Michigan Data Warehouse Case Study

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Executive Summary

A state or jurisdictional data warehouse brings together multiple sources of data from state agencies, community providers, and public health agencies that are integrated, managed, and shared. These data warehouses can be an important solution for better and more complete data, including data on homelessness and its impacts on health. While data warehouses were often originally developed to understand individuals' healthcare and services utilization, they can have tremendous potential to better understand and address individual and population health needs when linked to public health data.

This case study draws on key informant interviews and review of available documentation (methodology detailed im Appendix B) to report processes employed by Michigan to integrate Homeless Management Information System (HMIS) data into an existing state data warehouse. Michigan is currently using warehouse data to inform and address housing needs, assess other service needs, coordinate medical care and service provision, and coordinate public health intervention and prevention services. The data warehouse provides comprehensive data to inform state initiatives to identify people experiencing homelessness (PEH) and provide needed social and healthcare services. Initiatives implemented through HMIS data integration within the state data warehouse are described. Additionally, the case study reports on how public health agencies utilize data linkage to enhance public health prevention and intervention efforts for PEH.

Incorporating HMIS data into an existing state data warehouse can be challenging as evidenced by the lessons learned presented in the case study. Two primary factors led to successful HMIS data incorporation into the Michigan data warehouse: 1) the willingness of all Continuum of Care (CoC) organizations within the state to participate in the process and provide housing data, and 2) all CoCs use the same HMIS reporting data system reducing challenges with incorporating data into the warehouse.

Many jurisdictions are investigating ways to implement and manage a data warehouse that incorporates HMIS data. The Centers for Disease Control and Prevention (CDC) is providing this case study to help inform jurisdictions on important considerations when planning and implementing state data warehouses based on Michigan's experience, including warehouse structure, data sharing mechanisms and policies, real-life usage to advance public health, a discussion of the cost benefit, and lessons learned (Table 2).

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1 Introduction

Homelessness is an important factor that can impact an individual's health and well-being. People experiencing homelessness (PEH) are at increased risk of exposure to infectious diseases and violence and may experience higher rates of untreated chronic conditions [1]. A person's housing status (i.e., whether someone is experiencing homelessness or is housed) is a key social determinant of health (SDOH). SDOH are the social, economic, and environmental factors that affect health outcomes and quality of life.

A state data warehouse is a centralized repository for storing, managing, and sharing data from various sources such as state agencies, community providers, and public health agencies. Data warehouses consist of at least two datasets from different sources but may contain multiple state agency datasets [3].

The United States Department of Housing and Urban Development (HUD) is the federal entity that administers homelessness assistance programs and funding to state and local governments and nonprofit providers for housing services for individuals and families affected by homelessness [2]. HUD requires federally funded homeless assistance programs to collect data on individuals and services within the Homeless Management Information System (HMIS). Data on homelessness are imperative to understanding unmet social and healthcare needs for PEH (and other critical populations) and ensuring access to essential public health services. HMIS data can be integrated with medical records, other services data (e.g., welfare, supplemental nutrition assistance programs), and public health data to provide a more complete picture of the needs of individual PEH and the larger population. A data warehouse can centralize data management and link disparate data to coordinate social and healthcare services and prioritize interventions for PEH.

The Centers for Disease Control and Prevention (CDC) sought to better understand states' experiences with implementing data warehouses and how they are utilizing this tool to obtain better data on homelessness and address its impacts on health. This case study describes the implementation, structure, and use of the Michigan Data Warehouse. The benefits of data linkage to enhance planning and to provide an evidence base for policy action to improve population health are outlined. Additionally, the case study enumerates the challenges Michigan encountered with implementing a state data warehouse and provides lessons learned for other states considering establishing a data warehouse.

The primary sources for the information presented are key informant interviews and existing documentation such as materials from public presentations and news articles, and state agency and community websites. For more detail on the methodology used in conducting the case study, see Appendix B.

2 Background

HMIS data systems originated from a 1998 Congressional mandate directing HUD to explore the implementation of a data system to track homelessness, and the HUD Appropriations Act funded HMIS development in 2001 (Figure 1). Continuums of Care (CoCs) are local organizations mandated by HUD to provide planning and coordination for housing services and funding. In 2004, HUD released the HMIS data and technical standards which local CoCs are expected to follow when collecting information about homeless clients [4][4]. The HMIS data collected includes demographic and eligibility data on individuals and housing services received by PEH and those at risk of homelessness.

State CoC organizations collect and report HMIS data using varying data collection, storage, and reporting techniques [5]. CoCs can choose the software they use for collecting HMIS data and set their own data management processes. Information technology (IT) vendors develop differing HMIS software solutions, but all software must comply with HUD data collection, management, and reporting standards. CoC's ability to choose their own HMIS reporting software can complicate the integration of varied systems' data into a centralized state data warehouse. CoC participation in providing HMIS data to statewide data warehouses is voluntary so it is imperative for states to communicate the benefits of sharing data to get buy-in.

CoCs differ in their affiliation and location. They can consist of local governments, nonprofit organizations, advocacy groups, and other interested parties. They are located in urban and rural environments. At times, rural communities will create a single CoC in their state and these are known as Balance of State CoCs. There is no limit on the number of CoCs in a state. For instance, in 2021, Wyoming had four CoCs while California had 44 CoCs. At present, Michigan has 20 CoCs [6].

3 Michigan Data Warehouse

3.1 Data Warehouse Creation

Michigan created the state data warehouse in 1994 with approval and funding from the Centers for Medicare & Medicaid Services (CMS) to investigate Medicaid fraud and abuse. The warehouse was later expanded to include Medicaid analytics.

In 1994, two separate state agencies, the Department of Community Health, and the Department of Human Services, interacted with and collected data from the same populations. To address redundancies in data collection, improve reporting, and integrate data for analytics, the state IT and Human Services departments collaborated to develop and implement the enterprise data warehouse. Over time, additional datasets such as immunization records, vital statistics, lead testing, and the Special Supplemental Nutrition Program for Women, Infants, and Children data were added to the warehouse. Figure 1 shows the timeline for development of the Michigan data warehouse, including HUD's creation of HMIS standards.

