Patient Preference and Adherence

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ORIGINAL RESEARCH

Predictors of Medication Non-Adherence Among Hepatitis B Patients in South Sudan: A Health-Facility-Based Cross-Sectional Study

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Background: Despite the effectiveness of hepatitis B virus (HBV) antiviral treatment therapy in reducing the risk of liver-related complications, such as cirrhosis and hepatocellular carcinoma among chronically infected patients, medication non-adherence continues to hamper the successful management of the infection. The extent of HBV treatment adherence, associated facilitators, and barriers in South Sudan is not established. This study aimed to explore the predictors of medication non-adherence among HBV patients attending a public health facility in, South Sudan.

Methods: We conducted a facility-based cross-sectional study of 392 convenience-selected patients using a pretested interviewer-administered questionnaire premised on the information-motivation-behavioral skills (IMB) adherence model between December 2023 and March 2024. The relationship between medication non-adherence and antecedent variables was ascertained by logistic regression analysis.

Results: The sample was predominantly male (64.3%), and the mean age was 31.06 (30.19–31.93) years, with 28.1% reporting no formal education. The patients demonstrated inadequate HBV information (4.33±1.93), low motivation (8.20±2.69), and inadequate behavioral skills toward medication adherence (8.45±2.99), as measured on their respective rating scales. Further, more than two-thirds of the patients (70.2%) were HBV medication non-adherent. Younger age (AOR = 4.74, 95% CI = 2.13–10.56), being currently unmarried (AOR = 3.25, 95% CI = 1.76–6.01), unemployment (AOR = 4.19, 95% CI = 1.84–9.56), and increased behavioral skills (AOR = 1.12, 95% CI = 1.84–9.56) significantly influenced medication non-adherence. Lower education (AOR = 0.21, 95% CI = 0.10–0.46) and information adequacy (AOR = 0.63, 95% CI = 0.53–0.75) were associated with lower odds of non-adherence.

Conclusion: The study highlights key factors influencing the concerning rate of medication non-adherence among HBV patients in South Sudan. While these identified factors may explain the lingering burden of HBV-related complications, targeted interventions addressing demographic, socioeconomic barriers, and HBV-specific education are essential to enhance adherence and improve health outcomes.

Keywords: hepatitis B, treatment therapy, medication non-adherence, information adequacy, behavioral skills, South Sudan

Background

Hepatitis B virus (HBV) infection remains a significant global public health challenge, contributing to high rates of mortality and morbidity.[1,2] The World Health Organization (WHO) estimated that approximately 296 million individuals worldwide harbor chronic HBV infection, and around 1.1 million deaths were attributed to HBV infection in 2022, primarily from hepatic cirrhosis and liver carcinoma.[3] The high burden and chronicity of HBV infection in developing countries, especially sub-Saharan Africa (SSA), which stands at 65 million cases, is second only to the WHO Western Pacific Region, with relatively 100 million individuals chronically infected.[4–7] The Global Burden of Disease (GBD) acknowledged that, while there has been a significant decrease in the overall burden of other infectious diseases, HBV continues to pose an increasing burden in

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terms of years of life lost, measured as disability-adjusted life years (DALYs).[8] HBV-specific mortality is similar to deaths caused by tuberculosis but is significantly higher than deaths due to malaria or HIV.[9]

HBV infection is highly endemic in South Sudan, and the country harbors one of the highest burdens of HBV infection in the continent. The average national prevalence is estimated to be 22%,[5] contributing to a lifetime risk of HBV infection exposure for the majority of the population. HBV infection remains a public health threat in South Sudan largely due to over two decades of war, which have caused significant internal and external displacement of the South Sudanese population, increasing their vulnerability to HBV infection.[10] Hitherto, HBV infection accounts for over 80% of all viral hepatitis prevalence reported in the country.[11]

The biggest health threats posed by HBV infection are associated with its chronicity, and include cirrhosis, liver failure, and hepatocellular carcinoma.[12,13] WHO launched a global strategy in 2016 to end HBV as a public health threat by 2030, focusing on treating 80% of treatment-eligible individuals with chronic HBV world-wide.[7] Often required for an indefinite duration, antiviral treatment effectively prevents, delays, and reverses HBV progression to liver damage, thereby improving disease management and survival outcomes.[14] Adherence to antiviral therapy is imperative for successful management of chronic HBV, yet various psychosocial, environmental, and health system factors contribute to non-adherence.[15–17] Poor adherence among HBV infected individuals increases the risk of virological failure and accelerates HBV progression to cirrhosis and liver carcinoma.[16,18] Furthermore, reports from previous empirical studies have demonstrated that accurate HBV information, personal and social motivation, as well as adequate skills and self-efficacy, predict prevention behaviors and HBV medication adherence among vulnerable populations such as pregnant individuals and HBV patients.[19,20]

Despite the high burden of chronic HBV infection among the general population in South Sudan, there is a paucity of data on the extent of HBV treatment adherence and its associated factors among patients. Similar to other adherence studies, this burden may be explained by low treatment adherence and lack of availability of treatment in the public sector.[18,19,21] This knowledge gap in HBV research could hinder efforts to control HBV infection in South Sudan. Therefore, this study aimed to identify the predictors of antiviral treatment non-adherence among HBV patients in a public health facility in South Sudan in order to inform appropriate HBV control policies, ultimately achieving better adherence to HBV treatment regimens and reducing the risk of HBV-related complications in South Sudan.

Materials and Methods

Study Design

The study employed a hospital-based cross-sectional research design that collected quantitative data on the predictors of antiviral treatment non-adherence among hepatitis B patients. Health facilities are appropriate settings to capture pertinent HBV-related data, such as treatment adherence and the predictors in the infection dynamics, given that our sample was comprised of HBV outpatients. The information-motivation-behavioral skills (IMB) model, previously used to explain the psychological determinants and preventive behaviors of HIV,[22] HBV,[23] and health behaviors in sub-Saharan Africa,[20,24,25] informed our study design. The IMB model asserts that patients' health behavior is predicted by three major inseparable components: pertinent, high-quality, and accurate health-related information; motivation (either social or personal) for performing a health-promoting behavior; as well as adequate and relevant skills and self-efficacy for performing the health behavior.[22,26] We adopted the IMB model in this study to better understand the dynamics of treatment adherence and persistence among HBV patients. Figure 1 presents the conceptual framework derived from the IMB model to guide the study.

