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ORIGINAL ARTICLE

Immigration Factors and Monitoring of Chronic Hepatitis B Infection Among Foreign-Born: The FOCUS-HBV Multicentre Cohort

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Keywords: care cascade | immigrant health | social determinants of health | viral hepatitis

ABSTRACT

Background: Immigrants are the largest subgroup living with chronic hepatitis B (HBV) infection in the United States. It is not well understood how immigration and associated social and cultural factors impact adherence to HBV monitoring.

Methods: We conducted a multicentre multilingual survey among foreign-born adults with chronic HBV between 7/2021 and 4/2023. Participants were surveyed regarding (1) immigration factors, (2) acculturation and language preferences, (3) social determinants of health and (4) HBV-related clinical factors. The primary outcome was optimal adherence, defined as 100% of the time with at least annual testing of HBV DNA, ALT and ultrasound while under care. Logistic regression was used to examine survey factors associated with the outcome.

Results: Two hundred and seventy-four foreign-born patients with HBV (median 57 years, 57% male) from 32 birth countries were included. Thirteen per cent had immigrated within the past 10 years, and 62% were US citizens. Nearly all (92%) reported seeing a specialist for HBV, with 72% currently on treatment. 44% of participants had optimal adherence to monitoring over a median of 6 years (2–7) under care. Factors associated with more optimal adherence on multivariate testing included non-English survey language (OR 2.32, 95% CI 1.15–4.66), non-US citizens (OR 2.05, 95% CI 1.01–4.15) and higher education (college vs. high school or less: OR 2.39, 95% CI 1.09–5.24). Medicare insurance (vs. private) was associated with less optimal adherence (OR 0.42, 95% CI 0.19–0.94).

Conclusion: Adherence to long-term monitoring is suboptimal among a diverse cohort of immigrants with chronic HBV. More efforts to engage and retain immigrants in care are needed.

Abbreviations: ALT, alanine aminotransferase; DC, District of Columbia; FB, foreign-born; HBV, hepatitis B virus; HCC, hepatocellular carcinoma; LAC, Los Angeles County; SDOH, social determinants of health; VIA, Vancouver Index of Acculturation.

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1 | Introduction

Chronic hepatitis B virus (HBV) infection disproportionately affects foreign-born (FB) in the United States, particularly immigrants from Asia and sub-Saharan Africa, where seroprevalence rates may exceed 5% and perinatal/horizontal acquisition is dominant [1]. Estimated HBV seroprevalence among US FB is 3.9% in Asians, 1.9% in Blacks, 0.6% in Whites and 0.2% in Hispanics, approximating nearly 550,000 total affected individuals [2]. Continued immigration has kept FB prevalence constant over the past two decades, whereas rates among US-born individuals have declined [2]. Altogether, FB reflects the largest subgroup of Americans with HBV and yet has suboptimal awareness of infection [3]. Chronic HBV patients continue to have higher mortality compared to the general population despite highly effective therapies [4]. Delays in care may play a role for FB, with presentation at older ages and longer duration of disease resulting in more advanced disease and liver-related complications at diagnosis [5].

Current studies on HBV care delivery are largely retrospective and administrative, leading to a lack of granular and accurate data on country of birth, time of immigration, citizenship and degree of acculturation [6, 7]. These are important factors that may affect healthcare access and outcomes for foreign-born patients. There is a notable paucity in literature addressing the impact of both immigration-related and other social determinants of health (SDOH) on healthcare delivery for patients with HBV. The primary focus previously has been on awareness/screening, yet linkage to care after diagnosis and care retention are equally important [8, 9]. As chronic HBV is a lifelong diagnosis currently without a cure, longitudinal follow-up and monitoring are essential to determine disease trajectory, treatment indications and offer cancer surveillance. Limited access to language interpretation services, cultural stigma and lack of health insurance have been identified as potential barriers in the FB population, but it is unclear if such factors impact long-term care and outcomes [10].

To address these knowledge gaps, this multicenter survey study aimed to characterise immigration-related factors and SDOH among a diverse cohort of FB adults with chronic HBV infection. Furthermore, we examined rates of completion of guideline-based HBV care metrics and the association between immigration and SDOH with long-term disease monitoring.

2 | Materials and Methods

2.1 | The FOCUS-HBV Cohort and Study Setting

The Foreign-Born Care Cascade in US for Hepatitis B (FOCUS-HBV) cohort is a multicentre cross-sectional survey study of FB patients with chronic HBV. We recruited from primary and specialty clinics from July 2021 to April 2023 from two diverse immigrant populations: Los Angeles County (LAC; California) and the greater Washington DMV area (District of Columbia, Virginia, Maryland). These cities ranked 3rd and 20th in the world for the largest absolute number of immigrants. Recruitment occurred at the following sites: (1) Keck Medical Center at the University of Southern California (Keck USC); (2) Los Angeles General Medical Center (LAG); (3) MedStar Georgetown healthcare systems (GT) and (4) National Institutes of Health (NIH). Keck USC and GT are both tertiary care facilities with large transplant programs, while LAG is the largest safety net facility in LAC. GT provides additional ambulatory services to the DMV area.NIH subjects were recruited from the Liver Disease Branch outpatient hepatology clinic at the NIH Clinical Center. [Correction added on 12 May 2025 after first online publication: The previous sentence has been modified in this version.] Institutional review board approval was obtained from the corresponding regulatory body for each participating site.

