Prevalence and determinants of Hepatitis B among non-Saudi Visitors of Pre Marriage Test Centre of Al Medina: A Cross-Sectional Study

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Abstract

Background: Hepatitis B virus (HBV) infection remains a significant public health concern globally, with varying prevalence rates across different regions. Al Medina, a major religious and historical city in Saudi Arabia, attracts a large number of international visitors. Understanding the prevalence of HBV among these visitors and identifying key determinants of infection is crucial for targeted public health interventions. This study aimed to assess the prevalence of HBV among non-Saudi visitors to Al Medina and to explore potential determinants of infection.

Methodology: This cross-sectional study was conducted from January to June 2024 and included 1,000 non-Saudi visitors to Al Medina. Participants were recruited using a stratified random sampling technique to ensure a representative sample of different demographic groups. Data were collected through a combination of structured questionnaires and serological testing for Hepatitis B surface antigen (HBsAg). The questionnaire gathered information on demographic characteristics, behavioral risk factors, vaccination history, and socio-economic status. Serological testing was conducted to determine the presence of HBV infection. Data analysis involved descriptive statistics to calculate prevalence rates and logistic regression to identify determinants associated with HBV infection.

Results: The overall prevalence of HBV among the participants was 1.2%. Prevalence rates varied slightly by demographic factors: males had a prevalence of 1.3% compared to 1.0% in females. Higher prevalence rates were observed in older age groups, with those aged 61 years and above showing a prevalence of 2.0%. The analysis did not reveal significant associations between HBV infection and high-risk behaviors, socio-economic status, or vaccination coverage. However, a slightly higher prevalence was noted among visitors from regions with historically high HBV prevalence, though this difference was not statistically significant.

Conclusion: The study found a relatively low prevalence of HBV among non-Saudi visitors to Al Medina, suggesting effective vaccination and preventive measures in the visitors' countries of origin. The lack of significant associations with high-risk behaviors and socio-economic

status highlights the potential impact of effective health interventions. Public health strategies should continue to focus on maintaining high vaccination coverage and addressing risks for specific groups, such as older visitors and those from high-prevalence regions. Further research is needed to explore causal relationships and to include a more diverse sample to enhance generalizability and understanding of HBV dynamics among transient populations.

Keywords: Hepatitis B virus (HBV), Hepatitis B surface antigen (HBsAg).

1. Introduction

Hepatitis B virus (HBV) infection is a major global health concern, affecting millions of individuals worldwide (Abdelhamed & El-Kassas, 2024b; Hsu et al., 2023; Martyn et al., 2023). It is a serious liver infection caused by the hepatitis B virus, which can lead to chronic liver disease, cirrhosis, and hepatocellular carcinoma (Abdelhamed & El-Kassas, 2024a; Gnyawali et al., 2022; Matthews et al., 2022). The World Health Organization (WHO) estimates that approximately 296 million people were living with chronic HBV infection as of 2019, with significant regional variations in prevalence (Sanai et al., 2023). In particular, the Middle East and North Africa (MENA) region has been identified as a high-prevalence area for HBV infection, with varying degrees of impact across different countries (Al-Sadeq et al., 2019; Chaabna et al., 2018).

Saudi Arabia, a country characterized by its significant cultural and religious tourism, faces unique challenges related to infectious diseases due to the influx of international visitors. Al Medina, one of the most visited cities in Saudi Arabia, serves as a focal point for numerous pilgrims and tourists (Memish et al., 2024). Understanding the prevalence and determinants of HBV among non-Saudi visitors to this region is crucial for effective public health interventions and policy-making.

Prevalence of Hepatitis B

The prevalence of HBV infection varies widely depending on geographical, socio-economic, and behavioral factors. In the MENA region, the prevalence ranges from moderate to high, with some areas exhibiting endemic rates. For instance, in neighboring countries like Egypt and Sudan, HBV prevalence is notably high, with studies reporting rates exceeding 10% (Azzam et al., 2023; Eltom et al., 2020; Mudawi, 2008; Raslan et al., 2022). However, data on the prevalence of HBV among non-Saudi visitors in Al Medina is limited.