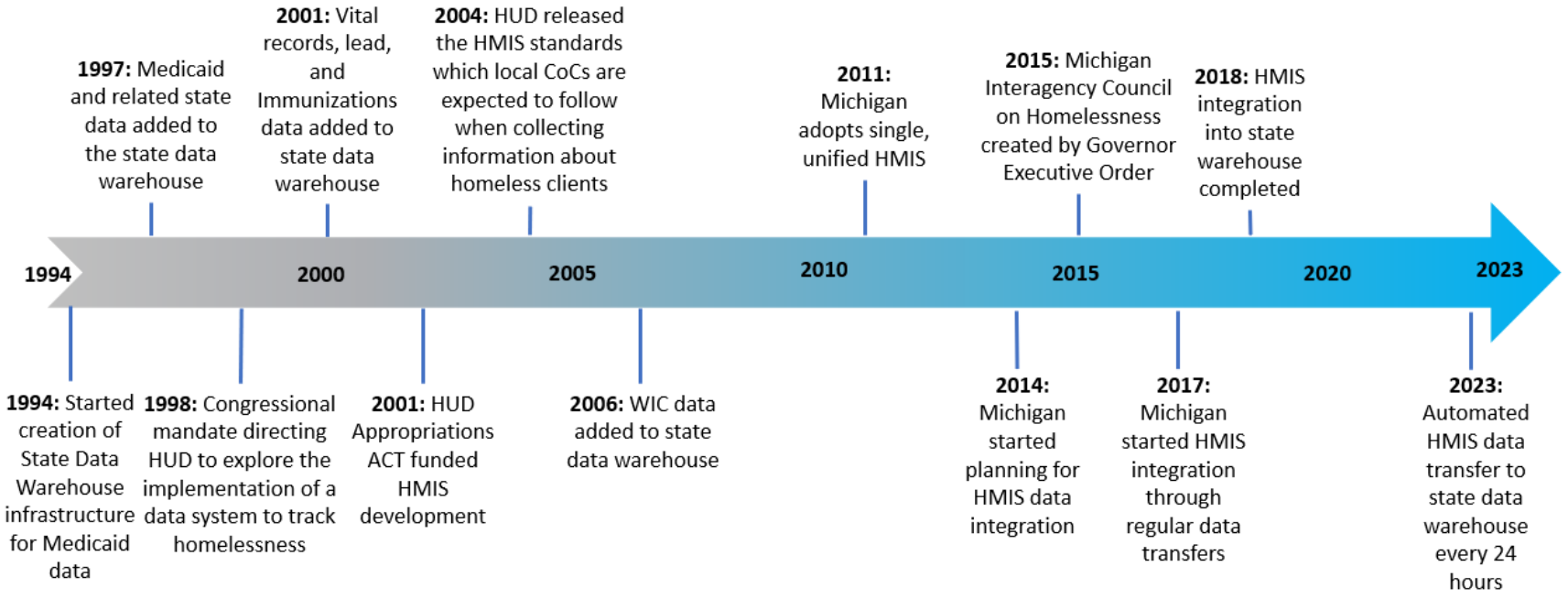

Figure 1: Michigan Data Warehouse Timeline

Accessible Text Version:

1994- Started creation of State Data Warehouse; 1997- Medicaid and related state data added to the state data warehouse; 1998- Congressional mandate directing HUD to explore the implementation of a data system to track homelessness; 2001- Vital records, lead, and immunization data added to state data warehouse and HUD appropriations act funded HMIS development; 2004- HUD released the HMIS standards which local CoCs are expected to follow when collecting information about homeless clients; 2006- WIC data added to state data warehouse; 2011- Michigan adopts single, unified HMIS; 2014- Michigan started planning for HMIS data integration; 2015- Michigan Interagency Council on Homelessness created by Governor Executive Order; 2017- Michigan started HMIS integration through regular data transfers; 2018- HMIS integration into state warehouse completed; 2023- Automated HMIS data transfer to state data warehouse every 24 hours.

The need to include HMIS data in the data warehouse arose when state agency queries of existing datasets (e.g., health and housing data) indicated homelessness was an important issue to address, though data collected about homelessness and housing status were of poor quality. The state wanted to better understand the interactions of PEH with state agency programs. The inclusion of HMIS data with its required HUD homelessness standardized data elements [7] enabled an inclusive and comprehensive analysis. Michigan Department of Health and Human Services (MDHHS) staff developed the following questions for analyses on homelessness to inform the development of interventions for PEH:

1. What are the commonalities among PEH?
2. What trends do we see in the data?
3. What can be done programmatically to improve the quality of life for PEH?
4. What additional services can be provided to PEH beyond obtaining housing?
5. How can state agencies work together to address and improve SDOH in PEH?
6. How can the data be used to ensure PEH are included for services?

Michigan recognized that access to consolidated datasets would benefit multiple state and community partners that work with PEH such as community behavioral, mental, and physical health organizations, local health departments, school systems, and hospitals.

From 2013-2017, Michigan planned for the addition of the state's HMIS data to their data warehouse. Though it is not uncommon for a state's CoCs to use various data management tools for HMIS reporting, in 2011 all 20 Michigan CoCs began using a single, unified HMIS reporting system. This unified system was an important component in the smooth integration of CoC data into the state data warehouse.

HMIS integration started in 2017 with a progressive data transfer model that began with manual data transfers on an ad hoc basis. Michigan completed the HMIS data transfer process in 2018. As capacity grew, subsequent data transfers occurred monthly via requests to the single statewide CoC HMIS vendor. A grant from the Michigan Health Endowment Fund allowed the development of an automated data feed. As of February 2023, automated transfers occur every 24 hours. The integration required a collaborative effort by multiple state and stakeholder partnerships described in **Table 1**.

Table 1. Michigan HMIS Data Warehouse Partners

Agency/Organization	Role in HMIS Integration	Notes
Michigan Coalition Against Homelessness (MCAH)	HMIS Data Trustee	Nonprofit state advocacy organization. Provides education, training, and legislative recommendations. Manages the Michigan Statewide HMIS Learning Center and serves as a central location where users from agencies across Michigan can complete the necessary certification to be able to use HMIS.
Michigan State Housing Development Authority	Manages the Balance of State Continuum of Care and sends HMIS data to the warehouse.	Provides financial and technical assistance to create and preserve affordable housing, engages in community economic development, and addresses homelessness issues.
Michigan Department of Health and Human Services (MDHHS)	Houses and manages the data warehouse.	Business owner and repository for Health and Human Services data. Chief Data Steward and Privacy Officer are responsible for data access requests.
Michigan Continuums of Care (CoCs)	Collects and reports HMIS data to HUD for homelessness and housing grants to fund programs and projects.	Twenty statewide local/regional CoCs using a unified HMIS. Provide intake and assessment services, emergency, transitional and permanent supportive housing. Conducts the HUD Point-in-Time count.[1]
Michigan Interagency Council on Homelessness (ICH)	Advises on planning and policy development. Promotes systems integration to increase efficiency and effectiveness.	Thirteen-member centralized state advisory council representing 8 state agencies, 1 member of the court, and 4 members of the public.

