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Effectiveness of a clinician-laboratory collaborative proactive follow-up management model in improving the HBV/HCV care cascade: A real-world controlled study

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Abstract

Background

To evaluate the effectiveness of a hospital-based proactive follow-up management model integrating clinical and laboratory resources in improving the HBV and HCV care cascade and virological outcomes.

Methods

We conducted a single-center real-world controlled before-and-after study among individuals with HBV or HCV infection identified through hospital-based screening. Patients managed between July and December 2023 received routine care, whereas those identified between July and December 2024 received a proactive follow-up intervention incorporating clinician–laboratory collaboration, laboratory-triggered case identification, and dedicated case management. The primary outcomes were completion of the care cascade, including specialist consultation, diagnostic confirmation, antiviral treatment initiation, and follow-up retention, as well as virological responses.

Results

A total of 1,502 individuals with HBV infection (638 controls and 864 interventions) and 664 individuals with HCV infection (308 controls and 356 interventions) were included. Baseline characteristics were comparable between groups. Compared with routine management, proactive follow-up significantly improved care cascade completion among individuals with HBV (89.12% vs. 41.54%, $P < 0.001$) and HCV (83.43% vs. 23.05%, $P < 0.001$) infection. The intervention also increased specialist linkage, diagnostic confirmation, and antiviral treatment initiation in both cohorts (all $P < 0.001$). Among treated patients, HBV virological response rates were higher in the intervention group (78.89% vs. 52.94%, $P < 0.001$), and HCV patients achieved higher SVR12 rates (95.81% vs. 64.08%, $P < 0.001$). Multivariable logistic regression demonstrated that proactive follow-up management was independently associated with improved care cascade completion for both HBV (OR = 13.446, 95% CI: 10.162–17.792, $P < 0.001$) and HCV (OR = 24.152, 95% CI: 15.474–37.698, $P < 0.001$) infections.

Conclusion

A hospital-based proactive follow-up management model substantially improved linkage to care, treatment uptake, care cascade completion, and virological outcomes among individuals with HBV and HCV infection. This model represents a feasible and scalable approach for optimizing hospital-based viral hepatitis management and may contribute to achieving hepatitis elimination targets.

Introduction

Chronic hepatitis B virus (HBV) and hepatitis C virus (HCV) infections remain major global public health challenges and continue to be leading causes of cirrhosis, hepatic decompensation, and hepatocellular carcinoma worldwide[1]. Although the widespread availability of potent antiviral therapies has substantially improved clinical outcomes, major gaps persist across the viral hepatitis care cascade in routine clinical practice. A considerable proportion of individuals with HBV or HCV infection fail to complete key steps, including specialist referral, confirmatory evaluation, treatment initiation, and longitudinal follow-up, resulting in delayed care and suboptimal treatment outcomes[2, 3]. These deficiencies are particularly evident after in-hospital screening, where the transition from laboratory identification to clinical management frequently breaks down[4–6]. Consequently, incomplete linkage to care remains a major obstacle to achieving the World Health Organization (WHO) targets for viral hepatitis elimination by 2030, which aim for 90% of infected individuals to be diagnosed and 80% of treatment-eligible patients to receive antiviral therapy[7].

To address these gaps, integrated care strategies incorporating multidisciplinary collaboration, patient navigation, and case management have been increasingly adopted to strengthen linkage to care and improve retention throughout the care cascade[8–13]. Previous studies have demonstrated that these approaches can enhance healthcare efficiency and are cost-effective in improving patient engagement and continuity of care. However, most existing interventions focus on isolated stages of the care pathway, such as screening, referral, or treatment initiation. In contrast, evidence regarding hospital-based models that integrate the entire continuum of care remains limited. To address this unmet need, our institution developed a Proactive Follow-up Management Model Integrating Clinical and Technical Resources. This hospital-based case management strategy combines multidisciplinary collaboration, electronic information systems, and dedicated case managers to facilitate systematic patient identification, proactive follow-up, timely specialist referral, standardized antiviral treatment, and continuous longitudinal management.

In this study, we evaluated the effectiveness of this hospital-based management model in improving the care of individuals with HBV and HCV infection. Specifically, we assessed its impact on completion of the screening–consultation–diagnosis–treatment–follow-up care cascade and on subsequent virological outcomes. We anticipate that our findings will provide real-world evidence supporting the implementation of standardized, sustainable hospital-based case management strategies for viral hepatitis and contribute to ongoing efforts toward viral hepatitis elimination.

Materials and Methods

1.1 Research Design

1.1.1 Study Design

This single-center, real-world, controlled before-and-after study was conducted at the Affiliated Hospital of Youjiang Medical University. Individuals with HBV or HCV infection who received routine management between July and December 2023 were assigned to the control group, whereas those managed under

the Proactive Follow-up Management Model Integrating Clinical and Technical Resources between July and December 2024 comprised the intervention group. The patient selection process is illustrated in Figure 1.

1.1.2 Eligibility Criteria

Inclusion criteria were as follows: (1) age ≥18 years; and (2) confirmed HBsAg and/or anti-HCV positivity based on serological testing performed at the study hospital.

Exclusion criteria were: (1) a history of antiviral therapy before study inclusion; (2) severe comorbid conditions with an expected survival of <1 year; and (3) psychiatric disorders or cognitive impairment that precluded participation in follow-up or adherence to the study protocol.

1.2 Interventions

1.2.1 Routine Management (Control Group)

Under the routine management model, positive HBsAg and anti-HCV test results generated automated alerts within the Laboratory Information System (LIS) and Hospital Information System (HIS), which were visible to the ordering physicians. Outpatients with positive results could be referred to the Infectious Diseases Clinic at the discretion of the treating physician, whereas hospitalized patients were evaluated through consultation with the Infectious Diseases Department upon request. Infectious disease specialists provided diagnostic and treatment recommendations and advised post-discharge follow-up when appropriate. No dedicated case managers were assigned, and no active patient tracking, standardized follow-up pathway, or coordinated case management was implemented beyond routine clinical practice.