Setting

The study was conducted in a large public health institution in Central Equatoria State, South Sudan. Given the limited number of functional primary health centers in the country, this facility is one of the few offering specialized medical services and serves a large number of patients from various regions, particularly for primary care, obstetrics, emergency care, vaccinations, and the management of chronic infectious diseases such as HIV/AIDS and HBV.[27,28] The justification

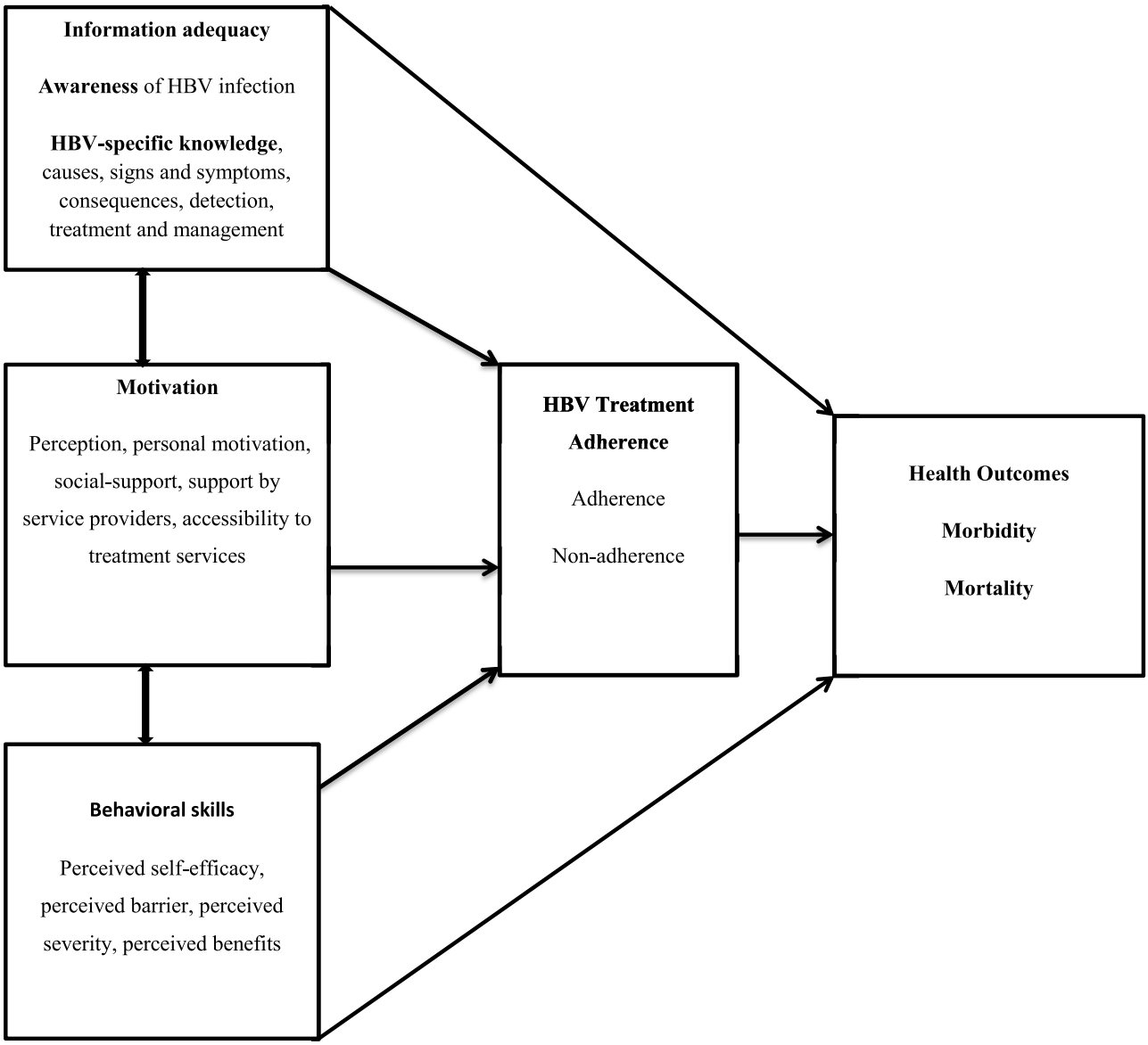

Figure 1 Conceptual Framework derived from IMB model for the diagnosis of health outcomes related to HBV infection via medication adherence.

for choosing this high-capacity facility is the anticipation that the findings from this study will inform HBV control policies to support the achievement of global HBV elimination targets.

Study Population and Inclusion Criteria

The study included hepatitis B patients (with persistent hepatitis B surface antigen test (HBsAg) positivity for more than 6 months) registered for treatment at the selected health facility, who were at least 18 years of age, and were able to give a written and oral informed consent to participate in the study procedures. Patients who were pregnant or severely indisposed (eg, with liver cancer, cirrhosis, or co-infections) and unable to complete the study procedures were excluded.

We employed the Kish Leslie formula for cross-sectional studies[29] to estimate a minimum sample size of 384 based on a 50% prevalence of treatment adherence reported from the pilot of the study instrument, a 95% confidence level, a precision level of 5%, and a 5% maximum acceptable error. After taking attrition into consideration, a total sample of 392 patients were recruited using convenience sampling until the desired sample size was met.