[1] The Point-in-Time count is a count of sheltered and unsheltered people experiencing homelessness on a single night in January. HUD requires that CoC's conduct an annual count of people experiencing homelessness in emergency shelters, transitional housing, and Safe Havens and a count of unsheltered people experiencing homelessness every other year (odd numbered years).

The governor of Michigan, Rick Snyder, who served from 2011–2018, was a key champion for ending homelessness and enacted policy to improve services for PEH. The expansion of the data warehouse to include HMIS data allowed for significant improvements in services coordination for PEH as described later in this document in the section on public health impacts. The Governor's Executive Order 2015-2 created the Michigan Interagency Council on Homelessness (ICH), a statewide, centralized advisory council in 2015 [8]. The Council provides planning and policy development, incorporates public input, and allows for efficient collaboration among state agencies. The ICH at creation consisted of thirteen members appointed by the Governor. The ICH includes directors from eight state agencies (Figure 2) and is chaired by a member from the Michigan State Housing Development Authority. The large state agency presence helped support efficient data integration collaboration efforts for the state data warehouse. These vested parties had knowledge of the intended purposes and understood that data integration could result in providing more efficient and effective services and programs. The membership composition of the Council is currently being restructured to ensure representation of those with lived experience of homelessness in Michigan on the ICH [9].

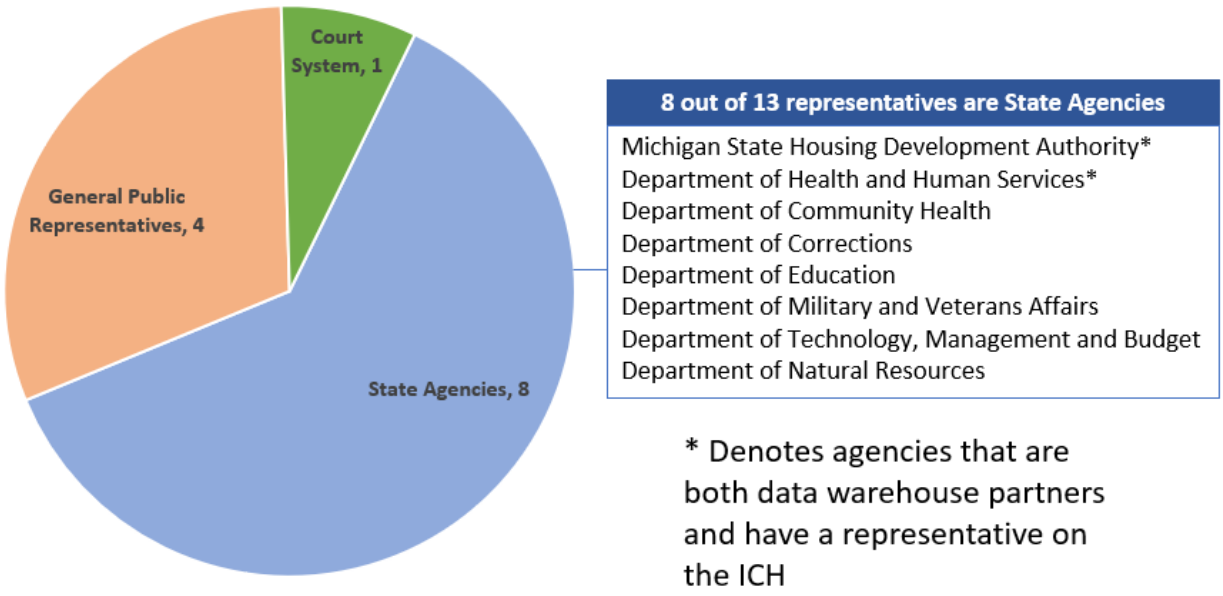

Figure 2: Michigan Interagency Council on Homelessness Composition as of 2015-2022

Accessible Text Version: Denominator is 13 total representatives on the Michigan ICH. The largest section of the pie chart is for 8 state agencies (these include: Department of Community Health, Department of Corrections, Department of Education, Department of Military and Veterans Affairs, Department of Technology Management and Budget, and Department of Natural Resources, Michigan Housing Development Authority, and Michigan Department of Health and Human Services- the last two of these, Housing Development and Health and Human Services, are both on the ICH and are data warehouse partners). The second-largest pie chart section is for the 4 general public representatives, and the final and smallest section denotes the one court system representative.

3.2 Warehouse Structure and Data Sharing Mechanisms

The state data warehouse is stored in a shared services environment of the Michigan Department of Technology, Management, and Budget. The MDHHS specified portion of the data warehouse consists of four component databases: Health, Assistance Programs, Child Protective Services,

and Child Support. Participating state agencies have direct access to their agency data in the warehouse to conduct queries of various populations but must submit a request to access HMIS data.

The Michigan Coalition Against Homelessness is the trustee of HMIS data and oversees CoC activities regarding HMIS data management and incorporation. The data are transmitted into the warehouse, replicated at ingestion, and enhanced with additional transformed and/or calculated values such as risk indicators. Requests to access CoC HMIS data for matching or other purposes are managed by a full-time MDHHS Data Warehouse Project Director who serves as the Chief Data Steward and Privacy Officer.

The transmission of HMIS data into the warehouse occurs daily via an automated transmission process. HMIS data is a stand-alone database within the warehouse environment and is connected to other warehouse datasets via queries that use the Master Person Index (MPI), which is described below.

3.2.1 Consent and Data Matching

Michigan's consent process used for the data warehouse was honed during the planning and implementation of their CMS State Innovation Models Initiative, which supported the development and testing of jurisdictional models to improve health system performance [10]. Michigan spent approximately 2 years developing privacy policies and processes for data sharing to address client privacy concerns. Initial aggregate level data queries to determine client risks regarding housing and physical and mental health needs are covered under inter-agency agreements as described in Section 3.2.2. Client consent is required when clients with identified risk factors are referred to appropriate interventions. If needs are identified that could be met with available resources, the client must agree to provide a second release of information to verify the client's eligibility to receive identified resources.

To enable data matching, Michigan uses a MPI algorithm to identify clients to match client records within and among databases. The intent of the MPI is to prevent duplication of client records and to provide consistent and accurate information across all systems [11]. The MPI consists of a client's first name, last name, date of birth (DOB), Social Security number (SSN), address, and other client identifiers, if available. These MPI data elements are prioritized for matching in the following order: SSN, DOB, last name, first name, address, and if needed and available, additional client identifiers. Incomplete data on PEH can be problematic and agencies are urged to collect complete client and household information at intake as data quality affects the algorithm's data matching ability to determine client/household program eligibility.

