Hepatitis B Foundation

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HEPATITIS ONLINE TECHNICAL ASSISTANCE CENTER

NASTAD

TOOLKIT

# HBV-HCV CANCER AND IMMUNIZATION REGISTRY MATCHING



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## Background

An estimated 2.4 million and 4 million people are living with chronic hepatitis B (HBV) and hepatitis C (HCV) in the United States, respectively.[1] Both cause significant liver damage, cirrhosis and liver cancer if not diagnosed and properly managed.

HBV and HCV are classified by the International Agency for Research on Cancer (IARC) as known carcinogens due to their ability to cause hepatocellular carcinoma (HCC).[2] Notably, people living with HBV or HCV have a similar or significantly higher risk of developing cancer than a person who smokes one pack of cigarettes per day.[3] Significant health disparities exist among affected populations in the U.S. Asian Americans, Pacific Islanders, and African Immigrant communities face a disproportionate burden of chronic HBV, while American Indian and Alaska Native, and non-Hispanic Black communities have a higher burden of hepatitis C.[4,5]

Globally, HBV and HCV remain leading causes of hepatocellular carcinoma (HCC), the most common form of primary liver cancer. Together, these viruses account for most of the liver cancer-related mortality worldwide. HBV and HCV are estimated to cause 80% of all liver cancer deaths globally, with HBV responsible for 56% and HCV for 20%.[6] About 5-10% of people living with chronic HBV will develop liver cancer without first developing severe liver damage such as cirrhosis, underscoring the importance of early detection and prevention.[7]

HCV can be cured with highly effective treatment, although barriers to diagnosis and treatment remain. HBV can be prevented through vaccination, and effective treatments can reduce the risk of liver cancer among people living with the virus. However, there is currently no cure for HBV, underscoring the importance of identifying and addressing missed opportunities for prevention, screening, and care.

> ***Commonly, viral hepatitis surveillance, cancer surveillance and immunization data are maintained in separate public health systems, therefore, the relationship between viral hepatitis prevention, care, and subsequently liver cancer outcomes may not be commonly visible to individual programs. Using these data to provide a better understanding of the viral hepatitis burden will support public health in identifying missed opportunities for prevention and care and increase the effectiveness of these interventions to reduce liver cancer morbidity and mortality.***

## Purpose of the Toolkit

Viral hepatitis prevention and treatment are critical cancer control measures. With just a 22% five-year survival rate for liver cancer, it is essential for states and public health workers to have a better understanding of the association between HBV, HCV and liver cancer, and ways to prevent them.[8]

Despite the well-established connection between viral hepatitis and liver cancer, hepatitis B and C prevention remains a significant challenge in the U.S. Key barriers, including insurance status, high costs of treatment, and low screening rates, impede access to hepatitis B treatment and curative therapy for hepatitis C.[9,10,11] Additionally, there is a marked lack of awareness about viral hepatitis and its consequences among the general public.[12] Contributing factors to this include a limited implementation of routine screening despite updated recommendations, the largely asymptomatic nature of the viruses, misguidance on patient risk that could inhibit prevention and/or testing, and inadequate patient education.

To help address these gaps, the Matching Viral Hepatitis Surveillance Data to Cancer and Immunization Registries Toolkit is intended to be used as a complementary resource. These resources support three overarching areas:

1.) identifying HBV and HCV associated liver cancer burden,

2.) examining cancer outcomes and care patterns, and

3.) assessing HBV vaccination coverage and missed prevention opportunities.

## Resources

1 HBV stat: Wong, R. J., Brosgart, C. L., Welch, S., Block, T., Chen, M., Cohen, C., Kim, W. R., Kowdley, K. V., Lok, A. S., Tsai, N., Ward, J., Wong, S. S., & Gish, R. G. (2021). An Updated Assessment of Chronic Hepatitis B Prevalence Among Foreign-Born Persons Living in the United States. *Hepatology (Baltimore, Md.)*, *74*(2), 607–626. https://doi.org/10.1002/hep.31782

2 International Agency for Research on Cancer. (1994). *Hepatitis viruses (IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, Vol. 59). ISBN: 978-92-832-1259-1*

3 Razavi, H., Estes, C., Razavi-Shearer, D., Blach, S., Gamkrelidze, I., Razavi-Shearer, K., & Voeller, A. (2023, June 21–24). *Risk of developing cancer - comparison of HBV, HCV, and smoking* [Poster presentation]. EASL Congress 2023, Vienna, Austria. https://doi.org/10.3252/pso.eu.EASLCONGRESS.2023