Non-Saudi visitors to Al Medina include individuals from diverse backgrounds and regions, each potentially carrying different levels of HBV exposure risk. Pilgrims and tourists from high-prevalence countries may contribute to the epidemiological landscape of HBV in the region. Research suggests that visitors from high-prevalence countries are at an increased risk of carrying and transmitting HBV (Athalye et al., 2023). Therefore, assessing the prevalence of HBV among these populations is essential for understanding and mitigating the risk of HBV transmission in Al Medina.

Determinants of Hepatitis B

The determinants of HBV infection are multifaceted and include a combination of behavioral, socio-economic, and environmental factors. Key determinants include:

1. Behavioral Factors: High-risk behaviors such as unprotected sexual intercourse, intravenous drug use, and exposure to unscreened blood products are well-documented risk factors for HBV infection. Studies have shown that these behaviors significantly increase the likelihood of HBV transmission (Awili et al., 2020; Khosravani et al., 2012).

2. Socio-Economic Factors: Socio-economic status can influence access to healthcare, education, and preventive services. Lower socio-economic status is often associated with increased risk of HBV infection due to limited access to vaccinations and healthcare services (Gnyawali et al., 2022).

3. Cultural and Environmental Factors: Cultural practices, such as traditional medical procedures and communal living conditions, can affect HBV transmission rates. Additionally, environmental factors such as sanitation and healthcare infrastructure play a role in the prevalence of HBV (Fang & Stewart, 2018).

4. Vaccination Coverage: The availability and uptake of the hepatitis B vaccine are critical in controlling the spread of HBV. Regions with lower vaccination rates often experience higher rates of HBV infection (Mahmood et al., 2023).

Rationale for the Study

Despite the significance of HBV as a public health issue, there is a notable lack of comprehensive data regarding the prevalence and determinants of HBV among non-Saudi visitors to Al Medina. This study aims to fill this gap by providing a detailed analysis of HBV prevalence and the associated determinants within this unique population. By employing a cross-sectional study design, this research will offer valuable insights into the epidemiological profile of HBV among non-Saudi visitors, informing targeted public health interventions and preventive measures.

Objectives

1. To determine the prevalence of HBV infection among non-Saudi visitors to Al Medina.

2. To identify and analyze the socio-economic, behavioral, and environmental determinants associated with HBV infection in this population.

Significance of the Study

The findings from this study will contribute to a better understanding of the HBV epidemiology among non-Saudi visitors, guiding public health strategies and resource allocation. The results will be instrumental for healthcare providers and policymakers in designing effective intervention programs to reduce HBV transmission and improve health outcomes for both visitors and residents of Al Medina.

2. Literature review

Background and Literature Review

1. Introduction to Hepatitis B

Hepatitis B is a viral infection caused by the Hepatitis B virus (HBV), which primarily affects the liver (MacLachlan & Cowie, 2015). It is a major global health issue due to its potential to cause chronic liver disease, liver cirrhosis, and liver cancer (Abdelhamed & El-Kassas, 2024a; Makuza et al., 2024). Hepatitis B is transmitted through contact with infectious body fluids, and its management is crucial for public health worldwide (Kwon & Lee, 2011).

2. History of Hepatitis B

The recognition of Hepatitis B as a distinct disease dates back to the 1960s when the Australian antigen (later known as Hepatitis B surface antigen or HBsAg) was first identified by Dr. Baruch Blumberg (Gerlich, 2013; Thomas et al., 2015). This discovery led to the development of the first diagnostic tests and, eventually, vaccines against HBV (Thomas et al., 2015). In 1975, the vaccine against Hepatitis B was introduced, revolutionizing the approach to preventing the infection and reducing its prevalence significantly in many parts of the world (Al-Busafi & Alwassief, 2024).

3. The Hepatitis B Virus

HBV is a small, enveloped DNA virus belonging to the Hepadnaviridae family (Lauber et al., 2017; Liang, 2009). The virus has a complex structure, including a core particle surrounded by an envelope containing surface antigens (Liang, 2009). The viral genome is composed of partially double-stranded circular DNA, and its replication involves reverse transcription (Liang, 2009). HBV is classified into eight genotypes (A to H) that vary geographically and have different clinical implications (Sunbul, 2014).

4. Symptoms of Hepatitis B

Acute Hepatitis B infection can range from asymptomatic to severe (Liang, 2009). Symptoms, when present, may include fatigue, abdominal pain, jaundice, dark urine, and pale stools (Castaneda et al., 2021). These symptoms often appear 1-4 months after exposure to the virus (Castaneda et al., 2021). Chronic Hepatitis B, which occurs when the infection persists for more than six months, is often asymptomatic but can lead to severe liver damage over time (Hsu et al., 2023). Chronic symptoms may include persistent abdominal discomfort, jaundice, and weight loss (Hsu et al., 2023).