A common challenge to this process of matching client data between different datasets is the difficulty that people and families experiencing homelessness encounter in obtaining and retaining documents commonly used for identity verification. The lack of a permanent mailing address and access to secure storage makes it difficult to obtain and retain documentation such as birth certificates, state identification (ID) cards, and SSN. To alleviate barriers to obtaining needed identification, Michigan provides fee waivers for PEH to obtain state IDs and birth certificates through two legislative actions spearheaded by the MCAH and the State ID Task Force, the Free for Me ID program and the birth certificate agency reimbursement program administered by MDHHS 0. Michigan provides PEH HMIS ID cards and Homeless Verification letters to serve as proof of eligibility for the fee waiver programs. People who obtain

identification through these programs are easier to match across data sources to verify eligibility for available services and resources.

3.2.2 Data Security and Sharing

In the data warehouse, aggregated data are shared among agencies through inter-agency agreements and only on a need-to-know basis. The inter-agency agreements contain a research clause where aggregated data can be used for data matching, though individual client data are protected and can only be shared with the client's consent to release of information at each step of the process. For the regional CoCs, protecting client and household data is of utmost importance, and multiple layers of policies and procedures are in place to ensure that client data are protected.

The foundation for client privacy of the Michigan HMIS data is the Health Insurance Portability and Accountability Act (HIPAA) of 1996 which protects against unauthorized sharing of patient data [13]. MDHHS is a hybrid department where some programs (e.g., Medicaid) must be HIPAA-compliant, while other areas that assess eligibility for human services are not covered entities under HIPAA. However, all participating systems that interact with HMIS data are held to HIPAA privacy rule requirements for two main reasons. First, MDHHS policy requires protection at the highest level based on the regulations specific to the data and MDHHS data classification. Secondly, this establishes the standard to unify privacy protections across all agencies.

On top of HIPAA, Michigan is also incorporating the five tenets of the Blueprint for an AI (Artificial Intelligence) Bill of Rights 0 which will serve as a governance model for data privacy for the state data warehouse:

- Safe and Effective Systems: You should be protected from unsafe or ineffective systems.
- Algorithmic Discrimination Protections: You should not face discrimination by algorithms and systems should be used and designed in an equitable way.
- Data Privacy: You should be protected from abusive data practices via built-in protections, and you should have agency over how data about you are used.
- Notice and Explanation: You should know when an automated system is being used and understand how and why it contributes to outcomes that impact you.
- Human Alternatives, Consideration, and Fallback: You should be able to opt out, where appropriate, and have access to a person who can quickly consider and remedy problems you encounter.

3.3 Applications for Public Health

State data warehouses can provide extensive data that can be used for public health efforts to understand and address individual and population health. When public health data are included in or matched with data in a state data warehouse, the availability of timely and complete data can enhance efforts to inform public health interventions, direct research, and guide prevention efforts. The rich data provided by a data warehouse can help federal, state, and local partners to coordinate resources and collaborate to direct public health efforts.

Michigan shared several initiatives that utilize the state data warehouse in addressing population health. For example, the Blood Lead Module of the Michigan Care Improvement Registry enables providers to view serum lead testing results and Medicaid Well Child visit records

through a real-time connection to the data warehouse. The Blood Lead Module also suggests an interpretation of the results and recommended actions based on test results [15].

3.3.1 HMIS and Medicaid data linkages: CareConnect360 and Medicaid Frequent User Pilot

While there are several population health initiatives, the focus of this case study is on how the data warehouse can be utilized to improve individual care and population health for PEH. The MDHHS Housing and Homeless Services Division relies on these data to measure progress, identify gaps, and inform policy and program decisions [15]. Michigan has implemented various pilot programs and initiatives to determine how PEH interact with existing programs and services. These data are used to inform how to best identify and mitigate service gaps, improve health and SDOH outcomes for PEH, reduce service duplication, and save healthcare resources. The pilot programs and initiatives below describe how Michigan is using HMIS data linkages to improve PEH healthcare access, guide treatment interventions, and reduce related costs.

CareConnect360, a care management tool that provides a comprehensive view of individuals and populations, was originally established in 2014 for the state's Medicaid health plans to link physical and behavioral health data for integrated care. Providers reported that individuals with behavioral illnesses experienced higher rates of chronic conditions such as diabetes and cardiovascular disease. Linking physical and behavioral health-related data, as well as human services data, allowed a holistic picture of an individual's care needs and improved care coordination [17]. The effort has been nationally lauded. Following a presentation on CareConnect 360 at the 2016 Medicaid Enterprise Services Conference, a staff member of the Office of the National Coordinator noted the system's ability to advance health outcomes and control healthcare costs [17]. In 2017, MDHHS expanded CareConnect360 to incorporate data from the foster care system, which allowed for a comprehensive picture of a child's medical history to ensure the child's medical needs are met while in foster care [18].

In 2018, Michigan started an ongoing initiative to link HMIS and Medicaid data through the state data warehouse in a pilot study to connect people insured by Medicaid with higher medical needs to available services. The pilot focused on improving data quality through data integration, optimizing the capacity of the homeless response system, and improving the quality of permanent supportive housing. An additional focus was on building capacity to leverage Medicaid reimbursement. Michigan has applied for a waiver through CMS to reimburse some tenant-based support services. The state is offering training to permanent supportive housing agencies to obtain eligibility to bill Medicaid for housing-based services or to contract with Medicaid-billable agency for reimbursement [20].

The program started by identifying individuals insured by Medicaid who frequently accessed medical services and cross-referenced HMIS data using the MPI [18]. Through the data matching process, if a client was identified as eligible to receive additional services, they were placed on a list that went back to their case manager. The case manager could then relay to the client that they may be eligible for additional services. If a client was interested and provided consent via a secondary release process, data from the warehouse could be used to verify eligibility for accessing the services.

MDHHS has since leveraged CareConnect360 as a tool to foster collaboration between healthcare providers and homelessness service providers. The goal is to improve coordination between health and housing systems through real-time data integration, ultimately to improve

quality of life as well as health outcomes for PEH. Specifically, the linkage of CareConnect360 with HMIS data enables the calculation of two vulnerability scores to help healthcare and homeless services providers to better prioritize and assess PEH for needed services: a homeless vulnerability score and a medical vulnerability score.

