 3A and 3B.

In general hospitals, patient follow-up rates at 1 and 5 years differed significantly by hospital tier ($P < 0.05$), while the 3-year rate approached significance ($P = 0.075$). Secondary or lower-tier hospitals had lower median follow-up rates and interquartile ranges at 1, 3, and 5 years compared to tertiary hospitals. In infectious disease/hepatology specialty hospitals, no significant differences were observed by hospital tier. Department type was significantly associated at the first, third, and fifth follow-up rates ($P < 0.05$), with hepatology-related departments exhibiting higher medians and interquartile ranges than other departments. Regarding geographic region, only the 5-year follow-up rate in the central region reached statistical significance ($P < 0.05$). However, compared with all regions, the central region consistently had higher medians and interquartile ranges than the other

four regions; the east, south, and west regions showed no significant differences, while the northern region had higher rates than the remaining regions. No statistically significant differences were observed for sex, educational level, or professional title overall. Nevertheless, chief and associate chief physicians had higher medians and interquartile ranges for 1-, 3-, and 5-year follow-up rates compared to attending or lower-ranking physicians (70% vs 60%, 60% vs 45%, 50% vs 35%; 50–80% vs 30–75%, 35–75% vs 25–65%, 25–65% vs 25–55%). Clinicians with a bachelor's degree or lower had slightly lower medians at 3- and 5-year follow-up compared with those with a master's degree or higher (50% vs 55%, 40% vs 45%). Male physicians also had slightly lower medians than female physicians at 3- and 5-year follow-up (50% vs 55%, 40% vs 45%).

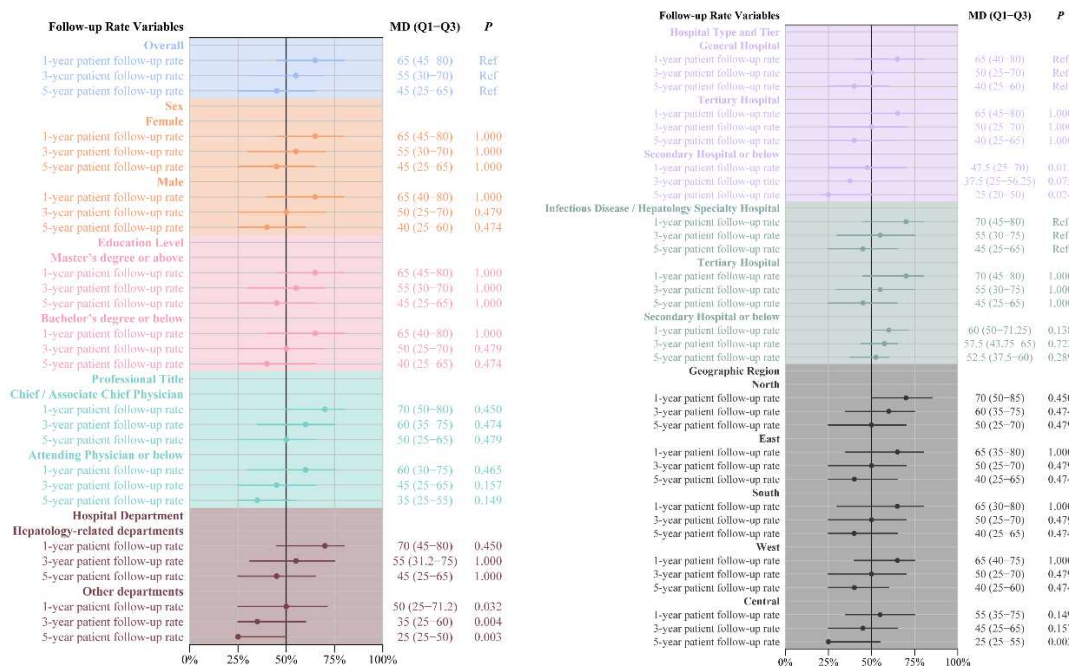


Figure 3. Forest plots showing stratified 1-, 3-, and 5-year follow-up rates for hepatitis B patients reported by clinicians. (A) Forest plots stratified by overall sample, sex, educational level, professional title, and hospital department; (B) Forest plots stratified by hospital type and tier, and geographic region. MD: median follow-up rate; Q1: lower quartile (25th percentile); Q3: upper quartile (75th percentile).