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Instrument and Data Collection Procedure

The study employed a pretested, five-sectioned, interviewer-administered questionnaire to obtain data on the study variables, including socio-demographic attributes, IMB constructs, and adherence to the HBV treatment regimen among the study participants from December 2023 through March 2024. The validity of the instrument was ensured by designing the variables based on the theoretical diagnostic framework operationalized in the IMB adherence model. The IMB constructs were adapted from previous empirical studies that applied the IMB model in the context of HBV.[20,25] The validity and relevance of the items were further established through feedback and suggestions from local experts in HBV research. Furthermore, we conducted a pilot test of the instrument for internal consistency using 10 patients from another hospital (20 km from the study setting), after which the patients were followed up for a retest of the instrument for reliability. The statistical analysis of the pilot test revealed a Cronbach alpha (α) score of 0.73 for the internal consistency of the instrument. (Please see supplementary file 1 for the instrument).

Prior to the collection of the study-related data, two research assistants who have completed training courses on ethics in human subject research and with strong understanding of English and Arabic Languages were recruited for data collection from the health facility. The research assistants, a male and a female, underwent a three-day training on the study procedures, including the study objectives, inclusion and exclusion criteria, and the expected outcomes. Upon completion of the training, the research assistants administered the questionnaires to eligible patients, introduced the objectives, and obtained their oral and written informed consent. They also assisted the respondents, using their preferred languages, in better explaining any items in the questionnaires that were difficult for them to easily comprehend. Thus, we reported a 100% participation rate.

Variables and Measurements

The independent variables measured in our study included socio-demographic characteristics such as age, gender, educational attainment, marital status, religion, occupation status, year of HBV detection, and medication duration. Respondents' age was operationalized as a continuous variable and subsequently categorized into three groups: 18–28 years, 29–39 years, and 40 years and above. Gender was measured using a binary response (male and female). Educational attainment was measured categorically and dichotomized into 'low education' (secondary education or below, ie, secondary, primary, or no formal education) and 'high education' (above secondary education, ie, post-secondary, vocational, or university education). Marital status was also measured categorically and dichotomized into 'single/currently unmarried' (including separated, divorced, widowed, or never married) and 'married' (currently married). Religion was measured as a categorical variable and transformed dichotomously into 'Islam/Others' and "Christianity." Employment status was dichotomized into 'employed' (including those with current jobs or self-employed) and 'unemployed' (those without current employment). The year of HBV diagnosis and the duration of current HBV medication were both measured as categorical variables and dichotomized into '≤ 1 year' or "> 1 year", and '≤ 2 years' or "> 2 years", respectively.

As described, the IMB model framed our survey instrument. IMB predictor variables measured included information-adequacy related to the knowledge of HBV infection, operationalized as the patients' awareness of HBV severity and their comprehension of the characteristics of HBV infection, such as its cause, transmission, complications, and treatment strategies. Information-adequacy was measured dichotomously on a 10-point reference scale using "Yes or No" responses; every correct answer was scored "1", and incorrect answers were scored "0." Motivation towards HBV treatment adherence was measured with a 7-item question series, each scored on a 4-point Likert scale response ("strongly agree", "agree", "disagree", and "strongly disagree"), with 21 points as the highest total score possible. Furthermore, we measured behavioral skills towards treatment adherence, defined operationally as the confidence and self-responsibility of patients to adhere to prescribed treatment regimens, with 6 questions on a 4-point Likert scale involving "very high", "high", "low", and "very low", for a maximum score of 18 points. The scores for each Likert scale range were scored from 0 to 3, indicating the lowest to the highest score, respectively.

The dependent variable assessed was the self-reported adherence to HBV treatment, measured by one question: "I take my HBV medications as prescribed by my doctor" on a 4-point Likert scale with responses of "not at all", "rarely", "occasionally", and "very often." The variable was further dichotomized to "high/complete adherence to medications" (if respondents

take their medications very often as prescribed) and "non-adherence" (if respondents do not take their medications at all or rarely/occasionally take their medications). Hence, non-adherence was coded "1", while high/complete adherence was coded "0."

Data Analyses

The quantitative data collected were entered into, processed, and analyzed using SPSS version 26 software (IBM Corp., Armonk, N.Y., USA). Categorical study variables were presented as frequencies and percentages. IMB predictor variables were further transformed into weighted aggregate scores to generate descriptive statistics such as mean, standard deviation, and 95% confidence interval (CI). We employed Pearson correlation to assess the linear relationship between the IMB predictors and conducted an independent sample *t*-test to evaluate the variability of the IMB variable scores across treatment adherence variables while using chi-squared tests to reveal the differences in the level of adherence across the socio-demographic variables.

Furthermore, to establish the predictors of medication non-adherence among the respondents, we used binary logistic regression analysis. Specifically, bivariate logistic regression was employed to obtain the crude odds ratio (COR) for each predictor variable. Based on the employed behavioral-change adherence model and evidence from previous studies,[17,25,30] all variables were included in the final binary multivariable logistic regression model to ascertain the significant independent predictors of treatment non-adherence, and the adjusted odds ratio (AOR) for the analysis was reported. While the categories of other predictor variables were used in the binary logistic regression analysis, composite variables generated for the IMB model constructs (ie, weighted aggregate scores) were used directly in the analysis. The level of statistical significance for all tests was set at $p \leq 0.05$.

Ethics

Ethical clearance was obtained from the Research Ethics Committee under the Ministry of Health of South Sudan (Reference Number REC/2023/12), following a thorough review of the study proposal and acknowledgment of the importance of filling the knowledge gaps in the prevention and control of HBV infection. We conducted the study in accordance with the Declaration of Helsinki and obtained written and oral informed consent from all participants before the data collection.

Results

Patients' Characteristics

The findings from this study showed that less than half of the study participants (44.9%) were aged between 18 and 28 years. A notable proportion of the respondents (28.1%) had non-formal education. Almost two-thirds of the patients (64.3%) were male, 85.7% were Catholic, and 42.1% were single. Almost half of the patients (45.2%) were self-employed. In terms of the onset of clinical identification of HBV infection, 43.1% of the patients were detected positive for HBV between one and two years prior to the study, and 46.2% reported that the duration of their current antiviral treatment regimen lies between one and two years (see Table 1).