Healthcare providers can use the homeless vulnerability score to understand their patient's housing status and how it may impact their medical care. The score uses linkages between Medicaid data and HMIS records from the previous two months to classify a person as low, medium, or high risk. The classification is made based on HMIS entries from day shelters, overnight shelters, and street outreach programs. A low-risk homelessness vulnerability score indicates one HMIS entry that is less than 30 days in length. Medium-risk scores indicate one to four HMIS entries with a combined length of stay of more than 30 days (or more than four HMIS entries with a combined length of less than 30 days). A high-risk score indicates five or more HMIS entries with a combined total of more than 30 days [20].

Homeless services providers can utilize the medical vulnerability score to help coordinate care for PEH. The medical vulnerability score is calculated based on Medicaid data on utilization of health services and inpatient care, comorbid physical conditions, behavioral health conditions (e.g., substance use disorder), historical diagnoses, pregnant/postpartum status, and certain demographics. The medical vulnerability score is assigned on a five-point scale, where scores of three, four, or five indicate a need to prioritize housing and care coordination between healthcare and homeless services providers. These vulnerability scores are a concrete example of how data linkages through the data warehouse and CareConnect360 has increased communication and transparency between healthcare and homeless services providers, providing opportunities for more tailored and holistic approaches to preventative care [20].

3.3.2 HMIS and Immunization Registry Linkages: COVID-19 Outreach Program

Racial and ethnic minority groups are overrepresented in homeless populations in the U.S. and in Michigan [21]. An aggregate study in Michigan compared COVID-19 outcomes and vaccinations across geographic, racial, and ethnic groups. The study showed that vaccine acceptance and vaccination coverage rates across Michigan were correlated with both the socioeconomic status and the racial and ethnic composition of a neighborhood [22]. The state established the Michigan Coronavirus Task Force on Racial Disparities to advance racial equity in access to COVID-19 public health services. The task force was created as an advisory body within the MDHHS.

Informants interviewed reported that the state linked HMIS data with immunization datasets to identify areas with low uptake of COVID-19 vaccines. MDHHS established mobile clinics to reach those areas of the state that may have had a significant at-risk population, to include PEH, and a dearth of vaccination sites. Areas with limited public transit and lower access to healthcare services were prioritized when deciding on locations for mobile clinics [23]. Informants reported that the program leveraged trusted partners in the community, such as pastors or county commissioners, to message on COVID-19 vaccination safety and effectiveness, which ultimately contributed to increased utilization of the program's mobile clinics. Being able to identify community locations in areas of need and having a trusted community liaison were pivotal to the COVID-19 vaccination outreach program's success.

Based on the linked HMIS and immunization data, MDHHS also initiated focused outreach to provide vaccinations onsite in homeless shelters. With data to justify the need, resources were directed to better serve the PEH population. A key informant noted that data linkage efforts aided in developing local level relationships to build strong connections between the homeless response system and local public health departments during the COVID-19 pandemic.

Michigan plans to use the processes and protocols developed for this COVID-19 outreach program to address current and future vaccination and related health needs for at-risk populations.

3.3.3 HMIS and Overdose Data Linkages: Substance Use Initiative

Michigan's latest data warehouse pilot program will match substance use disorder (SUD) data and HMIS data. Currently, this initiative is in the process of getting the necessary approvals for implementation with an anticipated start date in September 2023. This program will link HMIS data and data from MiCelerity, a distinct system that contains drug poisoning surveillance data. MiCelerity contains data from two main sources: electronic health record data on identifiable non-fatal overdoses and information on fatal overdoses from the Electronic Death Registration System.

The goal of the program is to cross-reference overdose data in MiCelerity with HMIS housing status data in the data warehouse, using the MPI. The pilot will focus on a defined period of time and codes indicating poisoning by either of the following: overdose, inadequate dose, or adverse effects from substance administration inadvertently or deliberately.[2] The quality of record matching will be reviewed based on linked identifiable fields from the MPI.

Interviewees from MDHHS stated the motivation for this project was cross-department interest in linking public health program data with HMIS data to enhance data quality and accuracy on housing status within MDHHS programs. Due to the strong associations between substance use, increased risk of viral hepatitis, and housing instability, the Viral Hepatitis Division was a key advocate for this pilot. The primary aim of this pilot study is to assess the extent of the correlation between housing status and the risk of SUD and to disseminate these results for program and policy use. Findings will supply a high-quality evidence base to apply for and increase grant funding for under-resourced communities to address housing needs and SUD.

3.4 Cost Benefit

While key informants noted that there are costs associated with implementing a state data warehouse, they emphasized that the opportunities for data linkages across governmental state agencies have substantial value. Informants noted that state data warehouses can increase the effectiveness of services, which can be measured, and influence funding distribution to better address needs.

The cost benefit of a state data warehouse is longitudinal in nature, as stated by informants, and is driven by preventative interventions that would result in cost savings over a long-term horizon.

[2] For the pilot linkage of MiCelerity and HMIS data, linkages will be restricted to individuals with admission or death dates between January 1, 2020, through June 30, 2023, and to diagnostic codes indicating probable poisonings as defined by International Classification of Disease 10 codes T36-50 [24] within the system. Each numerical T-code maps to a unique type of drug (e.g., antibiotics, narcotics, psychotropic drugs).

In instances where the state data warehouse has been connected to healthcare data, such as with vaccination and primary care visits, the state may be able to better prioritize opportunities to expand preventative care and increase connections to social services. Michigan may already be seeing the benefits of HMIS incorporation with healthcare data as MDHHS restructured services for homeless populations that were indicated as frequent users of Medicaid services and the emergency room (ER). By enrolling PEH into permanent supportive housing programs, case managers reported seeing a reduced number of ER visits, illustrating that the warehouse data linkages may have a significant role in enabling the necessary partnerships to address the social needs of the population. Positive overall health outcomes and lower costs on healthcare, including reduced ER utilization, were reported by informants.

Key informants described how the state data warehouse allows for a holistic picture of an individual, and can result in a comprehensive client record, non-duplication of services, connections to needed services and prioritized service provision, as well as the ability to provide timely public health prevention and intervention. MDHHS has better visibility on PEH that has enabled increased coordination of care and supportive services, which may reduce the burden of health conditions on individuals and the population overall. Currently, plans are in progress to incorporate additional datasets such as child protective services and correctional data, which could further benefit disproportionately affected populations.