2.2 | Recruitment and Survey Design

FB patients with HBV completed a survey that was linked to retrospective data on HBV management in the electronic medical record (EMR). Inclusion criteria included (1) self-reported birth outside of the United States, (2) adult (age > 18 years), (3) diagnosis of HBV with a positive hepatitis B surface antigen (HBsAg) test and (4) able to provide informed consent. Informed consent was obtained and the survey was administered by paper or an electronic tablet directly into REDCap. Translated surveys were available in Spanish, Traditional/Simplified Chinese and Vietnamese. If the preferred language was not available or the participant was illiterate, the survey was administered over the telephone with a certified translator or in-person with a language-concordant research coordinator if available. Participants received a gift card stipend.

The 43-item survey was pilot-tested on 10 participants. The final version (see Supplemental Survey) had four major components: (1) immigration factors, (2) acculturation, (3) self-reported healthcare utilisation and history of HBV management, and (3) demographics and social determinants of health. For immigration, we captured birthplace, duration in the United States, citizenship and primary language. We measured acculturation using the Vancouver Index of Acculturation (VIA) [11]. VIA is a validated bi-dimensional instrument that assesses orientations of an individual towards heritage (i.e., native country) and mainstream (i.e., host country) cultural domains using their values, social relationships and preferred cultural norms. VIA has been shown to have good reliability and validity among different cultural groups [12]. The instrument asks participants on a Likert scale how strongly they agree or disagree with 20 statements, with one item referring to the heritage culture and a mirror item referring to the mainstream culture. High scores towards mainstream indicate greater acculturation, while high scores towards heritage indicate lower acculturation. For HBV, the survey assessed disease awareness, access to subspecialty care, treatment history, frequency of monitoring and any liver-related complications. Lastly, participants answered demographic information and SDOH including highest education, employment, annual household income and insurance.

2.3 | Data Collection and Outcome Ascertainment

We collected clinical, laboratory and outcomes data on survey participants from EMR, including provider type, family

TABLE 1 | Survey results of FOCUS-HBV participants ($n = 274$).

Demographics and social determinants of health	
Age, *years*	57 (48–65)
Female sex	119 (43.3%)
Married or domestic partnership	181 (66.1%)
Race/Ethnicity	
Hispanic	16 (5.8%)
Asian	235 (85.8%)
Other	15 (5.5%)
Missing/Prefer not to answer	8 (2.9%)
Education	
High school or less	66 (23.0%)
Some or completed college	134 (48.9%)
Graduate degree	58 (21.2%)
Prefer not to answer/missing	19 (6.9%)
Employment status	
Employed	149 (54.4%)
Retired	51 (18.6%)
Unemployed	26 (9.5%)
Homemaker	11 (4.0%)
Other	11 (4.0%)
Disabled	6 (2.2%)
Prefer not to answer/missing	20 (7.3%)
Number of people in household	3 (2–4)
Annual Household Income	
Less than $25,000	43 (15.7%)
$25,000–$100,000	62 (22.6%)
More than $100,000	69 (25.2%)
Prefer not to answer/missing	100 (36.5%)
Insurance	
Private	109 (39.8%)
Medicare	67 (24.5%)
Medicaid	54 (19.7%)
Other	38 (13.9%)
Prefer not to answer/missing	6 (2.2%)
Immigration and Acculturation	
Duration in United States, *years*	30 (17–41)
Recent immigrant (less than 10 years in US)	36 (13.1%)
Citizenship status	
Citizen	170 (62.0%)
Permanent resident	50 (18.3%)
Temporary resident	17 (6.2%)
None of the above	11 (4.0%)
Prefer not to answer/missing	26 (9.5%)
Frequency of home country visits	
Within last 5 years	106 (38.7%)
More than 5 years ago	77 (28.1%)
Never returned	67 (25.5%)
Prefer not to answer/missing	24 (8.8%)
Preferred Language	
Only or more native	161 (58.8%)
Equal native or English	55 (20.1%)
More or only English	55 (20.1%)
Prefer not to answer/missing	3 (1.1%)
Non-English survey	66 (24.1%)
Acculturation (mean)	
Heritage score	6.7 (±1.7)
Mainstream score	6.3 (±1.7)

Note: Continuous data presented as median (interquartile range) or mean (±standard deviation). Categorical data presented as number and proportions.

history of hepatocellular carcinoma (HCC), treatment history and diagnosis of cirrhosis and/or HCC. Both current (within the past year) and historical monitoring of alanine aminotransferase (ALT), HBV DNA, imaging and alpha-fetoprotein were abstracted.

Adherence to monitoring was defined by at least annual testing of HBV DNA, ALT and ultrasound (or other imaging) for HCC surveillance. Ultrasound was included if the participant met AASLD guideline criteria of Asian or African male over the age of 40, Asian female over the age of 50 and/or history of cirrhosis [13]. Optimal adherence to monitoring was defined as 100% (number of years with at least annual testing divided by the total number of years under care) obtained among those who were not surveyed at their initial visit for chronic HBV.