Information Adequacy Related to Knowledge of HBV Infection

More than half of the sample (54.8%) had heard of HBV characterized as a "silent killer". Despite this awareness, approximately 60.2% of the respondents failed to know the risk factors of HBV infection by wrongly affirming that taking too much sugar predisposes an individual to the risk of HBV infection. Similarly, the majority of the respondents (97.3%) did not know HBV infection is acquired through contact with infected body fluids. Regarding the knowledge of the asymptomatic nature of HBV infection, 81.6% of the patients incorrectly stated that people always know about their HBV status without screening or testing.

Related to disease-specific knowledge, about two-thirds of the respondents, (64.3%), did not know that people would feel sick if infected with HBV. Further, a little over half of the patients (51.3%) were adequately informed that there are clinical tests to detect the magnitude of the virus in the blood beyond the first-time hepatitis B surface antigen test

Table 1 Frequency Distributions of Socio-Demographic Characteristics

Variables	Frequency (n)	Percentage (%)
Age (years):		
18–28	176	44.9
29–39	167	42.6
≥40	49	12.5
Gender:		
Male	252	64.3
Female	140	35.7
Educational attainment:		
No formal	110	28.1
Primary	81	20.7
Secondary	104	26.5
Post-secondary	53	13.5
University	44	11.2
Marital status:		
Single	165	42.1
Married	93	23.7
Divorced/Separated/Widowed	134	34.2
Religion:		
Catholic	336	85.7
Protestant	26	6.6
Islam	19	4.8
Others[a]	11	2.8
Occupation:		
Civil Servant	12	3.1
Self-Employed	177	45.2
Trader	108	27.6
Housewife	18	4.6
Teacher	7	1.8
Unemployed	70	17.9
When detected positive for HBV (years):		
<1	155	39.5
1–2	169	43.1
3–4	66	16.8
≥5	2	0.5
Duration of Antiviral Regimen (years):		
<1	36	9.2
1–2	181	46.2
>2	175	44.6

Note: [a]indicates no specified religious affiliation.

(HBsAg). Regarding the potential consequences of untreated HBV infection, 60.6% of the patients attested that untreated hepatitis B virus can destroy the liver, and a similar proportion of the respondents (62.5%) knew that oral antiviral treatments are effective in suppressing HBV infection. More than half (54.8%) incorrectly claimed that chronically infected HBV patients do not require treatment, and about 60% of the sample were unaware that regular monitoring and treatment can reduce damage caused by chronic HBV infection (see Table 2).

Motivation Towards HBV Antiviral Treatment Adherence

The findings on the respondents' motivation towards HBV treatment adherence revealed that more than half of the patients (56.1%) strongly agreed that they believe their current health condition is not very good. In terms of personal motivation, about 46% strongly believed that liver damage cannot be avoided even if they use their medication regularly.

Table 2 Findings on Information Adequacy Related to the Knowledge of HBV

Statements for Consideration	Frequency (n)	Percentage (%)
Have you ever heard of hepatitis B virus infection as a silent killer:		
Yes	215	54.8
No	177	45.2
Taking too much sugar predisposes one to the risk of HBV infection:		
Yes	236	60.2
No	156	39.8
HBV infection is not acquired through contact with infected body fluids:		
Yes	381	97.2
No	11	2.8
People always know that they have HBV infection without testing:		
Yes	320	81.6
No	72	18.4
People will not feel sick if they are infected with HBV:		
Yes	252	64.3
No	140	35.7
There are no further tests to detect the magnitude of the virus in the blood:		
Yes	191	48.7
No	201	51.3
Untreated HBV infection can destroy the liver:		
Yes	316	80.6
No	76	19.4
Use of oral antiviral treatments is effective in suppressing HBV infection:		
Yes	245	62.5
No	147	37.5
Chronically infected HBV patients do not require treatment:		
Yes	215	54.8
No	177	45.2
Regular monitoring and treatment can reduce liver damage caused by chronic HBV:		
Yes	163	41.6
No	229	58.4

Similarly, 43.9% strongly agreed that they are always frustrated with the use of their medications because the medications remind them that they are HBV-positive. Furthermore, almost 60% of the patients strongly affirmed that the duration of antiviral treatment use hinders their regular use of their medications, and three-fifths of the respondents (60.2%) agreed that reminders from family members encourage them to use their medications. Regarding social support from the health facility towards treatment adherence, about a third of the participants (30.1%) affirmed that they receive enough support from their healthcare providers in taking their treatment regimens as prescribed. On the availability of the prescribed treatment services, more than one-third of the study respondents (34.7%) disagreed that it is difficult to get the prescribed antiviral treatment for their HBV condition from the hospital (see Table 3).

Behavioral Skills Toward HBV Treatment Adherence

The findings regarding the respondents' behavioral skills toward HBV treatment adherence revealed that slightly more than half of the respondents (52.8%) reported very low confidence in their ability to use their medications regularly if it is difficult for them to afford. Further, 42.6% of the patients were highly confident that they would not forget their

Table 3 Motivation Towards HBV Antiviral Treatment Adherence

Statements for Consideration	Strongly Agree		Agree		Disagree		Strongly Disagree	
	n	%	n	%	n	%	n	%
I believe that my current health condition is not very good	220	56.1	97	24.7	0	0	75	19.1
I believe that liver damage cannot be avoided even I use my medication regularly	16	4.1	180	45.9	185	47.2	11	2.8
I am always frustrated to take my HBV medications because they remind me that I am HBV-positive	172	43.9	37	9.4	167	42.6	16	4.1
The required duration of the antiviral treatment use will stop me from regular use of the medications	228	58.2	135	34.4	18	4.6	11	2.8
Remainders from family members will encourage me to use my medications	29	7.4	236	60.2	28	7.1	99	25.3
I did not receive enough support from my healthcare provider in taking my treatment regimen as prescribed	102	26.0	96	24.5	118	30.1	76	19.4
It is difficult to get the prescribed antiviral treatment for my HBV condition from this hospital	106	27.0	91	23.2	136	34.7	59	15.1

medication use, even if they had to set a periodic reminder. The fear that others will know of the patients' HBV status constitutes one of the perceived treatment adherence barriers as reported by slightly more than three-quarters of the respondents (76.8%). Less than half of the sample (42.1%) reported that they were very confident that they do not need antiviral treatment regimens if they do not experience liver-complication-related symptoms. In terms of perceived severity, approximately 40% of the participants are confident that HBV infection could endanger their lives and deteriorate their financial status. Additionally, only 40.8% of the patients affirmed to be highly confident that if they used their medications regularly, their risk of developing liver cancer in the future would reduce (see Table 4).