1.2.2 Intervention Group: Proactive Follow-up Management Model Integrating Clinical and Technical Resources

(1) Organizational Structure and Staffing

A multidisciplinary collaboration framework was established under the coordination of the Medical Affairs Department, involving the Infectious Diseases Department, Laboratory Medicine Department, Information Technology Department, and relevant clinical departments. A dedicated WeChat (Electronic communication platform) group was created to facilitate real-time communication, notification of positive screening results, and coordinated management.The Infectious Diseases Department assigned a full-time case manager responsible for patient tracking and follow-up management. The case manager had more than 8 years of clinical experience, an intermediate or higher professional qualification according to the Chinese healthcare system, and had completed standardized training in viral hepatitis management. The Laboratory Medicine Department designated a senior laboratory technician as a liaison responsible for data extraction, reporting, and anonymization.

(2) Operational Mechanism

The LIS and HIS systems were integrated to enable automated identification and notification of positive HBsAg and anti-HCV results. Positive results were simultaneously communicated to ordering physicians through the existing alert system, and referral or consultation procedures were performed according to routine clinical pathways.

In addition, the Laboratory Medicine Department generated a daily list of newly identified positive cases, which was anonymized and shared through the multidisciplinary work group. The case manager subsequently initiated proactive patient follow-up, including result notification, health education, appointment coordination, treatment linkage, and longitudinal follow-up. This process established a standardized, end-to-end management pathway from screening identification to diagnosis, treatment initiation, and follow-up retention.

(3) Core Responsibilities of the Case Manager

The dedicated case manager was responsible for implementing the following standardized procedures:

- Patient information was retrieved within 2 working days after identification of positive screening results. Individuals who had previously initiated antiviral therapy were excluded, and eligible patients requiring follow-up were enrolled into the management pathway.
- Initial contact was established within 3 working days to communicate screening results, provide preliminary health education, and facilitate specialist consultation appointments.
- For patients who had not attended scheduled appointments, a second follow-up contact was conducted within 2 weeks to encourage linkage to clinical care.
- Relevant medical histories were collected, treatment eligibility was assessed in collaboration with infectious disease specialists, and individualized electronic follow-up records were established.
- Digital health–supported nursing services were used to provide medication reminders, monitor potential adverse events, and reinforce follow-up appointments.
- Routine follow-up was conducted every 3 months, with increased contact frequency for individuals considered at high risk of loss to follow-up.
- Targeted health education was provided to patients eligible for HBV functional cure strategies.
- Diagnostic and treatment outcomes were reviewed monthly, generating a continuous monitoring–feedback–quality improvement cycle to optimize the management pathway.

1.3 Treatment Regimens and Assessment of Efficacy

1.3.1 Definition of Treatment Eligibility and Virological Response in HBV Infection

Treatment eligibility and efficacy assessment for HBV infection were defined according to the Chinese Guidelines for the Prevention and Treatment of Chronic Hepatitis B (2022 edition).

Patients with HBV infection were considered eligible for antiviral therapy if they met any of the following criteria: (1) detectable HBV DNA accompanied by persistently elevated alanine aminotransferase (ALT) levels; (2) a family history of cirrhosis or hepatocellular carcinoma (HCC), age >30 years, liver inflammation grade ≥2 or fibrosis stage ≥2, or HBV-related extrahepatic manifestations.

Patients receiving nucleos(t) ide analogue (NA) therapy who achieved HBV DNA suppression, HBeAg seroconversion, and HBsAg levels <1,500 IU/mL were considered candidates for combination therapy with pegylated interferon-α (Peg-IFN-α) to pursue HBV functional cure.

Virological response was assessed after 48 weeks of NA therapy (24 weeks for patients with cirrhosis). HBV DNA ≤2,000 IU/mL was defined as an effective virological response, whereas values above this threshold were considered inadequate virological response.

1.3.2 Definition of Treatment Eligibility and Virological Response in HCV Infection

Treatment eligibility and efficacy assessment for HCV infection were based on the Chinese Guidelines for the Prevention and Treatment of Chronic Hepatitis C (2022 edition).

All patients with detectable HCV RNA were considered eligible for direct-acting antiviral (DAA) therapy.

Treatment efficacy was assessed based on sustained virological response at 12 weeks after completion of therapy (SVR12), defined as undetectable HCV RNA (<15 IU/mL) at 12 weeks after treatment completion.

1.4 Statistical Analysis

Data were entered into Microsoft Excel 2019 and analyzed using IBM SPSS Statistics version 26.0. Continuous variables were presented as the mean ± standard deviation (SD) or median (interquartile range, IQR), as appropriate. Comparisons of continuous variables between groups were performed using the independent-samples t test for normally distributed data or the Mann–Whitney U test for non-normally distributed data. Categorical variables were summarized as numbers and percentages [n (%)], and differences between groups were assessed using the chi-square (χ^2) test or Fisher's exact test when appropriate. Binary logistic regression analysis was performed to identify independent factors associated with completion of the HBV and HCV care cascade. All statistical tests were two-sided, and a P value <0.05 was considered statistically significant. Figures were generated using Microsoft Visio 2021 and GraphPad Prism version 10.0.

Results

2.1 Baseline Characteristics

The HBV cohort included 1,502 HBsAg-positive patients, including 638 patients in the control group and 864 in the intervention group. The HCV cohort comprised 664 anti-HCV-positive patients, including 308 in the control group and 356 in the intervention group. For both the HBV and HCV cohorts, baseline characteristics, including age, sex, ethnicity, and educational level, were comparable between the control and intervention groups, with no statistically significant differences observed (Table 1).

2.2 Effect of the Intervention on Linkage-to-Care and Confirmed Diagnosis Rates

2.2.1 HBV Infection

Among individuals with HBV infection, the linkage-to-care rate was significantly higher in the intervention group than in the control group (98.50% [851/864] vs. 78.53% [501/638], χ^2=162.793, $P < 0.001$). Similarly, the confirmed diagnosis rate increased significantly from 77.12% (492/638) in the control group to 93.98% (812/864) in the intervention group (χ^2=91.214, $P < 0.001$). Detailed results are presented in Table 2 and Fig. 2.

2.2.2 HCV Infection

Among individuals with HCV infection, the linkage-to-care rate was significantly improved in the intervention group compared with the control group (98.31% [350/356] vs. 74.68% [230/308], χ^2=83.508, $P < 0.001$). The confirmed diagnosis rate was also significantly increased from 52.92% (163/308) in the control group to 87.92% (313/356) in the intervention group (χ^2=99.660, $P < 0.001$). Detailed results are presented in Table 2 and Fig. 3.