2.4 | Statistical Analysis

Descriptive statistics were used to describe survey and clinical characteristics of the FOCUS-HBV cohort overall. Comparison testing of characteristics between those with and without optimal adherence was performed using Pearson's chi-square, Wilcoxon rank-sum testing and t-test when appropriate. Logistic regression models were used to examine the association between immigration, acculturation, social determinants and clinical factors with the primary outcome. Univariate predictors of outcome significant at $p < 0.10$ were included in a multivariable

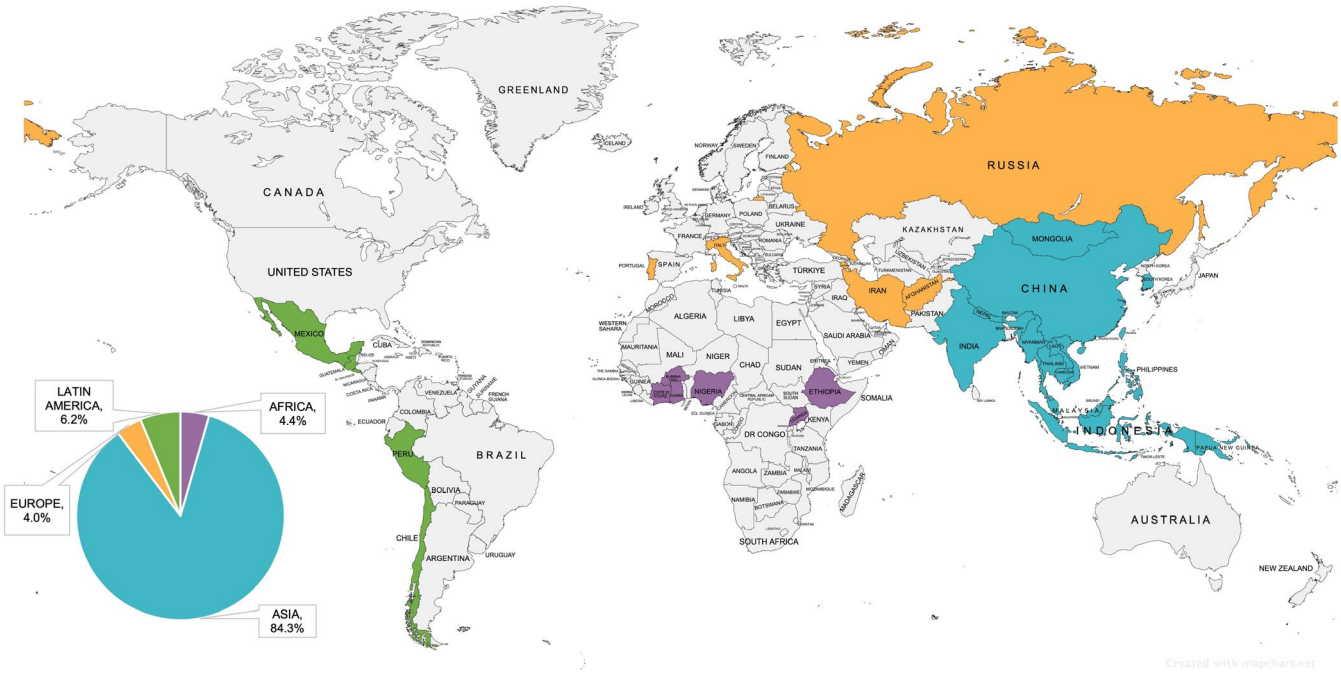


FIGURE 1 | Diversity of FOCUS-HBV participants. Created with mapchart.net.

logistic regression model with multiple imputation performed for missingness. Both recent immigration (less than 10 years in United States) and citizenship status met the criteria for inclusion in the multivariable model, but the two variables had high negative correlation; we chose to retain citizenship in the final model due to lower Akaike information criterion suggesting better model fit. Collinearity was checked with variance inflation factor testing. Multiple imputation using the multivariate normal distribution method was employed for variables with missingness (see Supplemental Methods for details) [14]. Statistical significance was set at an alpha of 0.05; analyses were performed using STATA v18 (College Station, TX).

3 | Results

Survey response rate ranged between 54% and 69%. A total of 274 FB chronic HBV were enrolled, with 33.9% from LAG, 26.6% from Keck USC, 28.5% from GT and 11.0% from NIH. Median cohort age was 57 years (IQR 48–75) and the majority (56.7%) were men (Table 1). 85.8% self-reported as Asian, 5.8% Hispanic, 2.6% Black, 2.6% White, 2.9% Other and 0.4% Native Hawaiian/Pacific Islander. Nearly half of the cohort (48.9%) had some or full college degree. 54.5% were employed, followed by 18.6% retired. The median household number was 3 persons (IQR 2–4), and median household income was split evenly, with 15.7% reporting less than $25 K, 22.6% between $25 and 100K, and 25.2% over $100K, with 36.5% choosing not to report their income. The highest proportion had private insurance (39.8%), followed by Medicare (24.5%), Medicaid (19.7%) and other insurance (13.9%).

Thirty-two unique birth countries were represented in the cohort (Figure 1). By country, 31.1% were from China or Hong Kong, 16.1% from Vietnam, 9.9% from South Korea, 8.0% from the Philippines, 6.9% from Taiwan, 4.7% from Thailand, 4.4% from Mexico and 3.3% from Cambodia. The remaining countries had < 3% representation.

The median duration of living in the United States was 30 years (IQR 17–41), with only 13.1% having immigrated to the United States within the past 10 years. Sixty-two per cent of the cohort had US citizenship, while 18.3% were permanent residents and 6.2% were temporary residents. Thirteen per cent had immigrated to the United States from a non-birth country. The majority (58.8%) preferred speaking their native language. Most completed their survey in English, though of the 24.1% who did not, 69.7% completed in Chinese, 16.7% in Vietnamese and 13.6% in Spanish.