Level of Information Motivation Behavioral Skills (IMB) Predictor Variables

Following the transformation of the IMB predictors into weighted aggregate scores in line with the employed theoretical model, it was observed that the respondents obtained a mean score of 4.33 (95% CI = 4.13±4.52) and a prevalence of 54.1%

Table 4 Behavioral Skills Toward HBV Treatment Adherence

Statements for Consideration	Very High		High		Low		Very Low	
	n	%	n	%	n	%	n	%
I am confident in getting and using my HBV medications regularly even if it is difficult to afford	76	19.4	101	25.8	8	2.0	207	52.8
I am confident that I will not forget my medication use even if I have to set a periodic reminder	76	19.4	167	42.6	102	26.0	47	12.0
I am not confident about using my medications because I do not want others to know about my condition	34	8.7	301	76.8	57	14.5	0	0.0
I am confident that I do not need antiviral treatment regimens if I do not experience liver complication related symptoms	165	42.1	127	32.4	15	3.8	85	21.7
I am confident that HBV infection cannot endanger my life and deteriorates my financial status	61	15.6	86	21.9	157	40.1	88	22.4
I am confident that if I use my medications regularly, I will have low risk of developing liver cancer in the future	103	26.3	160	40.8	90	23.0	39	9.9

Table 5 IMB Predictor Variable Scores Across Study Sample

Variables	Score on Reference Scale	Mean ($\bar{X}$) ±SD	Percentage (%)	95% Confidence Interval	r		p-value
					IMB		
Level of Information Adequacy[a]	8	4.33 ± 1.93	54.1	4.13 ± 4.52	0.370	0.472	<0.001**
Level of Motivation[b]	18	8.20 ± 2.69	45.6	7.93 ± 8.47	0.370	0.170	<0.001**
Level of Behavioral Skills[c]	17	8.45 ± 2.99	49.7	8.15 ±8.75	0.472	0.170	<0.001**

Notes: [abc]Indicates that each reference variable is tested against the other two IMB constructs with "r" reported in ascending order, r =correlation coefficient, $\bar{X}$= mean, SD= standard deviation, **p-value significant at <0.001 for the correlation between all the IMB predictors.

for information adequacy related to the knowledge of HBV infection. In addition, a mean score of 8.20 (95% CI = 7.93±8.47) and a percentage mean score of 45.6% were obtained for motivation towards HBV treatment adherence. In terms of the behavioral skills towards HBV treatment adherence, the mean score demonstrated by the respondents was 8.45 (95% CI = 8.15 ±8.75), which constitutes 49.7% of the total behavioral skills expected of the respondents. Likewise, from the correlation analysis of the linear relationship between information adequacy, motivation, and behavioral skills scores among the respondents, we observed significant linear relationships between all the IMB variables (p <0.001). Table 5 presents details of the summaries of descriptive statistics computed for the participants to assess the levels of the IMB predictors and their relationships. (See Figure 2 also).

HBV Antiviral Treatment Adherence Among the Study Participants

Our findings revealed that approximately 70% of respondents do not adhere to their HBV medication protocols. Testing the levels of information adequacy, motivation, and behavioral skills against treatment adherence consistently showed poor scores for information adequacy ($\bar{X}$ = 3.95, SD = 1.69), motivation ($\bar{X}$ = 8.03, SD = 2.77), and behavioral skills ($\bar{X}$ = 8.40, SD = 3.17) among non-adherent HBV patients. The mean scores for the IMB constructs across treatment adherence are detailed in Table 6 and Figure 3.

Predictors of HBV Antiviral Treatment Non-Adherence Among the Study Participants

Among the study participants, age, educational attainment, marital status, and employment status were identified as the socio-demographic factors independently associated with treatment non-adherence. Patients aged 18–28 years

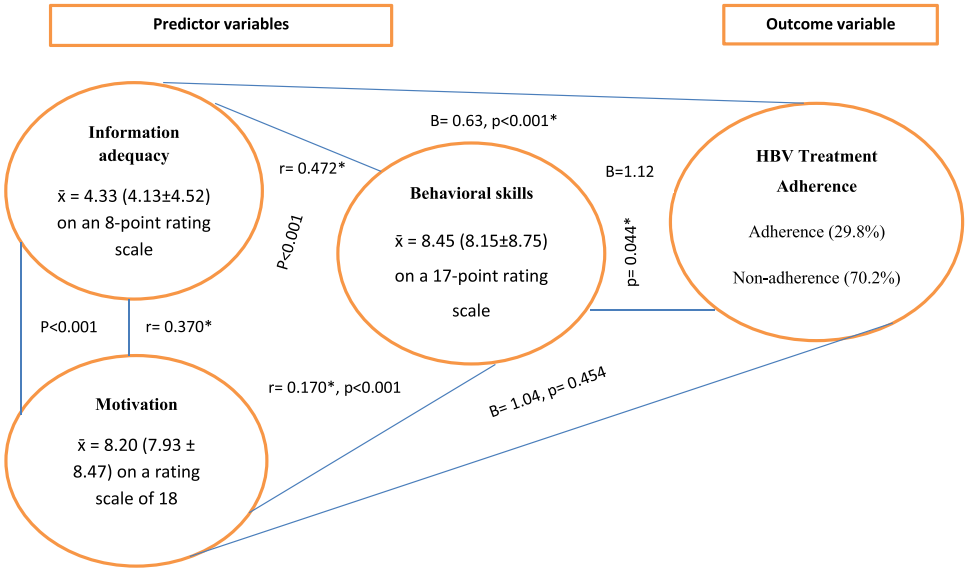

Figure 2 Relationship between IMB predictor variables and - medication non-adherence. Note: *p≤0.05; significant relationships in the connections between the variables, as determined by linear correlation and logistic regression analyses.