2.3 Effect of the Intervention on Antiviral Treatment Uptake and Virological Outcomes

2.3.1 HBV Infection

Among patients with HBV infection who met antiviral treatment criteria, the antiviral treatment uptake rate was significantly higher in the intervention group than in the control group (95.45% [777/814] vs. 79.47% [391/492], χ^2=160.42, $P < 0.001$).

Among patients eligible for HBV functional cure–oriented strategies, the proportion receiving combination therapy aimed at achieving functional cure was significantly increased in the intervention group compared with the control group (50.93% [55/108] vs. 12.50% [7/56], χ^2=23.159, $P < 0.001$).

Following antiviral therapy, the virological response rate was significantly higher in the intervention group than in the control group (78.89% [613/777] vs. 52.94% [207/391], χ^2=83.751, $P < 0.001$).

Detailed results are presented in Tables 3 and 4 and Fig. 2.

2.3.2 HCV Infection

Among patients with detectable HCV RNA, antiviral treatment uptake was significantly higher in the intervention group than in the control group (99.04% [310/313] vs. 63.19% [103/163], χ^2=116.865, P < 0.001).

The SVR12 rate was also significantly improved in the intervention group compared with the control group (95.81% [297/310] vs. 64.08% [66/103], χ^2=73.144, P < 0.001).

Detailed results are presented in Table 3 and Fig. 3.

2.4 Effect of the Intervention on Care Cascade Completion and Associated Factors

2.4.1 HBV Infection

Completion of the HBV care cascade (screening–consultation–diagnosis–treatment–follow-up) was significantly higher in the intervention group than in the control group (89.12% [770/864] vs. 41.54% [265/638], χ^2=387.86, P < 0.001).

In univariate analysis, older age and lower educational attainment were associated with a lower probability of care cascade completion. Patients aged ≥ 60 years had a lower completion rate than those aged < 60 years (78.77% [141/179] vs. 91.82% [629/685], χ^2=24.941, P < 0.001). Similarly, patients with junior high school education or below had a lower completion rate than those with high school education or above (87.29% [611/700] vs. 96.95% [159/164], χ^2=12.802, P < 0.001). No significant differences were observed according to sex or ethnicity (all P > 0.05). (Table 5)

Variables with P < 0.05 in univariate analyses were included in multivariate logistic regression. After adjustment for potential confounders, implementation of the proactive follow-up management model remained independently associated with improved HBV care cascade completion (OR = 13.446, 95% CI: 10.162–17.792, P < 0.001). Educational attainment of high school or above was also independently associated with higher completion rates (OR = 3.231, 95% CI: 2.226–4.692, P < 0.001), whereas older age was associated with reduced completion probability (OR = 0.566, 95% CI: 0.411–0.780, P < 0.001). The intervention model represented the strongest determinant of cascade completion. (Fig. 4)

2.4.2 HCV Infection

Completion of the HCV care cascade was significantly higher in the intervention group compared with the control group (83.43% [297/356] vs. 23.05% [71/308], χ^2=243.637, P < 0.001).

In univariate analysis, educational attainment was associated with care cascade completion. Patients with junior high school education or below showed lower completion rates than those with high school education or above (80.77% [231/286] vs. 94.29% [66/70], χ^2=6.485, P < 0.05). No significant differences were observed according to age, sex, or ethnicity (all P > 0.05). (Table 5)

Multivariate logistic regression analysis demonstrated that the proactive follow-up management model was independently associated with substantially increased HCV care cascade completion (OR = 24.152, 95% CI: 15.474–37.698, P < 0.001). Higher educational attainment remained an independent predictor of cascade completion (OR = 7.906, 95% CI: 4.419–14.145, P < 0.001), whereas older age was associated with reduced completion probability (OR = 0.498, 95% CI: 0.299–0.832, P < 0.05). Among all evaluated factors, the intervention model demonstrated the strongest association with successful cascade completion. (Fig. 5)

Discussion

In this real-world before-and-after study, we discovered that a hospital-based proactive follow-up management model integrating clinical and technical resources substantially improved completion of the HBV and HCV care cascade (HBV: 89.12% vs. 41.54%; HCV:83.43% vs. 23.05%), encompassing screening, consultation, diagnosis, treatment initiation, and follow-up, with the management model remaining the strongest independent determinant of cascade completion in multivariable analyses (HBV: OR = 13.446; HCV: OR = 24.152). These findings highlight that the major challenge in viral hepatitis elimination is no longer solely the availability of effective antiviral therapies, but rather the persistent failure to translate diagnosis into sustained clinical care. Previous global studies have consistently demonstrated substantial attrition along the viral hepatitis care cascade, particularly between screening identification, diagnostic confirmation, specialist linkage, and treatment initiation[14–16]. The WHO has emphasized strengthening the continuum of care as a core component of the 2030 viral hepatitis elimination strategy, requiring health systems to systematically identify and address losses at each cascade step[17]. The end-to-end closed-loop management system evaluated in this study was developed to address existing gaps and align with the WHO's call for action, aiming to overcome barriers within traditional healthcare processes and contribute to the implementation of hospital-based HBV and HCV elimination strategies.

Notably, the magnitude of benefit was more pronounced among individuals with HCV infection, which may be attributed to the differences in disease management strategies between HBV and HCV. HCV treatment currently aims to achieve viral eradication through DAAs, with a relatively fixed treatment duration that can usually be completed within 8–12 weeks. Therefore, the key priorities in HCV management are rapidly establishing linkage to care, ensuring treatment completion, and achieving sustained virological response[18]. In this study, the proactive follow-up management model significantly increased treatment initiation and further improved SVR12 achievement, suggesting that this strategy can effectively facilitate the real-world implementation of "test-and-treat" approaches and micro-elimination strategies[19]. Previous studies have demonstrated that active patient navigation, electronic health system-based tracking, and task-shifting models can significantly improve linkage to care and treatment completion among individuals with HCV infection[19, 20]. The current model integrates dedicated case manager follow-up with information-based tracking, representing an adaptation and implementation of these effective strategies within the hospital setting. In contrast, HBV management is

characterized by greater complexity and long-term requirements. Beyond antiviral treatment initiation, HBV care involves sustained viral suppression, maintenance of treatment adherence, and long-term surveillance for cirrhosis and hepatocellular carcinoma risk. Therefore, optimizing the HBV care cascade requires continuous patient engagement and longitudinal management. In our study, the end-to-end closed-loop management system not only increased antiviral treatment initiation among individuals with HBV infection but also improved long-term treatment-related outcomes, indicating that healthcare process optimization can effectively translate existing antiviral strategies into real-world health benefits. These findings further support a central principle of implementation science: the organization and delivery of healthcare services themselves are critical determinants of disease outcomes[21–23].