Mean acculturation scores were compared across other participant characteristics (Supplemental Table 1). Participants who preferred speaking their native language had higher heritage (6.89 ± 1.61 vs. 6.48 ± 1.58, $p = 0.04$) and lower mainstream scores (6.11 ± 1.71 vs. 6.64 ± 1.42, $p = 0.01$) than patients who reported predominantly English. Female participants had higher scores than males on the heritage subscale (6.94 ± 1.66 vs. 6.53 ± 1.61, $p = 0.04$), but not on the mainstream subscale. Non-English survey participants had lower mainstream scores (5.73 ± 1.90 vs. 6.46 ± 1.54, $p = 0.002$).

The majority of participants (> 90%) were aware of their HBV diagnosis and had linkage to care (Figure 2). 65.3% were diagnosed in the United States compared to 28.5% in their birth country at a median age of diagnosis of 34 years (IQR 23–49). Among those diagnosed in the United States, median years from immigration to diagnosis were 13 (IQR 7–23). Of those linked to specialty care, 80.2% identified their provider as a hepatologist, 26.9% as a gastroenterologist, 7.0% as infectious disease and 2.9% as other. 71.5% were on treatment. 14.2% and 9.9% reported a diagnosis of cirrhosis and HCC, respectively.

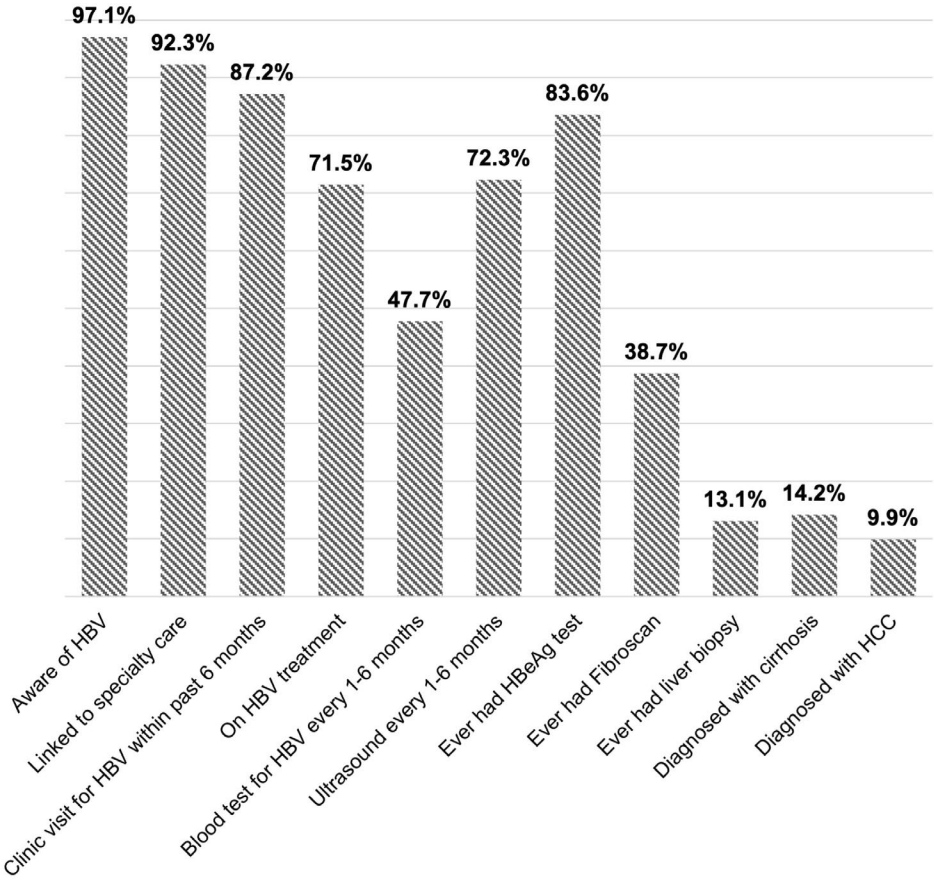


FIGURE 2 | Clinical characteristics of FOCUS-HBV participants.

Adherence to monitoring of labs and HCC surveillance could be ascertained in 239 (87.2%) participants who were not surveyed on their first visit for a diagnosis of HBV. The median number of years under care was 6 years (IQR 3–8). In the year prior to study enrolment, 91.2% had an HBV DNA checked, 96.4% had an ALT checked and 80.7% had an ultrasound. One hundred and four (43.5%) participants had optimal adherence to monitoring (100% of time under care with adherence). Among those with suboptimal monitoring (< 100%), the median % of time under care with adherence was 67.0% (IQR 50%–86%). Most (57.0%) were missing both labs and ultrasound, 27.4% were missing ultrasound only and 15.6% were missing labs only. There was no correlation between % adherence and years under care ($r = 0.03$).

Those with optimal (vs suboptimal) adherence were more likely to choose a non-English survey (30.8% vs. 21.5%), have a higher household income (>$100 K: 28.8% vs. 21.5%) and have private insurance (47.1% vs. 34.1%), though no comparison reached statistical significance (Table 2). Acculturation scores were higher for heritage than mainstream subscales for both groups. Clinical characteristics were similar, though the suboptimal adherence group was slightly more likely to report having a blood test for HBV every 6 months (51.9% vs. 47.1%, $p = 0.02$), but less likely to report an ultrasound every 6 months (72.2% vs. 82.5%, $p = 0.28$).