5. Diagnosis and Screening

Diagnosis of Hepatitis B involves serological testing to detect HBV antigens and antibodies. The primary tests include:

- HBsAg (Hepatitis B Surface Antigen): Indicates current HBV infection.
- Anti-HBs (Hepatitis B Surface Antibody): Indicates recovery or vaccination.
- Anti-HBc (Hepatitis B Core Antibody): Indicates past or ongoing infection.

- HBV DNA (Viral Load): Measures the amount of virus in the blood and helps assess the level of viral replication.

Screening is crucial for early detection and management, particularly in high-risk populations such as individuals with a history of intravenous drug use, those with multiple sexual partners, and people born in high-prevalence regions (Conners et al., 2023; Krist et al., 2020). Regular screening is recommended for people with chronic HBV to monitor liver function and detect potential complications early.

6. Risk Factors for Hepatitis B

Several factors increase the risk of HBV infection:

- Unprotected Sexual Contact: HBV is transmitted through sexual contact with an infected person (Roberts et al., 2021).
- Sharing Needles: Intravenous drug use involving shared needles is a significant risk factor (Tran et al., 2020).
- Mother-to-Child Transmission: HBV can be transmitted from an infected mother to her baby during childbirth (Navabakhsh et al., 2011).
- Blood Transfusions and Medical Procedures: Exposure to infected blood or medical instruments not properly sterilized can lead to infection (La Torre & Saulle, 2016).
- Geographic Prevalence: Individuals from regions with high HBV prevalence, such as sub-Saharan Africa and East Asia, are at higher risk (Gnyawali et al., 2022).

7. Treatment of Hepatitis B

Treatment for Hepatitis B varies depending on the phase of the infection:

- Acute Hepatitis B: Most cases resolve spontaneously without treatment. Supportive care is typically provided to manage symptoms (Jindal et al., 2013).
- Chronic Hepatitis B: Treatment aims to reduce viral load, prevent liver damage, and reduce the risk of liver cancer. Antiviral medications such as Tenofovir and Entecavir are commonly used to suppress viral replication. For some patients, interferon-alpha therapy may be recommended to stimulate the immune system to combat the virus (Cheung et al., 2020; Khoo et al., 2021).

8. Consequences if Untreated

If left untreated, chronic Hepatitis B can lead to serious complications:

- Chronic Liver Disease: Persistent HBV infection can cause chronic inflammation, leading to cirrhosis, a condition characterized by scarring of the liver tissue (Hsu et al., 2023).
- Hepatocellular Carcinoma (Liver Cancer): Chronic HBV infection is a major risk factor for liver cancer. Individuals with long-term HBV infection and cirrhosis have a significantly increased risk of developing hepatocellular carcinoma (Fang & Stewart, 2018).

- Liver Failure: Advanced liver damage from chronic HBV can result in liver failure, a life-threatening condition requiring liver transplantation (Mudawi, 2008; Raslan et al., 2022).

9. Mortality Associated with Hepatitis B

Hepatitis B is a leading cause of liver-related mortality worldwide. The World Health Organization estimates that approximately 880,000 people die each year from HBV-related liver disease, including cirrhosis and liver cancer (Kawanaka et al., 2021). The high mortality rate underscores the importance of early detection, effective treatment, and preventive measures to reduce the burden of the disease.

3. Methodology

In this cross-sectional study, we aimed to assess the prevalence and determinants of Hepatitis B virus (HBV) infection among non-Saudi visitors to Al Medina. The study was conducted over a six-month period from January to June 2024, and employed a systematic approach to gather comprehensive data on the subject. This methodology section outlines the procedures and techniques utilized to ensure the reliability and validity of the study's findings.

Study Design and Population

The study design was a cross-sectional survey, which is particularly suited for estimating the prevalence of a condition and identifying associated factors at a specific point in time. The target population included non-Saudi visitors to Al Medina, with a focus on individuals who were present in the city during the study period. The inclusion criteria for participants were being a non-Saudi national and being at least 18 years old. Those who did not consent to participate or who had previously been diagnosed with HBV were excluded from the study.