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Table 6 IMB Predictor Variable Scores According to HBV Antiviral Treatment Adherence

Treatment Adherence	Frequency (n)	Percentage (%)	Mean (±SD) on Information Adequacy	Mean (±SD) on Motivation	Mean (±SD) on Behavioral Skills
Adherence	117	29.8	5.21 (2.16)	8.62 (2.46)	8.56 (2.53)
Non-Adherence	275	70.2	3.95 (1.69)	8.03 (2.77)	8.40 (3.17)

Abbreviation: SD, standard deviation.

(AOR = 4.74, 95% CI = 2.13–10.56) and 29–39 years (AOR = 4.70, 95% CI = 2.13–10.39) were 4.7 times more likely to be non-adherent compared to those aged 40 and above. In terms of educational attainment, lower education was significantly associated with lower odds of medication non-adherence. Respondents with lower education (secondary and below) were 79% less likely to be non-adherent to HBV medication compared to highly educated patients (those with above secondary education) (AOR = 0.21, 95% CI = 0.97–0.46). Single/currently unmarried patients were approximately 3.3 times more likely to be non-adherent compared to married respondents (AOR = 3.25, 95% CI = 1.76–6.01), and the odds of medication non-adherence among unemployed respondents were approximately 4.2 times higher compared to employed patients (AOR = 4.19, 95% CI = 1.84–9.56). There was no significant association observed between medication non-adherence and gender, religion, year of HBV detection, or medication duration ($p > 0.05$).

Results of the multivariable logistic model demonstrate that information adequacy was significantly associated with medication non-adherence among the patients. Specifically, increasing levels of information adequacy are associated with lower odds of medication non-adherence. (AOR = 0.63, 95% CI = 0.53–0.75). Although motivation was negatively associated with non-adherence in the bivariate analysis, it was not significantly associated with medication non-adherence in the final model ($p > 0.05$). Interestingly, behavioral skills (AOR = 1.12, 95% CI = 1.84–9.56) were positively associated with treatment non-adherence after a non-significant negative association at the bivariate level. Table 7 details the predictors of medication non-adherence among the study participants.

Discussion

According to the WHO Africa 2020 report on Hepatitis B virus infection, South Sudan launched the first ever concertedly endorsed National Strategic Plan on Viral Hepatitis, along with Treatment and Care Guidelines for Hepatitis, in an attempt to

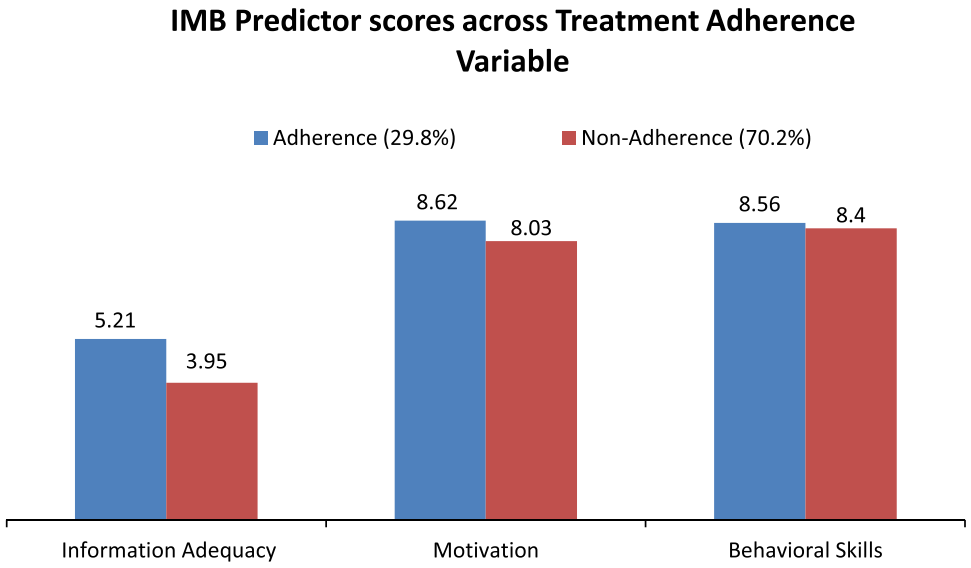

Figure 3 Level of medication adherence and IMB predictor scores among adherent and non-adherent patients.