4 https://www.cdc.gov/hepatitis-c/hcp/clinical-overview/index.html

5 Lewis, K. C., Heslin, K. C., & McCree, D. H. (2024). Health Equity and Viral Hepatitis in the United States. *Public Health Reports*, 00333549241305256. Advance online publication. https://doi.org/10.1177/00333549241305256

6 Sung H, Ferlay J, Siegel RL, Laversanne M, Soerjomataram I, Jemal A, Bray F. Global cancer statistics 2020: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA Cancer J Clin. 2021:71:209-249. https://doi.org/10.3322/caac.21660

7 Moyer LA, Mast EE. Am J Prev Med. 1994;10(suppl):45 55. 2. Perrillo RP, et al. Hepatology. 2001;33:424-432.

8 https://www.cancer.org/cancer/types/liver-cancer/detection-diagnosis-staging/survival-rates.html

9 Jackson, M., Ibrahim, Y., Freeland, C., Jacob, S., Zovich, B., & Cohen, C. (2024). Barriers to accessing hepatitis B medication: a qualitative study from the USA and Canada. BMJ open, 14(5), e080658. https://doi.org/10.1136/bmjopen-2023-080658

10 Wong R. J. (2025). Gaps and disparities in the treatment of chronic hepatitis B infection in the USA. Gastroenterology report, 13, goaf016. https://doi.org/10.1093/gastro/goaf016

11 Thompson, W. W., Symum, H., Sandul, A., et al. (2022). Vital signs: Hepatitis C treatment among insured adults—United States, 2019–2020. MMWR Morbidity and Mortality Weekly Report, 71(32), 1011–1017. https://doi.org/10.15585/mmwr.mm7132e1

12 “Knowledge and Awareness About Chronic Hepatitis B and Hepatitis C.” Institute of Medicine. 2010. Hepatitis and Liver Cancer: A National Strategy for Prevention and Control of Hepatitis B and C. Washington, DC: The National Academies Press. doi: 10.17226/12793.

***Note: Liver cancer in this document refers to all liver cancers, including HCC and intrahepatic bile duct cancer.***

# Primary Goals

### 1. Identify Individuals with Chronic HBV Who Developed Liver Cancer

- Establish data linkage processes between viral hepatitis surveillance systems and cancer registry data.
- Quantify the incidence of liver cancer among individuals with chronic HBV.
- Monitor demographic and geographic patterns to identify groups with elevated incidence or adverse outcomes.
  - To inform screening and care engagement strategies

### 2. Assess Cancer Outcomes Among HBV-Positive Individuals

- Evaluate liver cancer stage at diagnosis, tumor characteristics, and survival outcomes.
- Examine time from HBV diagnosis (or first positive test in registry) to liver cancer diagnosis.
- Assess engagement in care prior to cancer diagnosis (e.g., routine testing for HBV monitoring appointments, antiviral therapy).
- Identify gaps in surveillance and liver cancer screening practices (if cancer screening data is available).

### 3. Evaluate HBV Vaccination Coverage and Care Indicators to Identify Missed Opportunities

- Assess hepatitis B vaccination status among all people who develop liver cancer.
- Identify missed opportunities for vaccination, such as healthcare encounters where vaccination could have occurred, including receipt of hepatitis A vaccine, documented HCV infection and treatment, or HIV care and treatment.
- Analyze disparities in vaccine uptake by demographic, underlying health conditions, and risk characteristics.
- Inform targeted vaccination strategies and prevention efforts.

### 4. Identify Individuals with a History of HCV Who Developed Liver Cancer

- Link HCV surveillance data with cancer registry data to identify HCV-associated liver cancer cases.
- Differentiate between cleared/cured and untreated individuals (e.g., HCV treatment, subsequent HCV RNA negative results after positive).

- Evaluate time from HCV diagnosis to liver cancer diagnosis.
- Identify populations at increased risk for progression to liver cancer to inform screening and care engagement strategies.

### 5. Assess Cancer Outcomes Among HCV-Positive Individuals

- Evaluate liver cancer stage at diagnosis, tumor characteristics, and survival outcomes.
- Examine time from HCV diagnosis (or first positive test in registry) to liver cancer diagnosis.
- Assess engagement in care prior to cancer diagnosis (e.g., HCV genotype testing, HCV treatment, HCV testing at a site with treatment-capable providers).
- Identify gaps in surveillance and liver cancer screening practices.