3.5 Challenges and Lessons Learned

The development of the Michigan data warehouse was an extensive and time intensive endeavor spanning almost 30 years. Michigan's experience in integrating housing data into the state data warehouse was not without challenges and has culminated in lessons learned. The following table details those challenges experienced and lessons learned that could be useful for other states who are considering or embarking on implementing a state data warehouse.

Table 2. HMIS Data Integration and Use: Challenges and Lessons Learned

Challenge	Description from Case Study	Lessons Learned
Fostering CoC Collaboration	It was beneficial to Michigan's efforts that CoCs already trusted and engaged with MCAH for education, training, and certification for HMIS users. MCAH's support and collaboration on the addition of HMIS data to the data warehouse was a key factor in CoC participation. MCAH, as the statewide HMIS data trustee, prioritized and addressed the CoCs' data privacy concerns through privacy policy development and implementation, further enhancing the trust and collaboration between partners.	A strong partnership, based on trust, cooperation, and collaboration is needed for full CoC participation. The cultivation and maintenance of collaborative CoC relationships is crucial for HMIS data warehouse integration. Providing CoC HMIS data to a state data warehouse is voluntary so it is imperative for states to communicate the benefits of sharing data to get buy-in. CoCs are a critically needed partner and must invest time and resources for engagement in solution-oriented discussions about the benefits, roadblocks, procedures, and policies of HMIS incorporation. Investing in and maintaining collaborative relationships with CoCs is imperative.
Unification of HMIS Data Management Systems across CoCs	Michigan's efforts that all state CoCs use a unified HMIS reporting system prior to integrating HMIS data into the data warehouse mitigated potential problems caused by merging incompatible CoC datasets within the state data warehouse environment.	States that are considering implementing HMIS data into a warehouse should assess the compatibility of existing reporting systems used by their CoCs and consider merging HMIS data into a unified system prior to importing data into a state data warehouse.
Protecting Data Privacy	The development of policies and procedures to protect client data was a crucial component of HMIS data integration in Michigan. A primary concern of CoCs was the protection of client data from misuse and/or discrimination due to data breaches and inappropriate access. Michigan invested nearly two years to ensure thoughtful development of their agency privacy policies and client data safeguards.	Data privacy concerns are of the utmost importance when working with sensitive client data. These must be considered in line with federal and jurisdictional laws and policies. Where applicable, data policies developed by Michigan can serve as a model for other states. Michigan uses multiple privacy layers and protocols including HIPAA standards, the Blueprint for an AI Bill of Rights, inter-agency agreements, and multi-stage cues for client consent.
Optimizing Person-level Data Matching	Michigan uses their MPI to identify, clean, deduplicate, and merge client records. In Michigan, the MPI consists of first name, last name, DOB, SSN, address, and other program identifiers if available.	The process of matching client data within and between databases is complicated by duplicate records and incomplete data. It is important to develop a process to identify client records across datasets. To avoid duplicate records, a systematic method such as an MPI algorithm can be used to match and reconcile client data.

Challenge	Description from Case Study	Lessons Learned
Fostering Agency Collaboration	The Michigan Interagency Council on Homelessness (ICH), a statewide, centralized advisory council, provides planning and policy development, incorporates public input, and allows for efficient collaboration among state agencies. The ICH includes directors from eight state agencies (Figure 2) and is chaired by a member from the Michigan State Housing Development Authority. The large state agency presence helped support efficient data integration collaboration efforts for the state data warehouse. These vested parties had knowledge of the intended purposes and understood that data integration could result in providing more efficient and effective services and programs.	The formation of a state-level council or collaborative is key to coordinating across agencies and communicating the benefits of data integration, lessons learned, and best practices. The planning and implementation required to connect these datasets is a laborious process that can take years to complete. A robust state data warehouse provides the ability to connect multiple state agency datasets to provide deep insight on those shared populations served by the agencies.
Improving Equity in Representation	Racial and ethnic groups are overrepresented in homeless populations in the U.S. and in Michigan. In acknowledgment of this disparity, input from people with lived experience of homelessness is imperative. Goal 5 of Michigan's 2023-2025 Strategic Plan describes a multi-level approach for equity and inclusion in the planning and implementation of intervention strategies to address homelessness [9].	States should provide opportunities for people with lived experience of homelessness to be heard and to fully participate in the planning and implementation of data use in programs developing intervention strategies to address homelessness. Compensate people with lived experience for their time and contributions when participating in opportunities for input.
Providing Data to Inform Equity in Resource Allocation	Michigan data illustrate that the geographic distribution of PEH varies within a state and is dependent on a variety of factors, including access to services, transportation options, and weather conditions. Resource allocation for housing and services based on a comparison of demographic data and statewide per capita homeless data can provide a more equitable distribution of funds. As an example, Michigan inked HMIS and immunization data to justify the need for resources to provide vaccinations in homeless shelters. Goal 6 of the Michigan 2023-2025 State Action Plan provides strategies to assess funding based on equitable distribution [9].	When data warehouses, or other mechanisms for sharing HMIS data across state agencies, have been established, linked data should be used to determine PEH density in geographic locations across the state to provide equitable funding based on this distribution. Without data to make the case, it is difficult to prevail against systemic bias to ensure additional resources are allocated to higher need areas.
Leveraging Data during Public Health Emergencies	The Michigan Department of Health and Human Services and programs serving PEH were able to quickly mobilize in response to the COVID-19 pandemic by identifying critical locations to provide testing and vaccinations to PEH. Through knowledge gained from HMIS data linkages and practices implemented during the COVID-19 pandemic, Michigan is now well situated to address future public health emergencies.	During public health emergencies, states benefit by having a data warehouse in place so that partners can share data effectively and quickly for public health action. States should be cognizant that this requires a coordinated effort to stand up and maintain a state data warehouse prior to, during, and after emergency events.