In addition to the intervention effect, our study identified several sociodemographic factors associated with successful completion of the HBV and HCV care cascade. Multivariable analysis showed that younger age and higher educational attainment were independently associated with greater cascade completion, consistent with previous observations[24, 25]. Individuals with lower educational levels may experience delayed healthcare-seeking behaviors and poorer adherence due to limited health literacy, reduced disease awareness, and difficulties navigating complex healthcare systems[24]. Similarly, older individuals may face additional barriers, including multimorbidity, reduced mobility, and limited familiarity with digital healthcare tools, which may increase the risk of disengagement from long-term follow-up[25]. Importantly, these findings further emphasize that expanding screening coverage alone is insufficient to achieve viral hepatitis elimination. Previous studies have highlighted that structural barriers, including limited healthcare access and inadequate linkage mechanisms, remain major obstacles for both patients and healthcare providers, and that “screening alone cannot ensure completion of the prevention pathway”[26]. Therefore, effective elimination strategies require not only broader case identification but also integrated patient navigation, longitudinal follow-up, and improved accessibility throughout the care continuum[26, 27]. In future implementation of this model, dedicated case managers can provide personalized support—including appointment coordination, medication reminders, health education, and psychological support, thereby reducing disparities in healthcare engagement associated with sociodemographic characteristics. This approach embodies the principle of “precision implementation,” which involves tailoring healthcare interventions to patient-level risk characteristics while further optimizing health system processes[28, 29].

The scalability of this model is supported by several practical advantages. Importantly, the intervention does not require additional diagnostic technologies, novel medications, or substantial infrastructure investment; instead, it improves care delivery by integrating existing healthcare resources, including laboratory services, infectious disease specialists, information systems, and dedicated case management personnel. By establishing standardized workflows and clearly defined responsibilities, this approach aligns with international strategies emphasizing shared care and task shifting to strengthen chronic disease management[11, 20]. Previous studies have demonstrated that decentralized and collaborative approaches can effectively improve viral hepatitis management. In low-prevalence settings, general practitioner–led HBV screening and follow-up pathways have been shown to be cost-effective,

with an incremental cost-effectiveness ratio of approximately $5,688 per quality-adjusted life year (QALY) gained[11]. Similarly, community-based HCV screening combined with patient navigation services can substantially increase treatment initiation among individuals with HCV infection[19]. Building upon these principles, our study translated such implementation strategies into a hospital-based care pathway and demonstrated that health-system optimization can enhance the real-world impact of effective antiviral therapies. In our study, the higher virological response rate among patients with HBV infection and the improved SVR12 rate among patients with HCV infection were consistent with these findings.

Several limitations should be acknowledged. First, this was a single-center, controlled before-and-after study, and the non-randomized design may have introduced potential temporal or unmeasured confounding. Second, although the intervention demonstrated significant improvements in care cascade completion and virological outcomes, formal health economic evaluation was not performed. Third, the follow-up duration was insufficient to assess long-term clinical outcomes, such as progression to cirrhosis, hepatocellular carcinoma surveillance outcomes, and sustained retention in care. Future multicenter studies incorporating cost-effectiveness analyses and longer follow-up periods are warranted to further validate the generalizability and sustainability of this model.

Despite these limitations, our findings demonstrate that, in the era of highly effective antiviral therapies, improving viral hepatitis elimination requires not only access to treatment but also optimization of healthcare delivery systems. Restructuring in-hospital care pathways, integrating clinical and technical resources, and implementing proactive patient follow-up represent effective strategies for overcoming persistent gaps across the hepatitis care continuum. This hospital-based model provides a scalable and adaptable framework that can be incorporated into routine healthcare workflows and offers practical insights for strengthening integrated management of chronic infectious diseases, from screening and diagnosis to treatment and long-term follow-up.

Table 1
Baseline characteristics of patients with HBV and HCV infection in the control and intervention groups.

Category	**Control**	**Intervention**	**χ^2/t(Z)**	***P-value***
HBV	N = 638	N = 864		
Gender n/cases (%)				
Male	363(56.90)	527(61.00)	2.554	0.110
Female	275(43.10)	337(39.00)		
Age n/cases (%)				
< 60	519(81.35)	685(79.28)	0.985	0.321
≥ 60	119(18.65)	179(20.72)		
Nationality n/cases (%)				
Han nationality	110(17.24)	149(17.25)	5.374	0.068
Zhuang nationality	442(69.28)	561(64.93)		
Other nationalities	86(13.48)	154(17.82)		
Educational level n/cases (%)				
Junior high school and below	517(81.03)	700(81.02)	0	0.994
High school and above	121(18.97)	164(18.98)		
HCV	N = 308	N = 356		
Gender n/cases (%)				
Male	219(71.10)	264(74.16)	0.776	0.378
Female	89(28.90)	92(25.84)		
Age n/cases (%)				
< 60	246(79.87)	295(82.87)	0.981	0.322
≥ 60	62(20.13)	61(17.13)		
Nationality n/cases (%)				
Han nationality	40(12.99)	41(11.52)	4.946	0.084
Zhuang nationality	250(81.17)	306(85.96)		
Other nationalities	18(5.84)	9(2.53)		
Other nationalities: including the Yao, Miao, Buyi, Hui, and others.				

Category	Control	Intervention	χ^2/t(Z)	*P-value*
Educational level n/cases (%)				
Junior high school and below	249(80.84)	286(80.34)	0.027	0.869
High school and above	59(19.16)	70(19.66)		
Other nationalities: including the Yao, Miao, Buyi, Hui, and others.				