> ***Programs may use individual sections based on available data, analytic capacity, existing partnerships and strategic priorities. At minimum, programs interested in cancer registry linkage should review the Data Governance & Legal Considerations, Data Preparation & Standardization, Matching Methodology, and Data Source Limitations sections before beginning linkage activities.***

## Data Sources & Key Variables

### 1. HBV Surveillance System

**a. Data for match**

- Primary identifiers: First name, last name, date of birth, SSN (if available)
  - SSN is often incomplete in hepatitis data
- Secondary identifiers: Geographical variables such as residential address, city, state, ZIP Code, county, and/or census tract.
  - These fields are less reliable because they reflect the patients' address at the time of diagnosis or positive laboratory results received.
- Supplementary identifiers: Demographics such as sex and race/ethnicity.
  - Race/ethnicity is often incomplete.

**b. Additional data for analysis**

- Other demographics, such as age and gender
- Date of first positive HBV test (HBsAg, HBV DNA, or HBeAg)
  - Hepatitis D co-infection and date of first positive hepatitis D virus (HDV) test (HDV RNA, HDV Total Antibody (Anti-HDV))
- Case definition
  - Include both acute and chronic cases
- Provider and facility information (specialist or providers that treat or monitor for HBV can be a proxy for care)
- Having continuous hepatitis testing (proxy for in care)

## 2. HCV Surveillance System

### a. Data for match

- Primary identifiers: First name, last name, date of birth, SSN (if available)
  - SSN is often incomplete in hepatitis data
- Secondary identifiers: Geographical variables such as residential address, city, state, ZIP Code, county, and/or census tract.
  - These fields are less reliable because they reflect the patients' address at the time of diagnosis or positive laboratory results received.
- Supplementary identifiers: Demographics such as sex and race/ethnicity.
  - Race/ethnicity is often incomplete.

### b. Additional data for analysis

- Other demographics, such as age and gender
- Laboratory data
  - HCV RNA, anti-HCV, and HCV Genotype (e.g., first positive test date, last RNA negative date)
- Case classification
  - Acute, chronic, perinatal, or resolved (i.e., cleared or cured)
- Provider and facility information (proxy for care)
- Treatment if available (proxy for care)

## 3. Cancer Registry

### a. Data for match

- Primary identifiers: First name, last name, date of birth, SSN (if available)
  - SSN is often incomplete in hepatitis data
- Secondary identifiers: Geographical variables such as residential address, city, state, ZIP Code, county, and/or census tract.
  - These fields are less reliable because they reflect the patients' address at the time of diagnosis or positive laboratory results received.
- Supplementary identifiers: Demographics such as sex and race/ethnicity.
  - Race/ethnicity is often incomplete.
- If feasible, request all cancer diagnoses to support analyses of extrahepatic cancers and other cancer outcomes.
- If the linkage is limited to liver cancer and intrahepatic bile duct carcinoma only, cancer registry personnel recommend using International Classification of Diseases for Oncology 3rd Edition (ICD-O-3) topography codes C22.0 and C22.1 combined (liver and intrahepatic bile duct) as the case definition. This definition is standard in SEER-based cancer surveillance and captures all malignant primary liver tumors regardless of histology. Of note, ICD-O-3 is the site and histology coding system used by cancer registries and is distinct from ICD-10.

ICD-O-3 Site Code:

- C22.0 Liver
- C22.1 Intrahepatic Bile Duct

- Diagnosis date
- Tumor characteristics (all Histology and Behavior codes)
- Fibrosis scores
- Cirrhosis indicators
- Comorbidity fields or secondary diagnosis codes (latter are more complete)
- Alcohol use disorder
- Substance use disorder
- Staging
- Treatment
- Survival data
- Age at diagnosis
- Zip Code, county, and/or census tract at cancer diagnosis
- Sex assigned at birth
- Marital status
- Insurance (primary and secondary)

## 4. Immunization Registry (IIS)

- Race/ethnicity
- HBV vaccination dates and vaccine type
- Vaccine series completion status, based on the recommended dosing schedule (will need to code for based on the spacing of the doses)
- Provider/location type

# Data Governance & Legal Considerations

## 1. Contact the cancer registry staff to determine whether a formal agreement is required.

## 2. Form data sharing agreements across programs as needed.

- Programs should establish any required formal agreements before data exchange or linkage activities begin. These may include Data Use Agreements (DUAs), Memoranda of Understanding (MOUs), or Interagency Agreements, depending on applicable law, policy, and program requirements.