4 Discussion

This survey, combining a multicenter cross-sectional study with machine learning modeling, systematically revealed clinicians' awareness patterns regarding the *Guidelines for the Prevention and Treatment of Chronic Hepatitis B (version 2022)* and their impact on patient follow-up management. The study found that clinicians' educational level, professional title, and department specialty significantly influenced guideline awareness, while patient management efficiency was associated with hospital tier, department type, and geographic region. These awareness gaps and practical barriers together contributed to insufficient initiation of antiviral therapy and reduced patient follow-up rates.

From a cognitive perspective, clinicians exhibited substantial heterogeneity in their acceptance of guideline updates, with a pronounced professional gradient associated with educational level and professional title. Clinicians with a master's degree or higher demonstrated significantly higher guideline knowledge accuracy than those with a bachelor's degree or lower. This finding is consistent with Qin et al. (2021), who reported that "higher educational attainment is associated

with greater willingness to engage in learning and training"(11). Highly educated clinicians may be more motivated to leverage learning to realize personal value and advance their professional trajectory(12). Differences by professional title were observed, with senior physicians outperforming mid-level and lower-level physicians in guideline knowledge. Multiple studies indicate that individuals with senior professional titles often have greater access to high-quality academic resources, including research funding(13, 14), and may also engage more extensively in theoretical learning and scholarly output(15, 16). This pattern resembles the Matthew effect, exacerbating internal disparities(17). These findings are consistent with Sun et al. (2020), who reported a positive correlation between educational background, professional title, and understanding of disease(18). The feature importance ranking from the random forest model (educational level ranked second, professional title third) further supports this observation.

Departmental differences amplified this cognitive gap, with hepatology specialists demonstrating significantly higher mastery of key items compared to non-specialists, consistent with prior studies showing superior clinical competence among specialists(19). Notably, the random forest model identified educational level and professional title as core predictive factors. Although most geographic regions did not show significant differences, the northern region exhibited an anomalously high correct response rate for item 8 (21.7% vs 11% in the central region), potentially due to higher healthcare service demand, government initiatives, and stronger economic foundations in provinces such as Beijing and Jilin, which attract a greater number of high-quality clinicians(20-22). In our study, no significant differences were observed by sex ($P > 0.05$), reflecting the trend toward gender standardization and equality in modern medical education(23). However, some studies indicate that women remain underrepresented at higher medical and academic ranks(24), which may be related to differential access to higher education opportunities and the proportion of female academics within higher education institutions(25). These findings suggest that the roots of cognitive disparities encompass both modifiable professional training factors—such as depth of continuing education and participation in multidisciplinary specialty knowledge activities—and structural factors, including accumulation of professional experience and stable policy support(26).

Deficiencies in follow-up management were reflected in both overall and subgroup analyses, with patient follow-up rates declining stepwise over time. This pattern is closely associated with clinician-related factors (e.g., insufficient follow-up communication time, lack of efficient follow-up tools) and patient-related factors (e.g., limited disease awareness, tendency to self-discontinue therapy) (see Supplementary Figure 1). In clinical practice, limited consultation time restricts physicians' ability to conduct standardized follow-ups, while suboptimal patient adherence further exacerbates loss to follow-up, creating a vicious cycle of low follow-up rates, management failure, and resource waste. Notably, disparities in hospital tier contribute to differentiated follow-up rates among patients. The distribution of healthcare facilities in China forms a "positive triangle" in quantity, with primary-level hospitals outnumbering tertiary hospitals, but an "inverted triangle" in technical capacity and specialty services(27). Consequently, patients often distrust the quality of primary care and prefer to seek care at higher-tier hospitals(11, 28, 29).