Table 2
Comparison of linkage to care and diagnostic confirmation rates according to demographic characteristics between the control and intervention groups among patients with HBV and HCV infection.

Category	Control		Intervention	
	Linkage to care rate	Diagnostic confirmation rate	Linkage to care rate*	Diagnostic confirmation rate*
HBV	N = 501	N = 492	N = 851	N = 812
Gender n/cases (%)				
Male	281(56.09)	273(55.49)	518(60.87)	495(60.96)
Female	220(43.91)	219(44.51)	333(39.13)	317(39.04)
Age n/cases (%)				
< 60	413(82.44)	404(82.11)	677(79.55)	648(79.80)
≥ 60	88(17.56)	88(17.89)	174(20.45)	164(20.20)
Nationality n/cases (%)				
Han nationality	89(17.76)	89(18.09)	147(17.27)	140(17.24)
Zhuang nationality	352(70.26)	344(69.92)	551(64.75)	525(64.66)
Other nationalities	60(11.98)	59(11.99)	153(17.98)	147(18.10)
Educational level n/cases (%)				
Junior high school and below	393(78.44)	384(78.05)	688(80.85)	649(79.93)
High school and above	108(21.56)	108(21.95)	163(19.15)	163(20.07)
HCV	N = 230	N = 163	N = 350	N = 313
Gender n/cases (%)				
Male	166(72.17)	134(82.21)	259(74.00)	233(74.44)
Female	64(27.83)	29(17.79)	91(26.00)	80(25.56)
Age n/cases (%)				
< 60	192(83.48)	138(84.66)	289(82.57)	263(84.03)

*: P < 0.05 versus the control group.

Category	Control		Intervention	
	Linkage to care rate	Diagnostic confirmation rate	Linkage to care rate*	Diagnostic confirmation rate*
≥ 60	38(16.52)	25(15.34)	61(17.43)	50(15.97)
Nationality n/cases (%)				
Han nationality	27(11.74)	23(14.11)	39(11.14)	37(11.82)
Zhuang nationality	187(81.30)	131(80.37)	304(86.86)	269(85.94)
Other nationalities	16(6.96)	9(5.52)	7(2.00)	7(2.24)
Educational level n/cases (%)				
Junior high school and below	182(79.13)	121(74.23)	281(80.29)	246(78.59)
High school and above	48(20.87)	42(25.77)	69(19.71)	67(21.41)
*: $P < 0.05$ versus the control group.				

Table 3
Comparison of antiviral treatment uptake and virological outcomes according to demographic characteristics between the control and intervention groups among patients with HBV and HCV infection.

Category	Control		Intervention	
	Antiviral uptake	Virological response/SVR 12	Antiviral uptake*	Virological response/SVR 12*
HBV	N = 391	N = 207	N = 777	N = 613
Gender n/cases (%)				
Male	212(54.22)	103(49.76)	471(60.62)	376(61.34)
Female	179(45.78)	104(50.24)	306(39.38)	237(38.66)
Age n/cases (%)				
< 60	320(81.84)	168(81.16)	634(81.60)	505(82.38)
≥ 60	71(18.16)	39(18.84)	143(18.40)	108(17.62)
Nationality n/cases (%)				
Han nationality	70(17.90)	28(13.53)	139(17.89)	114(18.60)
Zhuang nationality	277(70.84)	154(74.40)	501(64.48)	396(64.60)
Other nationalities	44(11.25)	25(12.08)	137(17.63)	103(16.80)
Educational level n/cases (%)				
Junior high school and below	294(75.19)	133(64.25)	617(79.41)	482(78.63)
High school and above	97(24.81)	74(35.75)	160(20.59)	131(21.37)
HCV	N = 103	N = 66	N = 310	N = 297
Gender n/cases (%)				
Male	84(81.55)	55(83.33)	229(73.87)	217(73.06)
Female	19(18.45)	11(16.67)	81(26.13)	80(26.94)
Age n/cases (%)				
< 60	90(87.38)	60(90.91)	258(83.23)	249(83.84)

*: P < 0.05 versus the control group. Virological response:/SVR 12:Virological response was assessed for HBV infection, and SVR12 was assessed for HCV infection.

Category	Control		Intervention	
	Antiviral uptake	Virological response/SVR 12	Antiviral uptake*	Virological response/SVR 12*
≥ 60	13(12.62)	6(9.09)	52(16.77)	48(16.16)
Nationality n/cases (%)				
Han nationality	16(15.53)	12(18.18)	37(11.94)	36(12.12)
Zhuang nationality	82(79.61)	52(78.79)	266(85.81)	255(85.86)
Other nationalities	5(4.85)	2(3.03)	7(2.26)	6(2.02)
Educational level n/cases (%)				
Junior high school and below	64(62.14)	30(45.45)	243(78.39)	232(78.11)
High school and above	39(37.86)	36(54.55)	67(21.61)	65(21.89)

*: P < 0.05 versus the control group. Virological response:/SVR 12:Virological response was assessed for HBV infection, and SVR12 was assessed for HCV infection.

Table 4
Comparison of HBV clinical cure eligibility and treatment uptake according to demographic characteristics between the control and intervention groups.

Category	Control		Intervention	
	Clinical cure eligibility (n = 56)	Clinical cure uptake (n = 7)	Clinical cure eligibility* (n = 108)	Clinical cure uptake* (n = 55)
Gender n/cases (%)				
Male	30(53.57)	5(71.43)	64(59.26)	32(58.18)
Female	26(46.43)	2(28.57)	44(40.74)	23(41.82)
Age n/cases (%)				
< 60	48(85.71)	6(85.71)	93(86.11)	55(100.00)
≥ 60	8(14.29)	1(14.29)	15(13.89)	0(0.00)
Nationality n/cases (%)				
Han nationality	8(14.29)	3(42.86)	13(12.04)	6(10.91)
Zhuang nationality	39(69.64)	3(42.86)	67(62.04)	37(67.27)
Other nationalities	9(16.07)	1(14.29)	28(25.93)	12(21.82)
Educational level n/cases (%)				
Junior high school and below	24(42.86)	2(28.57)	67(62.04)	26(47.27)
High school and above	32(57.14)	5(71.43)	41(37.96)	29(52.73)

*: $P < 0.05$ versus the control group.