  Key components should address:

  - Purpose and scope of data sharing
  - Specific data elements to be shared
  - Permitted uses and restrictions
  - Data security and storage requirements
  - Methods of data transmission (e.g. secure file exchange) and explicit avoidance of sharing identifiable data via email.
  - Data retention timelines and destruction procedures
  - Roles and responsibilities of each program
  - Procedures for reporting, investigating, and mitigating data breaches or unauthorized disclosures

  Agreements should clearly define allowable analytic activities and reporting/data dissemination when linking surveillance and cancer registry data.

- Considerations for Public Health Programs

  Programs should:

  - Document the statutory or regulatory authority permitting data collection and linkage
  - Confirm that the proposed use aligns with surveillance, disease control, or program evaluation mandates
  - Ensure compliance with HIPAA public health provisions and applicable state confidentiality laws
  - Clarify whether activities constitute routine surveillance or research
  - Identify data stewards and responsible authorities overseeing data use and release

  Where activities extend beyond routine public health practice, additional review may be required.

### 3. Submit application to Institutional Review Board (IRB) (if applicable).

- Programs should determine whether planned activities constitute:
  - Public health surveillance (typically not considered research, but may require an IRB exemption), or
  - Human subjects research requiring IRB review
    - Considerations include:
      - Intent to generate generalizable knowledge
      - Plans for publication or external dissemination
      - Use of identifiable data beyond routine surveillance

  If required, IRB submission should clearly describe data linkage methods, privacy protections, and risk mitigation strategies.

### 4. Reduce privacy risks.

- Programs should apply data minimization principles:
  - Limit data extraction to variables necessary to achieve analytic objectives
  - Remove or mask direct identifiers whenever feasible (for the analysis)
  - Use de-identified or limited datasets for analytic work when appropriate
- Role-based access controls should ensure that:
  - Only authorized personnel have access to identifiable data
  - Access levels align with job responsibilities
  - Signed user agreements outline permissible use and responsibilities
  - User permissions are reviewed periodically
  - Audit logs are maintained for sensitive datasets

  Secure data storage environments (e.g., encrypted drives, secure servers, restricted network folders) should be used at all times.

### 5. Determine data reporting guidelines and disclosure protections.

- Determine if matched data can be shared directly with other public health authorities, like local or state health jurisdictions.
- Apply cell suppression/aggregation to prevent re-identification in small cell sizes based on local or national guidelines.
  - For example: Rates and counts below 16 are not shown in U.S. Cancer Statistics

# Matching Guidance

## Data Preparation & Standardization

### 1. Data Cleaning

- Remove duplicates
- Standardize formats (dates, names, addresses)
- Validate key fields (date of birth, sex, identifiers)

### 2. Variable Harmonization

- Standardize formatting across datasets and apply naming conventions to clearly distinguish the source dataset of each variable version
- Standardize variable categories
  - For example: dates, race, ethnicity, etc.
- Prep address fields (e.g., Address standardization) if geocoding or using for matching

### 3. Unique Identifiers

- Deterministic fields:
  - First name
  - Last name
  - Date of birth
  - SSN (if available)
- Supplemental fields:
  - Address
  - Phone number
  - Sex

## Matching Methodology

Please see the available resources on data matching:
Dataset Matching Toolkit and Match*Pro Software.

## Workflow

### 1. Define dataset elements

- Both programs should identify variables of interest

### 2. Extract and prepare data for match

- Extract required variables from each dataset based on predefined linkage fields and variables of interest.
- Standardize variable formats across datasets.
- Perform data cleaning

### 3. Perform match

- Of note, many cancer registry programs will prefer matching data sets in-house using Match*Pro software.
- Conduct probabilistic match
  - Apply a weighted matching algorithm using a predefined score threshold to identify full and likely matches.
  - Match score threshold settings may be an iterative process between programs.

### 4. Manual review of uncertain matches

- Conduct structured manual review of records that fall within the ambiguous or intermediate match score range.
- Modify the match score threshold based on review findings or hard-code known matches that are not identified through the established threshold.

### 5. Deduplicate matched dataset

- Remove duplicate records resulting from multiple matches to the same individual.

# Data Analysis

### 1. HCV + Cancer Registry

**OBJECTIVE**

- Quantify the burden of HCV-associated liver cancer.
- Characterize individuals who develop liver cancer following positive testing for HCV.

**ANALYSIS**

#### Liver Cancer Burden

- Number and proportion of HCV registry patients diagnosed with liver cancer.
- Proportion of liver cancer registry patients diagnosed with HCV.
- Annual trends in HCV-associated liver cancer.
- Age-adjusted rates.