Regional analysis indicated that mismatches between healthcare resource allocation and economic development further amplified disparities in follow-up management efficiency(30). In the central region, constrained healthcare resources limit the capacity of primary-level institutions, which lag in infrastructure upgrades, equipment renewal, and human resource development(31, 32). Concurrently, patient populations with low socioeconomic status (SES) face an increased risk of

loss to follow-up(33-35). In contrast, the northern region leverages its economic advantages to achieve comprehensive tertiary hospital support under policy guidance and has pioneered the establishment of regional medical information-sharing platforms, electronic health records, and other digital health services(36-38). This spatial heterogeneity underscores the strong correlation between healthcare resource allocation and regional economic development(39). We recommend implementing a GDP-oriented dynamic compensation mechanism to guide healthcare resource allocation toward central regions, promoting optimal and equitable distribution(40). Additionally, establishing a digital-economy–based intelligent follow-up scheduling system and cross-regional collaboration mechanisms can facilitate coordinated development and shared prosperity across regions(41).

5 Strengths of the Study

First, this was a multicenter study including 1,586 clinicians across 50 hospitals in 14 cities. Second, the study is methodologically innovative, integrating traditional analyses of a large-scale multicenter cross-sectional survey with random forest modeling. While conventional statistical methods provided fundamental evidence of associations, the random forest model captured complex interactions and nonlinear effects, jointly reinforcing the robustness of the study hypotheses. Finally, the study offers a comprehensive perspective by innovatively linking clinicians' cognitive assessments with long-term patient follow-up practices (1-, 3-, and 5-year follow-up rates) and incorporating geographic and economic dimensions, thereby providing precise data to inform differentiated intervention strategies.

6 Limitations

First, the representativeness of the sample was limited. The number of participants from secondary or lower-tier hospitals and non-hepatology departments was relatively small, which may amplify sampling error. Second, the random forest model developed in this study still has room for improvement in distinguishing between categories of guideline knowledge. Future studies could optimize questionnaire design by refining item structure and dimensional stratification to construct a more discriminative feature set. Finally, the follow-up data covered a limited time span. The 5-year follow-up rates reflect only short-term adherence, and longer observation periods are required to assess long-term outcomes.

7 Conclusions

This study demonstrates that Chinese clinicians exhibit a pronounced "professional gradient effect" in their awareness of the *Guidelines for the Prevention and Treatment of Chronic Hepatitis B (version 2022)*, attributable to differences in educational level, professional title, and departmental specialty. Additionally, patient follow-up management displayed a stepwise decline over time, which was associated with hospital tier, department type, and geographic region. Cognitive gaps and practical barriers (such as the lack of follow-up tools and uneven resource distribution) jointly constrained the clinical translation of the guidelines.

Acknowledgements

We greatly appreciate the participants for taking the time to participate in this study.

Ethics approval and consent to participate

The study protocol was approved by the Ethics Committee of Beijing Ditan Hospital, Capital Medical University, on November 21, 2024 (Approval No.: JDLZ[2024]No.(118)-01).

Consent for publication

All participants provided an electronic informed consent form before participating in the study.

Availability of data and materials

All datasets generated during this study are included in the article's Supplementary Information files.

Competing interests

The authors declare that they have no competing interests.

Funding

This study was supported by the Prevention and Control of Emerging and Major Infectious Diseases-National Science and Technology Major Project (no.2025ZD01906000, 2025ZD01906005), High-level Public Health Technical Personnel Construction Project (Subject leaders-02-16), Beijing Research Ward Excellence Program (BRWEP, no.BRWEP2024W102170100, BRWEP2024W102170116), Beijing Traditional Chinese Medicine New Era 125 Project (New 125 Talent).

Authors' contributions

GH was responsible for the study concept and design, was closely involved in data analysis and interpretation, and drafted the manuscript. YG participated in data analysis and interpretation and provided critical revisions to the manuscript. YK was closely involved in research methods, data analysis, and interpretation, and provided critical revisions to the manuscript regarding key academic content. ZY was closely involved in data analysis and interpretation, provided critical revisions to the manuscript concerning key academic content, and offered academic guidance and resource support. JL, XL, FY, HY, YX, and JJ participated in data collection and organization, provided resource support and fundraising, and critically revised the manuscript regarding key academic content. All authors read and approved the final manuscript.

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