Integration of Military Pediatric Immunization Records into a State Immunization Information System

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ABSTRACT

Background

Madigan Army Medical Center, a Military Treatment Facility (MTF) in Washington State, adopted the next generation electronic medical record, MHS GENESIS, in 2017. With this go-live, transmission of immunization data between the MTF and the Washington State Immunization Information System (WAIIS) ceased. Sharing this data allowed public health officials to more accurately assess immunization status and population health risk. Inclusion of external data helped to ensure complete immunization records of individuals treated at the MTF.

Objectives

We developed this project to facilitate information sharing between MHS GENESIS and the WAIIS. Parallel efforts aimed to both restore the basic flat-file functionality previously existing as well as establish a bi-directional HL7 interface.

Methods

Policy coordination occurred in parallel with data model development. Policy coordination occurred between Madigan Army Medical Center, the Washington State Department of Health, the Washington State Attorney General's Office, and the Defense Health Agency Office of the General Counsel. Data model development occurred in a parallel fashion as well, identifying existing HL7 message generation and transmission along with data element identification and verification for use in flat file generation. Policy, interface, and access constraints dictated the need for this parallel investigation within the data space.

Results

Re-establishment of immunization data sharing occurred via flat file monthly uploads. Prioritization of HL7 interface occurred at a program management level, with expected completion in 7-12 months.

Conclusions

Cross-organizational coordination, especially between federal and state entities, is a complex process requiring frequent engagement and priority coordination. Public health benefits of Immunization Information Systems for a transient population, such as Service member and their families, relies on coordination between jurisdictions.

Keywords

Information System, Policy, Military Personnel, Immunization

1. Introduction

Childhood immunizations represent one of the great medical interventions in history, with functional eradication of serval infectious diseases and reduced morbidity and mortality of many more.[1] Public Health efforts to eradicate these diseases rely, in large part, on high immunization rates. Without centralized records, assessment of an individuals' immunization status is difficult to ascertain.[1, 2] At a population level, aggregation compounds these individual uncertainties. Immunization Information Systems (IISs) provide a means of combining vaccination data to provide public health and individual benefits.[1, 3-5] Originating as a means of facilitating public health officials' risk estimations, IISs continue to become more sophisticated, facilitating the development of a multitude of individual and public health equities.[1, 6] Figure 1 provides a