Table 7 Variables Associated with HBV Antiviral Treatment Non-Adherence

Variables	Treatment Adherence		Crude Odds Ratio (95% CI)	p-value	AOR (95% CI)	p-value
	Adherence n (%)	Non- Adherence n (%)				
Patients' Age (in years)						
18–28	47 (40.2)	129 (46.9)	3.37 (1.75–6.48)	<0.001**	4.74 (2.13–10.56)	<0.001**
29-39	43 (36.8)	124 (45.1)	3.54 (1.83–6.86)	<0.001**	4.70 (2.13–10.39)	<0.001**
≥40	27 (23.1)	22 (8.0)	1		1	
Gender						
Male	69 (59.0)	183 (66.5)	1.38 (0.89–2.16)	0.153	1.22 (0.71–2.10)	0.479
Female	48 (41.0)	92 (33.5)	1		1	
Level of Education						
Low	106 (90.6)	189 (68.7)	0.23 (0.12–0.45)	<0.001**	0.21 (0.97–0.46)	<0.001**
High	11 (9.4)	86 (31.3)	1		1	
Marital status						
Single/unmarried	79 (67.5)	220 (80.0)	1.92 (1.18–3.13)	0.008*	3.25 (1.76–6.01)	<0.001**
Married	38 (32.5)	55 (20.0)	1		1	
Religion						
Islam/Others	8 (6.8)	22 (8.0)	1.19 (0.51–2.74)	0.692	1.01 (0.39–2.62)	0.982
Christianity	109 (93.2)	253 (92.0)	1		1	
Employment status						
Unemployed	14 (12.0)	56 (20.4)	1.88 (1.00–3.54)	0.050*	4.19 (1.84–9.56)	0.001*
Employed	103 (88.0)	219 (79.6)	1		1	
Year detected positive for HBV						
≤1 Year	43 (36.8)	112 (40.7)	1.18 (0.76–1.85)	0.462	0.85 (0.44–1.64)	0.633
>1 Year	74 (63.2)	163 (59.3)	1		1	
Duration of Current Medication						
≤2 Years	57 (48.7)	160 (58.2)	1.47 (0.95–2.26)	0.085	1.35 (0.72–2.56)	0.350
>2 Years	60 (51.3)	115 (41.8)	1		1	
IMB constructs						
Information-Adequacy			0.70 (0.62–0.79)	<0.001**	0.63 (0.53–0.75)	<0.001**
Motivation			0.92 (0.85–1.00)	0.048*	1.04 (0.94–1.14)	0.454
Behavioral skills			0.98 (0.91–1.06)	0.645	1.12 (1.00–1.24)	0.044*

Notes: *p-value significant at the level of ≤ 0.05; **p-value= 0.000 significant at <0.001.
Abbreviations: AOR, Adjusted Odds Ratio; 95% CI, 95% confidence interval.

halt HBV infection transmission while ensuring access to safe, affordable, and effective prevention, care and treatment services aimed at eliminating viral hepatitis.[11] Despite this concerted effort, HBV infection remains a significant public health challenge in the country with limited or no updated data on its epidemiological burden and the extent of prevention and treatment services uptake.[5,10] Consequently, our current study captured pertinent treatment adherence-related data from 392 conveniently selected HBV patients visiting a public health facility in South Sudan.

We observed that more than two-thirds of the patients were medication non-adherent. On the one hand, non-adherence was positively associated with younger age, being unmarried, unemployment, and behavioral skills; on the other hand, it was negatively associated with lower education and information adequacy. The poor level of adherence reported in this study is consistent with findings from previous studies in HBV-endemic settings, such as the study conducted by Xu et al[31] and Suh et al[32] in Asia, and Sheppard-Law et al[33] in Australia. In contrast to our findings, several other studies have reported better levels of medication adherence among their study participants, such as those conducted in India, the United States, and Tanzania.[34–36] This discrepancy could be attributed to the relative lower priority given to HBV infection by policy makers in sub-Saharan Africa compared to other chronic infectious diseases like HIV. Unlike HIV, which has benefited from high awareness campaigns and large-scale support programs for antiviral medications, similar initiatives for HBV infection remain largely absent.[37,38] Therefore, the high rate of medication non-adherence among our study participants implies the need for strong political commitment and healthcare provider-led interventions tailored to ensure adherence to treatment among HBV patients in South Sudan and across other HBV-endemic settings in sub-Saharan Africa. Without doubt, this approach is imperative for the successful elimination of HBV as a global public health threat by 2030 in line with the WHO global health strategy.[7]

Our study revealed patients' age to be a significant independent factor influencing medication non-adherence. Younger respondents, ie, patients aged 18–28 years and 29–39 years, were 4.7 times more likely to be non-adherent compared to older respondents (ie, patients aged 40 and above). The reason for this association could be that older respondents are more motivated to take their medications or may receive increased support from their relatives on medication adherence. On the other hand, younger patients may perceive themselves as having a low risk of severe HBV-related complications or have an inadequate understanding of the long-term benefits of medication adherence, causing them not to prioritize adhering to their medication regimens. Our finding on age and medication non-adherence is supported by previous studies reporting decreased medication non-adherence behavior with increasing age.[15,17,30,33] Therefore, interventions to promote medication adherence should target younger patients for positive health outcomes related to HBV infection in this setting.

Surprisingly, patients with lower education were 79% less likely to be medication non-adherent compared to highly educated patients, implying that patients with lower education were more likely to adhere as compared to those with higher education. This finding contradicts reports from previously conducted studies, such as that of[30,39] respectively conducted in Jordan and China, which highlighted a better level of medication adherence with a higher level of education. Our finding suggests that while it is expected that patients with higher educational attainment would have a better understanding of the importance of medication adherence and the disease-specific knowledge, they may be less motivated to take their medication regularly. This could be due to the confidence that they can self-manage their health combined with preoccupation with other responsibilities, leading to forgetfulness or difficulties in prioritizing medication adherence compared to patients with lower educational attainment. Alternatively, it may be that patients with lower educational attainment are more closely monitored by healthcare staff or receive additional support, such as parental reminders about medication adherence, as a considerable number of patients with lower education in our study are younger and likely living with their parents. Hence, educational attainment alone may not directly influence medication adherence among HBV patients, with further study required to understand these findings.