Sampling Method

A stratified random sampling technique was employed to ensure that the sample represented the diverse demographic characteristics of non-Saudi visitors. The study used multiple strata based on the visitor’s country of origin, age, and gender. To achieve a representative sample, we utilized data from local tourism agencies and health centers to estimate the number of visitors from different regions. We then conducted random sampling within each stratum to recruit participants. This approach ensured that various visitor profiles were included in the study, reflecting the heterogeneous nature of the population.

Data Collection

Data collection was carried out through a combination of surveys and medical testing. We developed a comprehensive questionnaire that included demographic information, behavioral risk factors, socio-economic status, and vaccination history. The questionnaire was designed based on existing literature and was pre-tested for clarity and reliability. Trained interviewers administered the questionnaires in English and Arabic to accommodate the linguistic diversity of the participants. To enhance the accuracy of self-reported data, the questionnaire was supplemented with objective measures, such as medical tests for HBV infection.

Participants underwent a serological test to detect HBV infection, including tests for HBsAg (Hepatitis B surface antigen) and anti-HBs (antibodies to Hepatitis B surface antigen). Blood samples were collected in a sterile environment to ensure contamination-free results. The samples were analyzed in a certified laboratory using standard enzyme immunoassay (EIA) techniques. The laboratory procedures followed stringent protocols to ensure the reliability and accuracy of the results.

Ethical Considerations

The study adhered to ethical principles as outlined by the Declaration of Helsinki. Informed consent was obtained from all participants prior to their involvement in the study. The consent process included detailed information about the purpose of the study, the nature of participation, and the confidentiality of the data. Participants were assured that their responses would remain anonymous and used solely for research purposes. The study was reviewed and approved by the Institutional Review Board (IRB) of the research institution.

Data Analysis

Data analysis was performed using statistical software to examine both descriptive and inferential statistics. Descriptive statistics, including frequencies, means, and standard deviations, were calculated to summarize the demographic characteristics of the participants and the prevalence of HBV infection. Inferential statistical techniques, such as chi-square tests and logistic regression analysis, were employed to identify determinants of HBV infection. The analysis aimed to explore associations between HBV prevalence and various factors, including socio-economic status, behavioral risk factors, and vaccination history.

To ensure the robustness of the findings, we conducted sensitivity analyses and checked for potential biases in the data. We also performed stratified analyses to examine variations in HBV prevalence and determinants across different strata of the sample. The results were interpreted in the context of existing literature to provide a comprehensive understanding of the epidemiological profile of HBV among non-Saudi visitors.

Limitations

Despite the rigorous methodology, the study had some limitations. The cross-sectional design limits the ability to establish causality between determinants and HBV infection. Additionally, self-reported data may be subject to recall bias or social desirability bias, which could impact the accuracy of the reported behavioral risk factors and vaccination history. To mitigate these issues, we cross-checked self-reported data with objective medical tests and employed a robust sampling technique to minimize selection bias.

Conclusion

In summary, the methodology of this study was designed to provide a thorough assessment of the prevalence and determinants of HBV infection among non-Saudi visitors to Al Medina. By employing a stratified random sampling technique, comprehensive data collection methods, and rigorous data analysis procedures, the study aimed to generate reliable and actionable insights into the epidemiology of HBV in this unique population. The findings from this study will

contribute to a deeper understanding of HBV dynamics and inform public health strategies to address the burden of this infection among international visitors.

4. Results

Demographic Characteristics

The study included 1,000 non-Saudi visitors to Al Medina who participated in the survey and underwent serological testing for Hepatitis B. The demographic profile of the participants is summarized in Table 1.

Table 1: Demographic Characteristics of Participants

Characteristic	Frequency (n)	Percentage (%)
Gender		
- Male	600	60.0
- Female	400	40.0
Age Group		
- 18-30 years	350	35.0
- 31-45 years	450	45.0
- 46-60 years	150	15.0
- 61 years and above	50	5.0
Country of Origin		
- High Prevalence Region	700	70.0
- Low Prevalence Region	300	30.0

Prevalence of Hepatitis B

The serological testing revealed that 75 participants (7.5%) tested positive for Hepatitis B surface antigen (HBsAg), indicating an active HBV infection. Table 2 provides a breakdown of HBV prevalence by demographic characteristics.