We examined the association between survey responses and adherence to monitoring (univariate in Supplemental Table 2; final model in Table 3). In our multivariable model, participants who completed the survey in a language other than English (OR 2.32, 95% CI 1.15–4.66) and those who were not US citizens (OR 2.05, 95% CI 1.01–4.15) had more optimal adherence. Compared to those with high school education or less, those who had some or completed college (OR 2.39, 95% CI 1.09–5.24) and those with a graduate degree (OR 2.15, 95% CI 0.83–5.56) had more optimal adherence, though the latter was not statistically significant. Lastly, less optimal adherence was observed among those with Medicare compared to private insurance (OR 0.42, 95% CI 0.19–0.94). There was no statistical difference in adherence by study site.

4 | Discussion

The FOCUS-HBV cohort captured the ethnic diversity of chronic HBV immigrants living in the United States. Although 84% of patients immigrated from Asia, 14 distinct Asian countries were represented. In addition, there was broad socioeconomic diversity, with representation from all strata of education, income and access to healthcare. Despite these differences, self-reported awareness, linkage to care, treatment uptake and routine visits and monitoring for chronic HBV were high. However, less than half had optimal (100%) adherence to long-term monitoring, defined as annual monitoring of liver panel, HBV DNA and HCC surveillance (if eligible). The frequency of monitoring required is the higher end of the 6–12 month interval recommended by AASLD guidelines [13]. This suggests efforts to retain and continually engage patients in care for this dynamic disease condition are still needed.

TABLE 2 | FOCUS-HBV cohort characteristics stratified by adherence ($n = 239$).

	Suboptimal adherence	Optimal adherence	p-value
	***N* = 135**	***N* = 104**	
Age, years	58.0 (50.0–65.0)	57.0 (45.0–66.0)	0.31
Female sex	64 (47.4%)	39 (37.9%)	0.19
Survey language			
English	106 (78.5%)	72 (69.2%)	0.10
Non-English	29 (21.5%)	32 (30.8%)	
Race/ethnicity			
Asian	122 (90.4%)	83 (79.8%)	0.14
Hispanic	5 (3.7%)	9 (8.7%)	
Other	5 (3.7%)	7 (6.7%)	
Missing/Prefer not to answer	3 (2.2%)	5 (4.8%)	
Region of origin			
East Asian	66 (51.6%)	49 (48.5%)	0.75
Southeast Asian	45 (35.2%)	35 (34.7%)	
Other	17 (13.3%)	17 (16.8%)	
Years in United States			
Less than 10	10 (7.6%)	15 (15.2%)	0.07
10 or more	122 (92.4%)	84 (84.8%)	
Citizenship Status			
Citizen	93 (68.9%)	61 (58.7%)	0.25
Non-citizen	30 (22.2%)	32 (30.8%)	
Prefer not to answer/missing	12 (8.9%)	11 (10.6%)	
Frequency of home country visits			
Within last 5 years	57 (42.2%)	38 (36.5%)	0.80
More than 5 years ago	38 (28.1%)	30 (28.8%)	
Never returned	29 (21.5%)	27 (26.0%)	
Prefer not to answer/missing	11 (8.1%)	9 (8.7%)	
Preferred Language			
Only or more native	79 (58.5%)	62 (59.6%)	0.29
Equal native or English	23 (17.0%)	24 (23.1%)	
More or only English	32 (23.7%)	16 (15.4%)	
Prefer not to answer/missing	1 (0.7%)	2 (1.9%)	
Acculturation (mean)			
Heritage score	6.9 (5.4–8.0)	6.8 (5.4–7.9)	0.70
Mainstream score	6.2 (5.3–7.4)	6.2 (5.0–7.5)	0.44
Marital Status			
Married or Domestic Partnership	89 (65.9%)	67 (64.4%)	0.97
Single, Divorced, Separated, Widower	41 (30.4%)	33 (31.7%)	
Prefer not to answer/missing	5 (3.7%)	4 (3.8%)	

(Continues)

TABLE 2 | (Continued)

	Suboptimal adherence	Optimal adherence	p-value
	N = 135	*N* = 104	
Education			
High school or less	41 (30.4%)	20 (19.2%)	0.20
Some or completed college	58 (43.0%)	56 (53.8%)	
Graduate degree	26 (19.3%)	22 (21.2%)	
Prefer not to answer/missing	10 (7.4%)	6 (5.8%)	
Employment status			
Employed	73 (54.1%)	59 (56.7%)	0.91
Not employed	53 (39.3%)	39 (37.5%)	
Prefer not to answer/missing	9 (6.7%)	6 (5.8%)	
Number of people in household	3.0 (2.0–4.0)	2.0 (2.0–4.0)	0.65
Annual Household Income			
Less than $25,000	26 (19.3%)	16 (15.4%)	0.08
$25,000–$100,000	25 (18.5%)	29 (27.9%)	
More than $100,000	29 (21.5%)	30 (28.8%)	
Prefer not to answer/missing	55 (40.7%)	29 (27.9%)	
Insurance			
Private	46 (34.1%)	49 (47.1%)	0.18
Medicare	40 (29.6%)	19 (18.3%)	
Medicaid	27 (20.0%)	23 (22.1%)	
Other	19 (14.1%)	11 (10.6%)	
Prefer not to answer/missing	3 (2.2%)	2 (1.9%)	
HBV treatment			
Currently on treatment	97 (72.9%)	85 (83.3%)	0.16
Previously treated	11 (8.3%)	6 (5.9%)	
Never treated	25 (18.8%)	11 (10.8%)	
HBV provider type			
Hepatologist	97 (76.4%)	79 (78.2%)	0.74
Gastroenterologist	32 (25.2%)	26 (25.7%)	0.93
Infectious disease	7 (5.5%)	7 (6.9%)	0.66
Primary care or other	2 (1.6%)	4 (4.0%)	0.26
Clinic visit for HBV in past 6 months	120 (88.9%)	91 (88.3%)	0.99
Blood test for HBV every 6 months	69 (51.9%)	48 (47.1%)	0.02
Ultrasound every 6 months	96 (72.2%)	85 (82.5%)	0.28
Cirrhosis	15 (11.1%)	18 (17.3%)	0.17
Hepatocellular carcinoma	8 (5.9%)	13 (12.5%)	0.08

Note: Continuous data presented as median (interquartile range) or mean (±standard deviation). Categorical data presented as number and proportions.