Challenge	Description from Case Study	Lessons Learned
Identifying Cost Savings	Michigan was able to identify and connect PEH to additional services to better coordinate care by linking Medicaid data to emergency room use for PEH. PEH may have more frequent needs for costly healthcare services.	Linking medical usage data and HMIS data can identify additional needed services to improve the health and well-being of PEH. The provision of primary care and preventative care services to PEH can reduce medical costs and improve health outcomes.
Identifying Funding and other Sources of Support	Michigan received Medicaid funding from CMS to initially implement the data warehouse. Funding from a state health endowment was used to support the addition of HMIS data. Michigan was able to leverage processes on consent and privacy practices from Michigan's planning for their state innovation model initiative through CMS to hone the privacy and consent processes for the data warehouse.	There are costs to stand up a state data warehouse that will need to be planned for. Seek out state and federal funding that may be available for use. In addition, look to other related projects to leverage processes that could support the development of a data warehouse.
Lack of Standard Identification Documents (ID)	Michigan developed policies and enacted legislation to mitigate the hardship some PEH face on documents required to obtain services, receive financial assistance, and to procure and maintain housing. People and families experiencing homelessness often have difficulty in obtaining and retaining documents such as SS cards, photo IDs, and birth certificates.	Michigan provides fee waivers for PEH to obtain state IDs and birth certificates through two legislative actions spearheaded by the MCAH and the State ID Task Force, the Free for Me ID program and the birth certificate agency reimbursement program administered by MDHHS [12]. Also, Michigan provides PEH HMIS ID cards and Homeless Verification letters that serve as proof of eligibility for the ID fee waiver programs. People who obtain identification through these programs are then easier to match across data sources to verify eligibility for available services and resources.
Engaging Key Leaders as Champions	The governor of Michigan was a key champion for ending homelessness and enacted policy to improve services for PEH. The expansion of the data warehouse to include HMIS data allowed for significant improvements in services coordination for PEH. Additionally, the Governor's Executive Order 2015-2 created the Michigan ICH, a statewide, centralized advisory council in 2015 [8]. The ICH, largely made up of state agency leaders, helped support efficient data integration collaboration efforts for the state data warehouse.	Research and understand your governor's policy priorities. Look to align efforts with policies that can support the creation of a state data warehouse. Seek out vested parties that have knowledge of the intended purposes of a data warehouse and understand that data integration can result in providing more efficient and effective services and programs.
Identifying Trends by SDOH	Data linkage through the data warehouse allowed Michigan to conduct analyses to able to identify people in areas and populations with higher risk for high lead levels for increased follow up and aided in identifying areas and populations with lower vaccination rates for COVID-19.	Data linkages extend beyond the individual benefit of identifying those in need of services but also allows detection of population-level SDOH trends that can improve care even for people that may not yet appear in the data warehouse.

4 Summary

The Michigan data warehouse was formed nearly 30 years ago to investigate Medicaid fraud and abuse. Over time, additional data sources were added and HMIS data incorporation was completed between 2017 and 2018.

When considering the stated challenges and lessons learned outlined in this case study, emphasis must be placed on two primary factors that led to successful HMIS incorporation: the participation of all state CoCs and the use of a unified HMIS reporting system. The independent nature of CoC organizations can be a challenge for states considering HMIS incorporation. Cultivation of trust, collaboration, and a shared vision are necessary for engagement and full participation. Existing CoC HMIS reporting systems must be assessed for compatibility when planning for data integration. With CoC participation, action plans can be developed to address system integration issues. While creating a state data warehouse that incorporates a unified HMIS database is a challenging and time-consuming endeavor, it can provide ample benefits to state programs and disproportionately affected individuals and populations.

At present, Michigan is using data linkages to inform and address housing needs, assess other service needs, coordinate medical care and service provision, and coordinate public health intervention and prevention services. This allows Michigan to be proactive rather than reactive when addressing and improving the health and well-being of disproportionately affected populations. Future data linkages will allow Michigan to screen for homelessness risk upon release among persons incarcerated. As longitudinal data become available, Michigan will have insight into state resource usage to better address efficiencies and decrease costs, as well as understand outcomes from interventions and programs to end homelessness.

A data warehouse with HMIS data integration provides the ability to identify and track service utilization across state and community programs to better understand the population served, including PEH. These insights allow states to improve inter-agency communication, collaboration, and better allocate resources. This can ensure provision of needed health and social services for PEH.

Lastly, Michigan has utilized the state data warehouse in addressing public health issues to improve individual and population health for PEH. When public health and housing data are incorporated, state data warehouses can be a powerful tool to help direct cost-efficient public health action. Similarly, CDC's ability to make evidence-based recommendations to support the overall health and well-being of PEH is predicated on timely and complete jurisdictional data. Therefore, data warehouses provide an opportunity to enrich both federal and state public health data. Enhanced public health data can inform CDC efforts to support public health interventions, direct research, and guide prevention efforts in collaboration with jurisdictions.

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Appendix A Key Informant Interview Questions

The interview questions were developed to provide general direction in conducting the interviews. It was not designed to be a strict questionnaire, but as a resource to facilitate conversation with the opportunity to pursue conversational threads of interest.

Interview Guide 1

Michigan Data Warehouse Case Study Interview Questions

Intended Respondent Role: Community/Agency Representative

Greetings/Introductions

1. What was/is your role in the creation/maintenance of the data warehouse?

2. When was the data warehouse implemented?

3. Why did you decide to implement the warehouse?

4. What challenges were encountered/overcome during planning for data integration (e.g., privacy, technology, political)?

5. How is the database structured and how is information received and shared?

6. What best practices would you recommend on implementing and maintaining a statewide data warehouse (e.g., collaboration, technology approach, data quality processes)?

7. What are your recommendations and lessons learned on metrics to monitor and evaluate data quality and usefulness of data in the warehouse?

8. Who did you collaborate with and how did you initiate those collaborations?

9.. How was it determined what data to integrate first?

10. What data is currently integrated?

11. What additional data will be integrated?

12. What is the value of the data warehouse in addressing homelessness?

13. Have there been any public health impacts (e.g., what public health questions can now be addressed because multiple, disparate data sources are housed in a single repository? Improvements in public health outcomes?)

14. Has research been conducted using the data?

    If yes: What goals/ issues were/will be addressed through research?

15. Are there plans to share data across state lines?

16. Future plans?

17. Are there other folks that we should talk to about the data warehouse?

18. Do you have any questions for us?

Interview Guide 2

Michigan Data Warehouse Case Study Interview Questions

Intended Respondent Roles: State Administrator, Governance Oversight

Greetings/Introductions/Permission

1. What was/is your role in the creation/maintenance of the data warehouse?

2. Why did you decide to implement the warehouse?

3. What challenges were encountered/overcome during planning for data integration (e.g., privacy, technology, political)?

4. Who did you collaborate with and how did you initiate those collaborations?

5. What best practices would you recommend on implementing and maintaining a statewide data warehouse (e.g., collaboration, technology approach, data quality processes)?

6. What are your recommendations and lessons learned on metrics to monitor and evaluate data quality and usefulness of data in the warehouse?

7. What is the value of the data warehouse in addressing homelessness (including cost effectiveness)?

8. Have there been any public health impacts (e.g., what public health questions can now be addressed because multiple, disparate data sources are housed in a single repository? Improvements in public health outcomes?)