Table 5
Univariate analysis of factors associated with hepatitis care cascade completion among patients with HBV and HCV infection.

Category	**Completed**	**Not completed**	**χ^2**	***P-value***
HBV				
Management strategy n/cases (%)				
Control (n = 638)	265(41.54)	373(58.46)	387.860	P < 0.001
Intervention (n = 864)	770(89.12)	94(10.88)		
Gender n/cases (%)				
Male (n = 527)	466(88.43)	61(11.57)	0.674	0.412
Female (n = 337)	304(90.21)	33(9.79)		
Age n/cases (%)				
< 60 (n = 685)	629(91.82)	56(8.18)	24.941	P < 0.001
≥ 60 (n = 179)	141(78.77)	38(21.23)		
Nationality n/cases (%)				
Han nationality (n = 149)	136(91.28)	13(8.72)	0.888	0.641
Zhuang nationality (n = 561)	498(88.77)	63(11.23)		
Other nationality (n = 154)	136(88.31)	18(11.69)		
Educational level n/cases (%)				
Junior high school and below (n = 700)	611(87.29)	89(12.71)	12.802	P < 0.001
High school and above (n = 164)	159(96.95)	5(3.05)		
HCV				
Management strategy n/cases (%)				
Control (n = 308)	71(23.05)	237(76.95)	243.637	P < 0.001
Intervention (n = 356)	297(83.43)	59(16.57)		
Gender n/cases (%)				
Male (n = 264)	218(82.58)	46(17.42)	0.535	0.464
Female (n = 92)	79(85.87)	13(14.13)		
Age n/cases (%)				
< 60 (n = 295)	251(85.08)	44(14.92)	3.422	0.064

Category	Completed	Not completed	χ^2	*P-value*
≥ 60 (n = 61)	46(75.41)	15(24.59)		
Nationality n/cases (%)				
Han nationality (n = 41)	35(85.37)	6(14.63)	1.952	0.377
Zhuang nationality (n = 306)	256(83.66)	50(16.34)		
Other nationality (n = 9)	6(66.67)	3(33.33)		
Educational level n/cases (%)				
Junior high school and below (n = 286)	231(80.77)	55(19.23)	6.485	0.011
High school and above (n = 70)	66(94.29)	4(5.71)		

Abbreviations

Abbreviations
HBV: hepatitis B virus
HCV: hepatitis C virus
WHO: World Health Organization
LIS: Laboratory Information System
HIS: Hospital Information System
ALT: alanine aminotransferase
HCC: hepatocellular carcinoma
NA: nucleos(t) ide analogue
Peg-IFN-□: pegylated interferon-α
DAA: direct-acting antiviral
SVR 12: 12 weeks after completion of therapy
QALY: quality-adjusted life year

Declarations

Conflicts of Interest

Hao Wang, Yun Huang, Yuefeng Huang, Ying Yang, Xiaoxian Wei, Junqi Huang, Liudan Liang, Meijin Huang, Shengkui Tan, Zhongheng Wei and Jiannan Lv have declare that they have no relevant financial or non-financial interests to disclose.

Ethics Statement

The study was conducted under the Declaration of Helsinki.This research protocol was approved by the Institutional Review Board of Fangchenggang First People's Hospital prior to the study's commencement.(No.2023034)

Consent

Informed consent was obtained from all patients.

Funding

Author Contribution

Author ContributionsH. W participated in the project implementation, analysed data and wrote the manuscript; Y. H participated in the project implementation and acquired data; YF.H, Y. Y, XX.W, JQ.H, LD.L and MJ.H participated in the project implementation and revised the manuscript; SK.T, ZH.W and JN.L designed the research and revised the manuscript. All authors read and approved the final manuscript.

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Data Availability

The datasets used and/or analyzed during the current study are not publicly available due to patient privacy concerns but are available from the corresponding author upon reasonable request.