Other studies have shown suboptimal rates of HBV treatment and monitoring after linkage to care [6, 15, 16], including one that estimated treatment uptake of ~56% in specialty settings [16]. A second examined 'care retention' defined as at least two additional visits for HBV after an initial visit, and estimated 70% [6]. A community-based cohort in Sacramento showed second visit attendance of 43% and treatment initiation at 16% [15]. Treatment uptake and monitoring in the year prior to the

survey were both high in our cohort, though not surprising as most patients were surveyed at a subspecialty clinic visit. However, long-term 100% adherence was only 44%, and efforts to augment adherence to testing and HCC surveillance even in specialty care settings are still needed.

Non-US citizens and participants who completed the survey in non-English language had higher rates of optimal monitoring. Similarly, recent immigrants (within the past 10 years) also had proportionally better adherence to monitoring. While our initial hypothesis was lower compliance among recent immigrants due to the complexities of navigating a new healthcare system and language barriers, the alternative finding is in line with health advantages observed among recent immigrants, a paradox termed the 'healthy immigrant effect' [17]. There is a self-selection of immigrants who are more physically fit or have healthier behavioural patterns, including heightened engagement towards their healthcare. As immigrants reside in the United States for longer, these behaviours may change [18]. The other potential explanation is shifting socioeconomic backgrounds of immigrant waves; recent immigrants from Asia tend to be more educated, wealthier and have more resources to healthcare access [19]. However, our data was mixed with both recent immigrants and non-citizens reporting lower income, but more recent citizens with a graduate degree. Interestingly, survey language but not preferred language was associated with primary outcome. Availability of preferred language, presence of English speaking caretaker who could assist, and literacy can all affect choice of survey language. Given that the non-English survey participants showed the lowest mainstream VIA scores, survey language may also be a proxy for stronger cultural mores and the healthy immigrant effect.

We found lower long-term optimal adherence among less educated and Medicare participants, highlighting education and insurance as important SDOH targets. A recent systematic review demonstrated that SDOH-focused interventions were largely effective in addressing HBV-relevant health outcomes, though heterogeneous in population and intervention structure [20]. Only one intervention targeted retention in care: this one-time in-person language-concordant patient educational intervention performed at a safety-net clinic successfully increased clinic follow-up, laboratory monitoring and uptake of treatment [21]. This simple culturally tailored patient-facing educational intervention appears feasible, though validating in other community-based settings would add value. The importance of insurance coverage and access to high-quality HBV care for immigrants also cannot be understated, as testing and treatment-related costs can be substantial [22]. National and state policies that enhance the stability of insurance coverage irrespective of citizenship or socioeconomic status are a key aspect of improving HBV care for immigrants.

In this study, acculturation did not differ by adherence status. While multiple measures to evaluate acculturation exist, the VIA score was specifically selected due to its bidimensional nature (both heritage and mainstream can be independent to each other), internal reliability, external validity among different cultural groups, and brevity [12, 23]. The association of acculturation with health outcomes in the literature has been quite inconsistent, though higher acculturation appears connected to poorer diet, less exercise and more metabolic conditions [24, 25]. Similar to our study, one study of the US Vietnamese population did not show acculturation to be associated with hepatitis B testing [26]. It is feasible that the level of acculturation impacts lifestyle choices more than medical compliance. The lack of an association of adherence with acculturation in this cohort could reflect a true absence of a relationship, though it must be interpreted cautiously considering the ethnic, linguistic and educational heterogeneity of those surveyed, and validation in other studies coupled with a closer examination through qualitative work is needed.

TABLE 3 | Multivariate model for optimal adherence to HBV monitoring.

Variable	OR	95% CI	*p*
Survey language			
English	ref	—	—
Non-English	2.32	1.15–4.66	**0.02**
Immigration status			
Citizen	ref	—	—
Non-citizen	2.05	1.01–4.15	**0.05**
Age, per year ↑	1.00	0.97–1.02	0.80
Education			
High school or less	ref	—	—
Some or completed college	2.39	1.09–5.24	**0.03**
Graduate degree	2.15	0.83–5.56	0.11
Insurance			
Private	ref		
Medicare	0.42	0.19–0.94	**0.04**
Medicaid	0.74	0.33–1.67	0.48
Other	0.50	0.20–1.28	0.15
Current HBV treatment			
No	ref		
Yes	1.84	0.93–3.66	0.08

Note: Bolded values were statistically significant at a *p*-value cut-off of < 0.05.

Those not diagnosed with CHB in their birth country had a prolonged time (13 years) from immigration to diagnosis. There is increasing data suggesting benefits of early treatment, including impeding oncogenesis [27]. Currently only tuberculous and syphilis testing are required during US entry health exams for immigrants, which represents a missed opportunity for early HBV diagnosis and linkage to care [28]. Paradoxically, HBV vaccination is also required without initial HBV testing. A recent modelling study suggested that if we screened all new incoming US immigrants since 2022, we would increase total HBV diagnosed by over 300,000 patients [29]. The simple incorporation of an HBV blood test to immigration policies and entry exams would be a positive step.