9. Has research been conducted using the data?

    If yes: What goals/ issues were/will be addressed through research?

10. Have there been any policy changes or new policies resulting from information/data provided in the warehouse?

11. What are the Future plans for the use of PEH/Public Health data in the warehouse?

12. The MI Strategic plan has five goals…

13. The MI strategic plan for 2023-2025 has an emphasis on equity − can you describe the vision for inclusion and addressing disparities?

19. Are there other folks that we should talk to about the data warehouse?

20. Do you have any questions for us?

Interview Guide 3

Michigan Data Warehouse Case Study Interview Questions

Intended Respondent Role: State Administrator

Greetings/Introductions/Permission

1. What was/is your role in the creation/maintenance of the data warehouse?

2. Why did you decide to implement the warehouse?

3. What challenges were encountered/overcome during planning for data integration (e.g., privacy, technology, political)?

4. Who are your strongest collaborators and how did you initiate those collaborations?

5. What best practices would you recommend for implementing and maintaining a statewide data warehouse (e.g., collaboration, technology approach, data quality processes)?

6. What are your recommendations and lessons learned on metrics to monitor and evaluate data quality and usefulness of data in the warehouse?

7. What is the value of the data warehouse in addressing homelessness (including cost effectiveness)?

8. Have there been any public health impacts (e.g., what public health questions can now be addressed because multiple, disparate data sources are housed in a single repository? Improvements in public health outcomes?)

9. Has research been conducted using the data?

    If yes/no: What goals/ issues were/will be addressed through research?

10. Have there been any policy changes or new policies resulting from information/data provided in the warehouse?

11. What are the Future plans for the use of PEH/Public Health data in the warehouse?

12. Goal 5 of The MI Strategic plan is to incorporate people with lived experiences with Homelessness using employment opportunities and opportunities to have a place at the table (i.e., serve on the MI Homeless Policy Council). How is that endeavor going (challenges, insights, etc.)?

13. Goal 4 of The MI strategic plan for 2023-2025 has an emphasis on equity − can you describe the vision for inclusion and how you are addressing disparities (i.e., the racial equity system analysis across CoCs)?

14. Do you have any questions for us?

Interview Guide 4

Michigan Data Warehouse Case Study Interview Questions

Intended Respondent Roles: MiCelerity-HMIS Linkage Project Team Members

Note: The interview questions below were modified as the interview progressed when we learned that the project is in its early stages and that data matching has not started.

Greetings/Introductions

1. Just to clarify, are you both employed by the state of Michigan or by the CDC, and what is your role?
2. What was the impetus for the MiCelery/HMIS linkage plan?
3. Who are you collaborating with and how did you initiate these collaborations?
4. What challenges were encountered/overcome during planning for data integration (e.g., privacy, technology, political)?
5. HMIS data is housed in the state data warehouse, is also MiCelerity housed in the warehouse?
6. How is the matched data shared and received?
7. According to your timeline, data matching and exploration is underway, how is the manual review of testing matched data for viability and fidelity going?
8. What identifiers are you using for the Master Person Index (MPI)?
9. Have there been any issues with the use of these identifiers?
10. What demographic and geographic data will be included in the analyses?
11. We know the project is in its early stages, but do you have any recommendations and lessons learned about evaluating the quality and usefulness of the matching data process?
12. What goals/issues will be addressed through your research?
13. Are there future plans to continue this project beyond August 2024?
14. Are there discussions/plans for additional Health and Human Service data to be linked with the HMIS data?
15. Do you have any questions for us?

Appendix B Methodology

For inclusion in this case study, CDC considered five states with publicly available information that they were either in the process of incorporating HMIS data into a data warehouse or that they had completed the integration process. To inform the selection process, a review of official state websites for HMIS, regional CoC planning bodies, and housing, health and human services agencies was conducted to understand each state's progress on integration and utilization of HMIS data. Existing literature and reports reviewed for the various states under consideration included press releases, program announcements and updates, annual homelessness state reports, and strategic plans to provide the basis for understanding each state's efforts.

Michigan was selected because HMIS data integration was completed in 2018. Michigan also had the benefit of a statewide, consolidated HMIS reporting system prior to integrating data in the state data warehouse. Many other states under consideration are still in the process of consolidating HMIS data for integration. Another factor that influenced the state's selection was Michigan's almost 30 years of experience in using the state data warehouse for prioritized service provision and to assess cost effectiveness and gain efficiencies in processes via data linkages.

This case study includes key informant perspectives on HMIS integration into a data warehouse from conception to implementation. The primary sources for the information presented are key informant interviews and existing documentation such as materials from public presentations and news articles, state agency and community websites.

Initial key informants were identified through an internet search of state and community representatives with firsthand knowledge of the Michigan data warehouse and HMIS integration. Additional key informants were identified by initial informant interviews and on recommendation of the CDC. In total, interviews were conducted with one informant representing the Michigan Coalition Against Homelessness and six informants from the Michigan Department of Health and Human Services.

Interview questions were developed to capture topics outlined as areas of interest by CDC. The interview questions were tailored to each informant based on their expertise and those topic areas they could best address. The interview questions for each session are included in Appendix A. Interviews were conducted virtually with an interviewer and a notetaker; with interviewee permission, sessions were recorded and transcribed to ensure capture of information. Individual informants participated in structured interviews to answer questions about the state data warehouse implementation, user policies, and research capabilities. Additional questions were asked on service provision and public health prevention and intervention activities conducted to improve social, health, and public health services for PEH by using the state data warehouse repository.

To ensure that the information in the case study report is complete and accurate, each informant received a draft of the report via email for a two-week review period. This report incorporates all information and feedback provided by informants.

Appendix C Acronyms

Term	Definition
AI	Artificial Intelligence
CDC	Centers for Disease Control and Prevention
CMS	Centers for Medicare & Medicaid Services
CoC(s)	Continuum(s) of Care
COVID-19	Coronavirus Disease 2019
DOB	Date of Birth
ER	Emergency Room
HIPAA	Health Insurance Portability and Accountability Act of 1996
HMIS	Homeless Management Information System
HUD	U.S. Department of Housing and Urban Development
ICH	Interagency Council on Homelessness
ID	Identification
IT	Information Technology
MCAH	Michigan Coalition Against Homelessness
MDHHS	Michigan Department of Health and Human Services
MHPC	Michigan Homeless Policy Council
MI	Michigan
MPI	Master Person Index
PEH	People Experiencing Homelessness
SDOH	Social Determinants of Health
SSN	Social Security Number
SUD	Substance Use Disorder
US	United States