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Figures

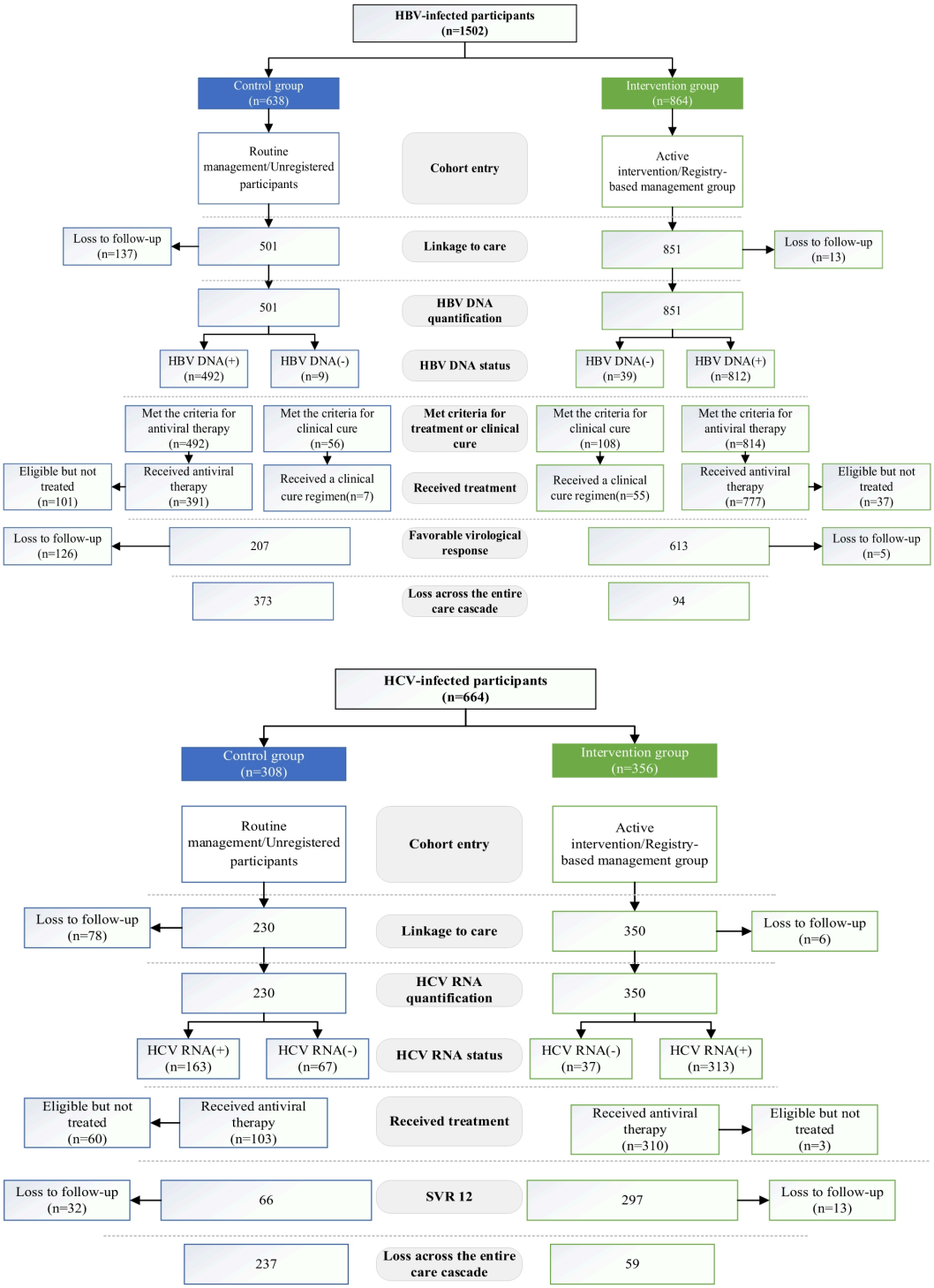


Figure 1

Patients Enrollment Process

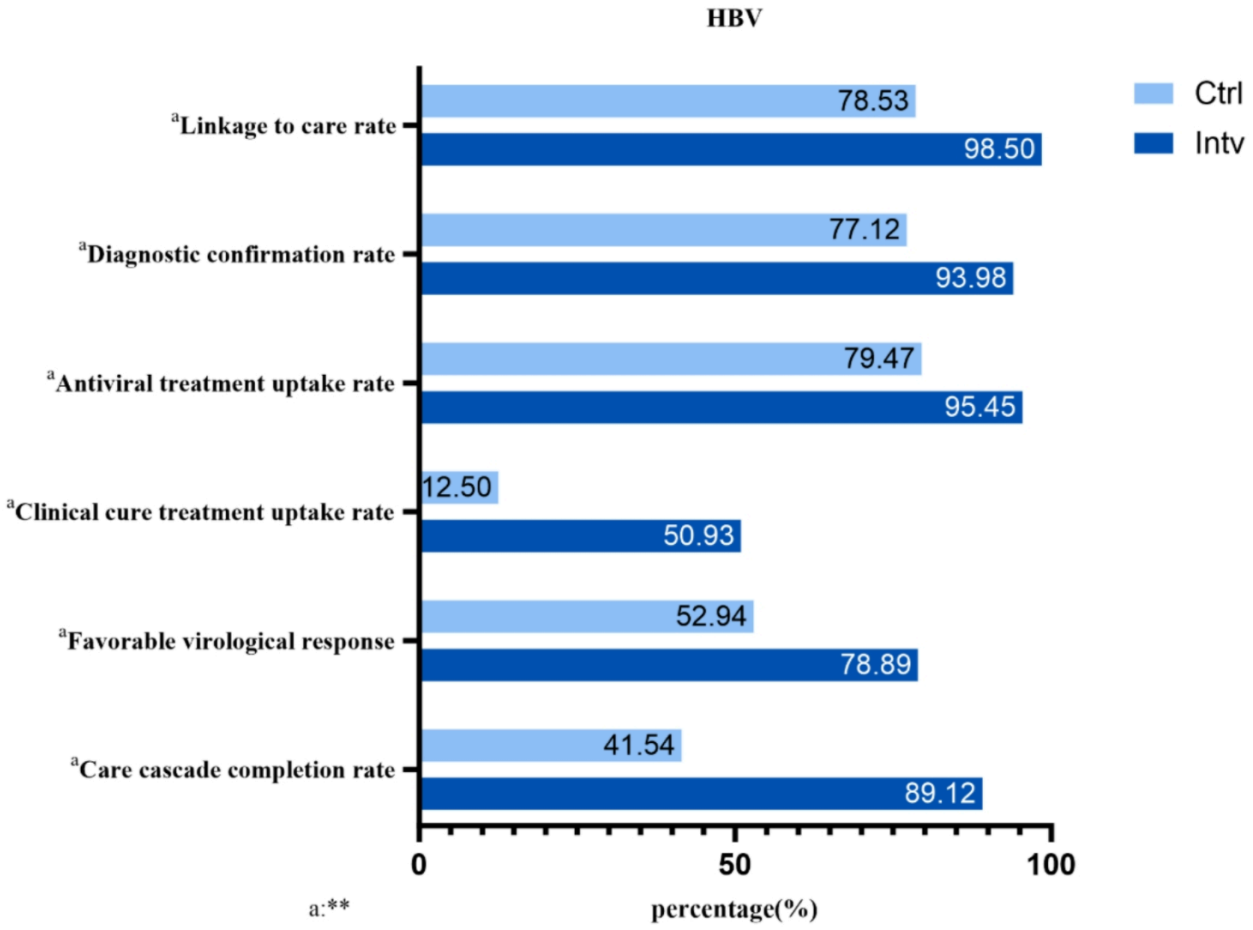


Figure 2

Effect of a medical–technical linkage proactive management model on the HBV care cascade.