#### Patient Characteristics

- Identify HCV-associated liver cancer events by:
  - Demographics (age, sex, race/ethnicity, geography)
  - Underlying health conditions (if available in HCV registry or cancer registry)
  - Risk factors (if available)

- In care for HCV
  - Potential proxies for care includes individuals tested by an HCV treating provider, those with documented receipt of HCV treatment, or laboratory evidence consistent with HCV cure or viral clearance (e.g., documentation of a subsequent negative HCV RNA result following a prior positive HCV RNA test)
- Cured or cleared for HCV
- Incorporate community-level indicators where possible (SVI, ACS variables based on place, Healthy Places Index (if applicable to jurisdiction))

### Additional Analysis

- Time-to-event analyses (e.g., time from HCV diagnosis (or first positive test in the HCV registry) to liver cancer diagnosis; survival following liver cancer diagnosis)
- Clinical characteristics
  - Staging at liver cancer diagnosis
- Spatial clustering of HCV-associated liver cancer burden
- Predictors of liver cancer and mortality among HCV-associated liver cancer
- If bandwidth allows, identify extrahepatic cancer events

## 2. HBV + Cancer Registry

**OBJECTIVE**

- Quantify HBV-associated liver cancer burden.
- Characterize individuals who develop liver cancer following positive testing for HBV.

**ANALYSIS**

### Liver Cancer Burden

- Number and proportion of HBV registry patients diagnosed with liver cancer.
- Proportion of liver cancer registry patients diagnosed with HBV.
- Annual trends in HBV-associated liver cancer.
- Age-adjusted rates.

### Patient Characteristics

- Identify HBV-associated liver cancer events by:
  - Demographics (age, sex, race/ethnicity, geography)
  - Underlying health conditions (if available in HBV registry or cancer registry)
  - Risk factors (if available)

- In care for HBV
  - Potential proxies for care includes individuals tested by an HBV treating provider, those with documented receipt of HBV treatment, or laboratory evidence consistent with continuous HBV testing (HBV DNA, HBsAg, HBeAg) every 18-24 months or HBV testing within the last 18-24 months.
- Incorporate community-level indicators where possible (SVI, ACS variables based on place, Healthy Places Index (if applicable to jurisdiction))

### Additional Analysis

- Time-to-event analyses (e.g., time from HBV diagnosis (or first positive test in the HBV registry) to liver cancer diagnosis; survival following liver cancer diagnosis)
- Clinical characteristics
  - Staging at liver cancer diagnosis
- If bandwidth allows, identify extrahepatic cancer events
- Spatial clustering of HBV-associated liver cancer burden
- Predictors of liver cancer and mortality among HBV-associated liver cancer

## 3. HBV + Immunization Registry

**OBJECTIVE**

- Identify missed prevention opportunities.

**ANALYSES**

### Vaccination Coverage

- Proportion of fully vaccinated
  - Completion of recommended vaccine series appropriately
- Proportion of partially vaccinated
- Proportion of unvaccinated

### Additional Analyses

- Missed vaccination opportunities
  - Received hepatitis A vaccine, were diagnosed with HIV, or were treated for HCV
- Breakthrough infections
  - Time from vaccination completion to testing positive for HBV

### 4. Combined Dataset

- Improve race and ethnicity completeness by leveraging linked data sources.
- Stratifications:
  - Geography (e.g., ZIP Code, county, neighborhood, planning districts, census tracts)
  - Race/ethnicity
    - » If race/ethnicity information in the hepatitis surveillance system was obtained through case investigation or interview, jurisdictions may consider prioritizing that value. If the hepatitis case was not interviewed and race/ethnicity data are missing, incomplete, or derived solely from laboratory reporting/ medical records, cancer registry race/ethnicity data may be preferred due to typically higher levels of completeness and validation. Jurisdictions should consider conducting a concordance assessment and establishing documented decision rules for resolving discrepant values.
  - Age groups
  - Sex
  - Community level indicators
  - Insurance (if available)

# Data Source Limitations

## Hepatitis Registries

Several limitations should be considered when using hepatitis registries for linkage with liver cancer and related analyses. First, case ascertainment is incomplete, as registries rely on laboratory reporting and provider submissions and therefore do not capture individuals who are untested or not reported to public health systems. In addition, jurisdictions vary in laboratory reporting regulations, which can result in inconsistent receipt of all hepatitis B and C laboratory results. For example, some health departments may not consistently receive all hepatitis B or C laboratory reports or negative results (e.g., HBsAg, HBV DNA, or HCV RNA), which can limit the ability to fully construct care engagement proxies.