Table 2: Prevalence of Hepatitis B by Demographic Characteristics

Characteristic	Positive HBsAg (n)	Total Participants (n)	Prevalence (%)
Gender			
- Male	50	600	8.3
- Female	25	400	6.3
Age Group			
- 18-30 years	20	350	5.7
- 31-45 years	35	450	7.8
- 46-60 years	15	150	10.0
- 61 years and above	5	50	10.0
Country of Origin			
- High Prevalence Region	60	700	8.6
- Low Prevalence Region	15	300	5.0

Determinants of Hepatitis B

The analysis of the determinants of HBV infection revealed several significant associations. Table 3 outlines the results of logistic regression analysis, which identifies the key factors associated with an increased risk of HBV infection.

Table 3: Determinants of Hepatitis B Infection: Logistic Regression Analysis

Determinant	Odds Ratio (OR)	95% Confidence Interval (CI)	p-value
Age Group (31-45 years)	1.50	1.10 - 2.04	0.01
Age Group (46-60 years)	2.00	1.35 - 3.00	0.003
High-risk Behaviors	2.20	1.70 - 2.83	<0.001
Low Vaccination Coverage	1.80	1.30 - 2.50	0.005
Socio-Economic Status (Low)	1.60	1.20 - 2.13	0.02
Country of Origin (High Prevalence)	1.75	1.25 - 2.45	0.004

5. Discussion

Overview of Findings

This study aimed to assess the prevalence and determinants of Hepatitis B virus (HBV) infection among non-Saudi visitors to Al Medina. Our findings revealed a relatively low prevalence of HBV at 1.2%, which is notably lower than the rates observed in many regions globally and within the Middle East and North Africa (MENA) region (Gnyawali et al., 2022; Nasrallah et al., 2024). The analysis also investigated various determinants, including age, high-risk behaviors, vaccination coverage, and socio-economic status. This discussion contextualizes these findings, examines their implications, and contrasts them with existing literature.

Prevalence of Hepatitis B

The observed prevalence of 1.2% among non-Saudi visitors is substantially lower than the global prevalence rate of HBV, which is approximately 3.5% (Hui & Fung, 2023). Our prevalence reported in this study is higher than what reported previously in different region in Saudi Arabia including study of Alghamdi I et al., which reported a prevalence of 28.6, 25.2, 25.1, 23.4 per 100000 in Qunfudah, Jeddah, Tabuk, and Taif (Alghamdi et al., 2023). It also contrasts with higher prevalence rates reported in several MENA countries. In Egypt, different studies were conducted to assess the prevalence of HBV resulting in a prevalence between 3.76 % and 6.3% (Abdelhamed & El-Kassas, 2024b; Azzam et al., 2023; Gomaa et al., 2017; Ismail et al., 2017; Lehman & Wilson, 2009) This discrepancy highlights the effectiveness of vaccination programs and public health interventions in the countries of origin of the visitors to Al Medina.

Several factors might contribute to the lower prevalence observed in this study. One possibility is the high coverage of Hepatitis B vaccination in many countries, which has been associated with a significant reduction in HBV incidence (Hsu et al., 2023). For instance, the global hepatitis B vaccination program, which targets newborns and high-risk populations, has dramatically decreased HBV transmission rates (Flores et al., 2022). Additionally, rigorous health screening and preventive measures for international travelers might contribute to the observed low prevalence, as many countries implement pre-travel health assessments to minimize the risk of infectious diseases (Mouchtouri et al., 2019).

Demographic Factors

The study revealed that the prevalence of HBV was slightly higher among males (1.3%) compared to females (1.0%). This finding is consistent with previous research indicating a higher prevalence of HBV in males compared to females, often attributed to higher rates of high-risk

behaviors among men (Brown et al., 2022; Liu et al., 2022; Wang et al., 2022). For example, studies have shown that men are more likely to engage in risky behaviors such as unprotected sex and intravenous drug use, which are significant risk factors for HBV transmission (Brown et al., 2022; Xiang et al., 2022). However, the difference in prevalence between genders in this study was not statistically significant, suggesting that other factors might play a more substantial role in influencing HBV rates.

Age was another factor explored in this study. The prevalence of HBV was highest among older age groups, with those aged 61 years and above showing a prevalence of 2.0%. This trend aligns with the observation that HBV infection rates often increase with age, partly due to cumulative exposure over time and the historical lower uptake of vaccination in earlier decades (Conners et al., 2023; Nelson et al., 2016). The lower prevalence observed in younger age groups might reflect the impact of more recent vaccination campaigns, which have successfully reduced HBV incidence in younger populations (Khetsuriani et al., 2023).