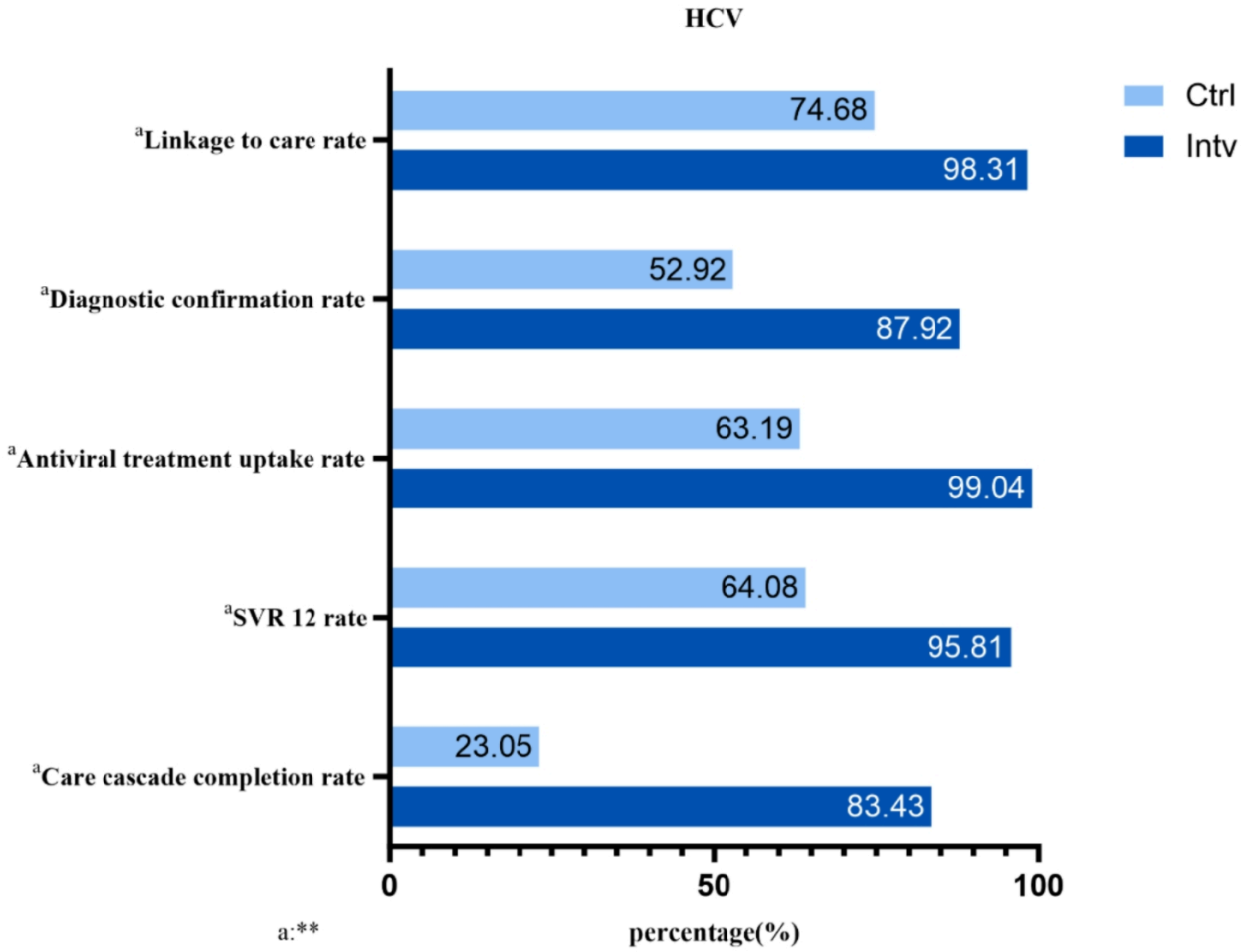


Figure 3

Effect of a medical–technical linkage proactive management model on the HCV care cascade.

	Variables	OR(95%CI)	P Value
HBV	Management model		
	Control (Ref.)		
	Intervention	13.446(10.162,17.792)	P<0.001
	Sex		
	Male (Ref.)		
	Female	1.274(0.977,1.661)	0.074
	Ethnicity		
	Han (Ref.)		
	Zhuang	1.169(0.824,1.659)	0.382
	Other ethnic minorities	0.941(0.598,1.481)	0.794
	Age		
	<60 years (Ref.)		
	≥60 years	0.566(0.411,0.780)	0.001
	Education level		
	Junior high school and below (Ref.)		
	High school and above	3.231(2.226,3.231)	P<0.001

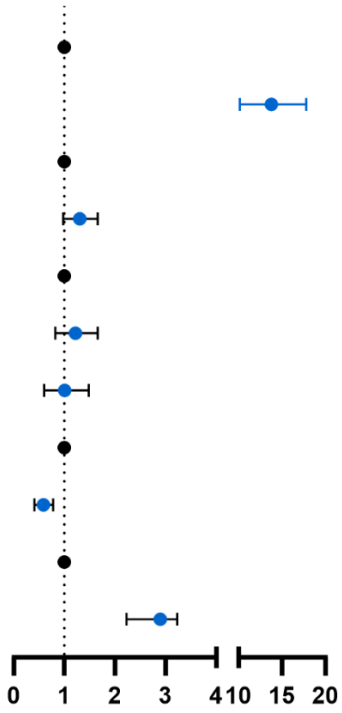


Figure 4

Forest plot showing adjusted odds ratios (ORs) and 95% confidence intervals (CIs) for factors associated with full HBV care cascade completion.

	Variables	OR(95%CI)	P Value
HCV	Management model		
	Control (Ref.)		
	Intervention	24.152(15.474,37.698)	P<0.001
	Sex		
	Male (Ref.)		
	Female	0.716(0.450,1.140)	0.159
	Ethnicity		
	Han (Ref.)		
	Zhuang	0.680(0.352,1.311)	0.249
	Other ethnic minorities	0.322(0.095,1.096)	0.07
	Age		
	<60 years (Ref.)		
	≥60 years	0.498(0.299,0.832)	0.008
	Education level		
	Junior high school and below (Ref.)		
	High school and above	7.906(4.419,14.145)	P<0.001

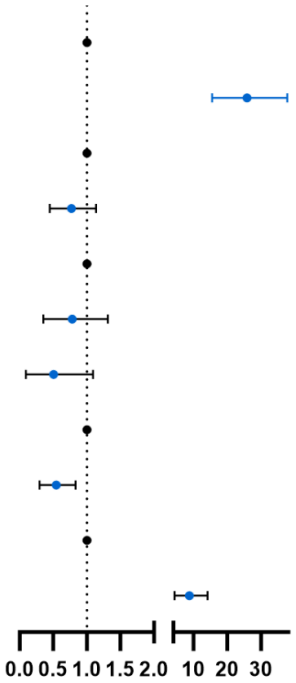


Figure 5

Forest plot showing adjusted odds ratios (ORs) and 95% confidence intervals (CIs) for factors associated with full HCV care cascade completion.

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