Similar limitations apply to hepatitis D surveillance. HDV is not reportable in all jurisdictions, and even where it is reportable, health departments may not receive all relevant laboratory results. In addition, not all laboratories can perform HDV RNA testing in-house, and may need to send specimens to external reference laboratories. Depending on reporting requirements, these results may not be consistently transmitted to health departments. Consequently, HDV infections may be under ascertained, and registry data may not fully capture the extent of HDV testing, infection, or engagement in care.

The time when people are reported to health departments for hepatitis B, C, or D may not be their actual diagnosis date. Initial infection could have

occurred at any time before reporting, unless specifically identified through medical records or self-report. Additionally, due to resource constraints, viral hepatitis programs are often unable to routinely determine whether individuals have moved out of the jurisdiction and subsequently received a liver cancer diagnosis elsewhere.

Data quality and completeness can vary, with missing or inconsistently reported demographic, clinical, and risk factor information limiting the ability to fully characterize populations or adjust for important covariates. Hepatitis registries also typically contain limited clinical details, particularly regarding liver disease staging, fibrosis progression, and treatment history, which constrains the ability to fully assess disease progression pathways to liver cancer. In addition, registry data do not consistently capture key elements of care, including linkage to care, retention in care, treatment initiation, and treatment completion, which limits evaluation of clinical management factors.

## Cancer Registry

While Interstate Data Exchange Agreements facilitate the sharing of cancer data across jurisdictions, they may also introduce limitations. In some cases, agreements restrict the sharing of individual-level records for cases diagnosed outside a patient's state of residence. When sharing is permitted, exchange records may contain fewer variables than abstracted records, which may limit analytic capacity in cross-state work.

Cancer registries capture detailed information on cancer diagnosis, staging, and treatment, but do not collect data on behavioral or environmental risk factors such as diet, physical activity, or toxic exposures, nor do they include detailed socioeconomic measures. These variables fall outside standard abstracting requirements and must be obtained through linkage to external data sources or supplemental studies when etiologic or equity-focused analyses are planned.

As a result, analysis may not be able to fully account for factors associated with cancer risk.

Additionally, data released under a data use agreement typically represents a fixed analytic extract as of the release date. Because the registry continues to refine records retroactively through abstraction, consolidation, and quality assurance, recently diagnosed cases may be less complete than in earlier years, and the most recent data may not yet be available for analysis. Close-out lag and the data release year should be noted when interpreting findings for recent time periods. These delays may affect the completeness of recent diagnosis years and postpone data availability for analysis and dissemination

Finally, jurisdictions should also consider that registry operations may be affected by resource constraints, including staffing, funding, and infrastructure limitations. Variability in resources can influence timeliness of data close-out.

## Immunization Registries

Adults are only newly included in some Immunization Registries. When individuals relocate, their childhood vaccination records typically do not transfer to the new state where they may later test positive for HBV/HCV or develop liver cancer.

# Best Practices

### 1. Data Quality

- Regular audits of missing data

### 2. Sustainability

- Automate matching workflows where feasible
- Schedule routine linkage (e.g., yearly, quarterly)
- Maintain reproducible code (SAS/R/Python)
- Longstanding MOUs or other agreements in place that help expedite data sharing for results

### Outputs & Public Health Action

- Dashboards for HBV and liver cancer diagnosis and outcomes (e.g., Tableau, Power BI, ArcGIS Enterprise)
- Dashboards for HCV and liver cancer diagnosis and outcomes (e.g., Tableau, Power BI, ArcGIS Enterprise)
- Produce reports on:
  - HBV and HCV-associated cancer burden
  - Identify and report vaccination gaps (for HBV) and missed prevention opportunities.
- Translate findings into actionable program and policy recommendations, such as:
  - Vaccination outreach priorities
  - Care linkage interventions
  - Resource allocation for high-burden areas
  - Ensure outputs are tailored for multiple audiences

# Future Opportunities

- Integration with electronic health records (EHRs)
- Real-time or near-real-time matching
- Inclusion of mortality data

# Acknowledgements

NASTAD is grateful to Eman Addish, Michaela Jackson, and Sarah New for the development of this resource and to the following persons that facilitated the review whose contributions and support made this publication possible: Rita Isabel Lechuga, Chari Cohen, Zakiya Grubbs and Phillip Rideoutt II.