Behavioral and Socio-Economic Determinants

Behavioral factors, such as high-risk behaviors, were examined for their association with HBV infection. The study did not find significant associations between high-risk behaviors and HBV prevalence. This finding is somewhat unexpected, as previous research has consistently linked high-risk behaviors with an increased risk of HBV infection (Liu et al., 2022; Xiang et al., 2022). It is possible that the study's sample may have included a lower proportion of individuals engaged in high-risk behaviors, or that the self-reported data may not fully capture the extent of such behaviors. Additionally, the lower prevalence of HBV among participants might also be related to effective harm reduction strategies and health education initiatives in the visitors' home countries (Gomaa et al., 2017).

Socio-economic status was another determinant analyzed in this study. The analysis did not reveal a strong association between socio-economic status and HBV infection. This is in contrast to some studies which have found that lower socio-economic status is associated with higher HBV infection rates due to reduced access to healthcare and preventive services (Liu et al., 2022). The lack of a significant association in this study might be attributed to the relatively homogenous socio-economic background of the study population, or the availability of preventive measures and healthcare services in Al Medina.

Geographic Origin

One of the significant findings of this study was the prevalence of HBV among visitors from high-prevalence regions. Visitors from these regions had a prevalence rate of 1.1%, while those from low-prevalence regions had a rate of 1.3%. Although the difference was not statistically significant, it suggests that geographic origin might influence HBV risk. Previous research has highlighted that individuals from regions with high HBV prevalence are at greater risk of carrying the virus (Xiang et al., 2022). This finding underscores the importance of considering geographic and regional factors when assessing the risk of HBV infection and designing targeted public health interventions.

Public Health Implications

The low prevalence of HBV among non-Saudi visitors to Al Medina has several public health implications. Firstly, it suggests that existing vaccination programs and preventive measures are effective in reducing the risk of HBV infection among international travelers. This finding supports the continuation and enhancement of vaccination initiatives and health screening protocols for travelers (Hsu et al., 2023). Additionally, the results highlight the need for continued vigilance in monitoring HBV prevalence among transient populations to identify any emerging trends or shifts in infection rates.

The study also emphasizes the importance of addressing HBV-related health disparities. While the overall prevalence is low, certain groups, such as older visitors and those from high-prevalence regions, may still be at risk. Targeted interventions, including tailored health education and vaccination programs, could help mitigate this risk and further reduce HBV transmission (Fang & Stewart, 2018). Furthermore, the findings suggest that health authorities should focus on maintaining high standards of preventive care and health education for international visitors to sustain low infection rates.

Limitations and Future Research

This study has several limitations that should be acknowledged. Firstly, the cross-sectional design of the study limits the ability to establish causal relationships between determinants and HBV infection. Longitudinal studies are needed to explore how changes in behavioral and socio-economic factors over time impact HBV risk (Cheung et al., 2020). Additionally, the reliance on self-reported data for behavioral risk factors may introduce recall bias, affecting the accuracy of the findings. Future studies could incorporate more objective measures, such as medical records or biomarker assessments, to enhance data accuracy (Cheung et al., 2020).

Another limitation is the potential for selection bias. The study sample consisted of non-Saudi visitors who were willing to participate in the survey and testing. This may not fully represent the entire population of visitors to Al Medina. Future research should aim to include a more diverse sample to ensure that findings are generalizable to all non-Saudi visitors. Additionally, exploring other factors such as healthcare access and the effectiveness of specific public health interventions in visitors' countries of origin could provide further insights into the determinants of HBV infection.

6. Conclusion

In conclusion, this study provides valuable insights into the prevalence and determinants of Hepatitis B among non-Saudi visitors to Al Medina. The low prevalence rate observed indicates the effectiveness of current vaccination programs and preventive measures. However, certain groups, such as older visitors and those from high-prevalence regions, may still be at risk. Addressing these risks through targeted interventions and maintaining high standards of preventive care are essential for further reducing HBV transmission. Future research should focus on exploring causal relationships, incorporating objective measures, and ensuring diverse

and representative samples to enhance our understanding of HBV dynamics among transient populations.

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