Strengths of the FOCUS-HBV cohort include diversity in study sites, countries of origin and socioeconomic backgrounds and

our study is novel in linking immigration and acculturation factors to outcomes in healthcare compliance. However, there are a few key limitations. Recruitment occurred mostly in specialty care clinics in academic centres, and results cannot be extrapolated to community-based or primary care settings. Our findings in a predominantly treated cohort likely skew towards better adherence to care. Patients were recruited during point of contact with the healthcare system and thus self-selected those who are more likely to be more compliant. Our study did not examine physician or system-level factors that could impact non-adherence, though differences in adherence by study site were not observed. We did not have an adequate sample size for most non-Asian racial and ethnic groups and therefore were unable to perform stratified analyses on race. To maintain parsimony in our survey, we did not assess other factors that might contribute to non-compliance, such as health literacy, medical mistrust, stigma and discrimination, but these are important dimensions to consider in future studies. Though response rates were reasonable across all sites (lowest from the safety net clinic), non-response bias is always a possibility: we expect that responders would be biased towards better adherence. Lastly, the time period of outcome assessment overlapped with the COVID-19 pandemic, which could have interrupted care; though the high adherence to testing in the year prior to enrolment (> 80% for labs and imaging) suggests marginal impact.

Engagement of immigrants, the largest subgroup with HBV in the United States, is critical to meeting the World Health Organization absolute targets of an annual mortality rate from HBV infection of ≤ 4 per 100,000 persons, achieved through ≥ 90% diagnosed and ≥ 80% treated among eligible [30]. Diagnosing, linking and retaining immigrants in care is a priority. Resources and programmes to amplify adherence to monitoring for FB with HBV, with greater emphasis on established immigrants and less educated, are needed to optimise long-term outcomes.

Author Contributions

Kali Zhou: conceptualization, investigation, funding acquisition, writing – original draft, writing – review and editing, supervision, data curation, formal analysis, methodology, visualization. **Marc G. Ghany:** writing – review and editing. **Jennifer L. Dodge:** methodology, formal analysis, writing – review and editing. **Harish Gopalakrishna:** writing – review and editing. **Jaha Norman-Wheeler:** project administration, data curation. **Norah A. Terrault:** writing – review and editing, conceptualization. **Christine C. Hsu:** conceptualization, investigation, writing – review and editing, writing – original draft, visualization, methodology, supervision. **Maria Mironova:** writing – review and editing. **Amol S. Rangnekar:** writing – review and editing. **Ariana Chen:** writing – review and editing, project administration, data curation. **Ariel Lee:** writing – original draft. **Christopher Wong:** writing – original draft, formal analysis, data curation, methodology. **Coleman I. Smith:** writing – review and editing. **Asif A. Hitawala:** writing – review and editing. **James Ajokubi:** project administration, writing – review and editing, data curation. **Andrea I. Keller:** writing – review and editing.

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Conflicts of Interest

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Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

References

1. J. J. Ott, G. A. Stevens, J. Groeger, and S. T. Wiersma, "Global Epidemiology of Hepatitis B Virus Infection: New Estimates of Age-Specific HBsAg Seroprevalence and Endemicity," *Vaccine* 30, no. 12 (2012): 2212–2219.

2. M. H. Le, Y. H. Yeo, R. Cheung, L. Henry, A. S. Lok, and M. H. Nguyen, "Chronic Hepatitis B Prevalence Among Foreign-Born and U.S.-Born Adults in the United States, 1999-2016," *Hepatology* 71, no. 2 (2020): 431–443.

3. K. Zhou and N. A. Terrault, "Gaps in Viral Hepatitis Awareness in the United States in a Population-Based Study," *Clinical Gastroenterology and Hepatology* 18, no. 1 (2019): 188–195.e4.

4. K. Zhou, J. L. Dodge, J. Grab, E. Poltavskiy, and N. A. Terrault, "Mortality in Adults With Chronic Hepatitis B Infection in the United States: A Population-Based Study," *Alimentary Pharmacology & Therapeutics* 52, no. 2 (2020): 382–389.

5. E. Tang, S. Torres, B. Liu, R. Baden, T. Bhuket, and R. J. Wong, "High Prevalence of Cirrhosis at Initial Presentation Among Safety-Net Adults With Chronic Hepatitis B Virus Infection," *Journal of Clinical and Experimental Hepatology* 8, no. 3 (2018): 235–240.

6. E. Tang, B. Liu, T. Bhuket, and R. J. Wong, "Low Rates of Linkage and Retention Into Care Among Patients With Chronic HBV Infection," *Clinical Gastroenterology and Hepatology* 17, no. 9 (2019): 1909–1911.

7. N. B. Ha, H. N. Trinh, T. T. Nguyen, et al., "Prevalence, Risk Factors, and Disease Knowledge of Chronic Hepatitis B Infection in Vietnamese Americans in California," *Journal of Cancer Education* 28, no. 2 (2013): 319–324.

8. K. Zhou, T. Fitzpatrick, N. Walsh, et al., "Interventions to Optimise the Care Continuum for Chronic Viral Hepatitis: A Systematic Review and Meta-Analyses," *Lancet Infectious Diseases* 16, no. 12 (2016): 1409–1422.

9. D. J. Hu, J. Xing, R. A. Tohme, et al., "Hepatitis B Testing and Access to Care Among Racial and Ethnic Minorities in Selected Communities Across the United States, 2009-2010," *Hepatology* 58, no. 3 (2013): 856–862.