Furthermore, we observed that unmarried or otherwise single patients were three-times more likely to be non-adherent compared to married patients. This finding is in agreement with previous studies of other chronic diseases that revealed that single patients were more likely to demonstrate poor medication adherence.[39,40] Better medication adherence among married patients may be attributed to spousal support of regular medication use. Efforts to promote medication adherence among HBV patients should therefore pay more attention to ensuring adequate social support for unmarried patients. This approach has been reported to improve medication adherence and patients' health outcomes in numerous studies.[41,42]

The patients' employment status was associated with medication non-adherence. Specifically, unemployed patients were four times more likely to be non-adherent compared to employed patients. This is consistent with previous studies which reported that employed patients, particularly those with demanding jobs, are more prone to medication non-adherence compared to nonworking patients.[43–45] Employment creates a structured daily routine which may foster

adherence to their medication regimens, whereas unemployed patients may struggle to remember medication dosing in the absence of such routine. Our findings may also be explained by financial constraints hindering the affordability of medications experienced by unemployed respondents, as reported by similar studies conducted in China and Ethiopia.[31,40] This has implications for HBV prevention and control policy to consider subsidization of antiviral treatments for patients to effectively tackle HBV-related complications in low-resource circumstances. We found no significant association between medication non-adherence and gender, religion, year of HBV detection, and or medication duration, suggesting that these factors may not influence patients' adherence behaviors in this study population.

In addition to the patient characteristics, medication non-adherence was significantly associated with information adequacy related to HBV knowledge, and behavior skills toward medication adherence. Our study revealed an unsatisfactory level of information related to HBV-specific knowledge among the patients. This inadequate HBV-specific and adherence knowledge is in line with the reports from studies conducted by Bhimla et al[35] among Chinese and Vietnamese people with HBV infection, and Mude et al,[46] among South Sudanese people from refugee backgrounds with chronic hepatitis B in Australia. It was further observed that medication non-adherence decreases with increasing HBV-specific knowledge, consistent with findings from previous studies that reported positive relationship between adequate disease-specific information and medication adherence.[39,47,48] Therefore, our findings support development of robust educational interventions geared towards improving HBV-specific knowledge among HBV patients and the general population for better medication adherence in South Sudan.

While motivation is an important psychological predictor of health-promoting behaviors, such as medication adherence,[26,31] our study found a low level of motivation towards medication adherence among HBV patients, with a prevalence of 45.6%. Notably, we found no significant association between motivation and medication non-adherence, suggesting that motivation may not be an independent psychological predictor of adherence in this population. Therefore, addressing other factors that could influence patients' motivation towards adherence would be necessary to promote medication adherence among HBV patients.

Respondents generally exhibited inadequate behavioral skills related to medication adherence, although strangely the odds of medication non-adherence were 1.1 times higher with increased behavioral skills. Contrary to our findings, many studies report a positive association between health-promoting behaviors, such as medication adherence, and behavioral skills or related constructs like self-efficacy.[20,48] This discrepancy with our findings may be explained by intermediate factors, as we founded behavioral skills to be significantly correlated with HBV-related information as well as motivation. Consequently, even when patients have confidence in their ability to take their medications as prescribed, they may not consistently adhere if their motivation is low. In fact, complex behavioral skills may sometimes not be required for the performance of health behavior when information and motivation directly influence behavior.[23] Hence, to promote sufficient adherence and improve HBV-specific information that shapes patients' motivation and behavioral skills positively, healthcare providers may benefit from focusing on clear communication about the purpose and benefits of HBV antiviral treatment, as well as emphasizing the importance of social support. Nonetheless, further research exploring the effectiveness of behavioral change interventions on HBV medication adherence would be relevant in South Sudan.

Strengths and Limitations

This current study revealed the predictors of HBV infection treatment adherence including the dynamics of the socio-demographic, motivations and behavioral change influences among a relatively large sample at risk of liver carcinoma and HBV-related mortality. Since the IMB model of adherence has not been applied to predict HBV treatment adherence in South Sudan, this study enhances our understanding of the interventions required to effectively reduce the burden of HBV infection, liver-related complications, and mortality in South Sudan and similar endemic settings in sub-Saharan Africa.

Our study has important limitations. First, our sample was limited to patients who visited a health facility for treatment services and may not be generalizable to the broader population of chronic hepatitis B patients in the country. Second, the sample was biased towards individuals who were actively engaged in health services, such that medication non-adherence is anticipated to be even more severe among marginalized HBV-positive individuals. Third, we did not assess the important role regimen types may play in non-adherence, with some medications associated with more significant or unpleasant side effects. Fourth, we based the medication adherence variable on a single-item retrospective self-report, which, while practical for this

setting, lacks the robustness of validated multi-item measures. This design is inherently subject to systematic non-disclosure and recall bias. However, due to the limited health literacy of many participants and the absence of adherence-related data in medical records, we opted for this simplified, culturally tailored approach. We ensured the item was pilot tested, and our well-trained research assistants employed effective probing techniques to mitigate potential biases in our results. Finally, our sample was skewed in terms of sex, given that men have great mobility to visit the hospital and city centre.[49] Recruitment of a greater number of female respondents may have yielded different predictors of HBV medication adherence. A large community-based study comprised of multi-healthcare centers combining the pill count method[21,50] with validated self-reported measures of assessing medication adherence, may need to be conducted to further identify the extent and dynamics of the predictors of HBV treatment adherence in this setting.

Conclusion

The current study revealed a high level of medication non-adherence among more than two-thirds of the patients. Non-adherence was positively associated with younger age, being currently unmarried, unemployment, and increased behavioral skills, and negatively associated with lower education and information adequacy. Given the critical importance of adherence in HBV management, we recommend targeted HBV-specific patient education based on these findings, along with policy interventions to subsidize antiviral treatments, to promote medication adherence and improve health outcomes among this vulnerable population. Further research is also needed to explore the broader factors associated with medication non-adherence in more diverse populations and how to address them.

Abbreviations

AIDS, Acquired Immunodeficiency Syndrome; AOR, Adjusted Odds Ratio; ANOVA, Analysis of Variance; COR, Crude Odds Ratio; GBD, Global Burden of Disease; DALYs, Daily-Adjusted Life Years; HBsAg, Hepatitis B Surface Antigen; HBV, Hepatitis B Virus; IMB, Information-Motivation-Behavioral Skills; SPSS, Statistical Package for Social sciences; WHO, World Health Organization.

Data Sharing Statement

The data spreadsheet used for analysis is available upon a reasonable request from the corresponding author.

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