10. M. Bride, P. V. Perumalswami, A. Ly van Manh, and L. Jandorf, "Assessing Hepatitis B Knowledge Among Immigrant Communities in new York City," *Journal of Immigrant and Minority Health* 20, no. 2 (2018): 502–506.

11. A. G. Ryder, L. E. Alden, and D. L. Paulhus, "Is Acculturation Unidimensional or Bidimensional? A Head-To-Head Comparison in the Prediction of Personality, Self-Identity, and Adjustment," *Journal of Personality and Social Psychology* 79, no. 1 (2000): 49–65.

12. Q.-L. Huynh, R. T. Howell, and V. Benet-Martínez, "Reliability of Bidimensional Acculturation Scores: A Meta-Analysis," *Journal of Cross-Cultural Psychology* 40, no. 2 (2009): 256–274.

13. N. A. Terrault, A. S. F. Lok, B. J. McMahon, et al., "Update on Prevention, Diagnosis, and Treatment of Chronic Hepatitis B: AASLD 2018 Hepatitis B Guidance," *Hepatology* 67, no. 4 (2018): 1560–1599.

14. K. J. Lee and J. B. Carlin, "Multiple Imputation for Missing Data: Fully Conditional Specification Versus Multivariate Normal Imputation," *American Journal of Epidemiology* 171, no. 5 (2010): 624–632.

15. T. Wang, Y. Liu, D. Letran, et al., "Healthcare Disparities Identified Between Hmong and Other Asian Origin Groups Living With Chronic Hepatitis B Infection in Sacramento County 2014-2017," *Journal of Community Health* 45, no. 2 (2020): 412–418.

16. V. H. Nguyen, A. K. Le, H. N. Trinh, et al., "Poor Adherence to Guidelines for Treatment of Chronic Hepatitis B Virus Infection at Primary Care and Referral Practices," *Clinical Gastroenterology and Hepatology* 17, no. 5 (2019): 957–967.

17. F. Riosmena, R. Kuhn, and W. C. Jochem, "Explaining the Immigrant Health Advantage: Self-Selection and Protection in Health-Related Factors Among Five Major National-Origin Immigrant Groups in the United States," *Demography* 54, no. 1 (2017): 175–200.

18. A. Ro, "The Longer You Stay, the Worse Your Health? A Critical Review of the Negative Acculturation Theory Among Asian Immigrants," *International Journal of Environmental Research and Public Health* 11, no. 8 (2014): 8038–8057.

19. Pew Research Center, "The Rise of Asian Americans," 2012, accessed May 8, 2024, https://www.pewresearch.org/social-trends/2012/06/19/the-rise-of-asian-americans/.

20. K. Anyiwe, A. Erman, M. Hassan, et al., "Characterising the Effectiveness of Social Determinants of Health-Focused Hepatitis B Interventions: A Systematic Review," *Lancet Infectious Diseases* 24 (2024): e366–e385.

21. R. J. Wong and M. Khalili, "A Patient-Centered Hepatitis B Virus (HBV) Educational Intervention Improves HBV Care Among Underserved Safety-Net Populations," *Journal of Clinical Gastroenterology* 54, no. 7 (2020): 642–647.

22. T. A. Lee, D. L. Veenstra, U. H. Iloeje, and S. D. Sullivan, "Cost of Chronic Hepatitis B Infection in the United States," *Journal of Clinical Gastroenterology* 38, no. 10 Suppl 3 (2004): S144–S147.

23. S. Testa, M. M. Doucerain, A. Miglietta, T. Jurcik, A. G. Ryder, and S. Gattino, "The Vancouver Index of Acculturation (VIA): New Evidence on Dimensionality and Measurement Invariance Across Two Cultural Settings," *International Journal of Intercultural Relations* 71 (2019): 60–71.

24. M. Fox, Z. Thayer, and P. D. Wadhwa, "Assessment of Acculturation in Minority Health Research," *Social Science & Medicine* 176 (2017): 123–132.

25. M. Fox, Z. Thayer, and P. D. Wadhwa, "Acculturation and Health: The Moderating Role of Socio-Cultural Context," *American Anthropologist* 119, no. 3 (2017): 405–421.

26. M. Vu, V. N. Huynh, C. J. Berg, et al., "Hepatitis B Testing Among Vietnamese in Metropolitan Atlanta: The Role of Healthcare-Related and Acculturation-Related Factors," *Journal of Community Health* 46, no. 4 (2021): 767–776.

27. Y. S. Lim, W. R. Kim, D. Dieterich, et al., "Evidence for Benefits of Early Treatment Initiation for Chronic Hepatitis B," *Viruses* 15, no. 4 (2023): 997.

28. E. N. Nyangoma, C. K. Olson, J. A. Painter, et al., "Syphilis Among U.S.-Bound Refugees, 2009-2013," *Journal of Immigrant and Minority Health* 19, no. 4 (2017): 835–842.

29. D. Razavi-Shearer, I. Gamkrelidze, C. Q. Pan, et al., "The Impact of Immigration on Hepatitis B Burden in the United States: A Modelling Study," *Lancet Regional Health. Americas* 22 (2023): 100516, https://doi.org/10.1016/j.lana.2023.100516.

30. World Health Organization, "Guidance for Country Validation of Viral Hepatitis Elimination and Path to Elimination: Technical Report," 2023.

Supporting Information

Additional supporting information can be found online in the Supporting Information section.