graphical overview of modern IISs, demonstrating both the complexity and the potential
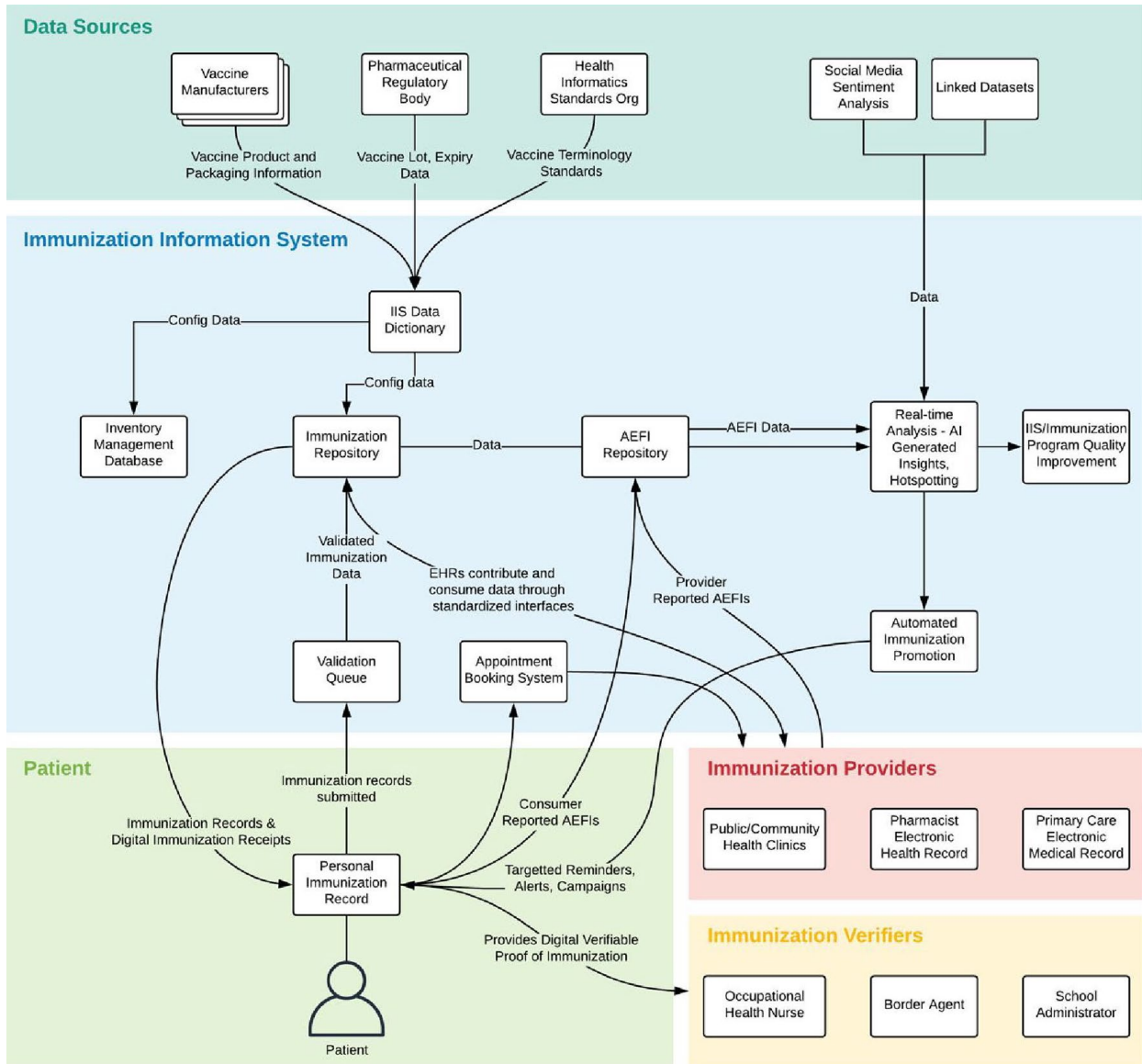
beneficiaries of such a system.

Figure 1. Data sources and components of a modern immunization information system. AEFI,

adverse events following immunization; AI, artificial intelligence; IIS, immunization information

system. (Atkinson KM, Mithani SS, Bell C, Rubens-Augustson T, Wilson K. The digital

immunization system of the future: imagining a patient-centric, interoperable immunization

information system. Ther Adv Vaccines Immunother. 2020;8:2515135520967203.

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The Military Heath System (MHS) provides worldwide pre-hospital, institutional, and occupational care and care coordination to military and associated personnel. The MHS provides direct and contracted care through administration of the Tricare benefit. As a worldwide heath care program, Tricare provides medical benefits for more than 9.6 million Service members and their families.[7] In FY19, Immunizations and Screening for Infectious Disease accounted for more than $289M in total costs.[7] While medical records of Tricare beneficiaries are portable world-wide within the military healthcare system, inclusion of outside immunizations, even with paid claims, are incomplete at best. Frequent movement of military families increase the potential for the fragmentation of immunization records. Community healthcare organizations report immunization data to the state, while military treatment facilities (MTFs) currently do not. Public Health officials, both military and civilian, rely on health system reporting to determine community status and guide policy to prevent disease outbreaks.

No capacity to send immunization information from MTFs located in Washington State to the WAIIS has existed since the MHS GENESIS go-live in 2017. MHS GENEIS is the cloud-based implementation of Cerner Millenium with an additional dental module and Department of Defense (DoD) Cybersecurity.[8] Prior to 2017, the Clinical Informatics Department of Madigan Army Medical Center (MAMC) in Tacoma, WA shared immunizations data with the WAIIS through a flat file data extract from the prior DoD EHRs. MAMC and the Washington State Department of Health signed the data sharing agreement enabling this relationship in 2007.

MAMC shared data from its main and child facilities as well as Naval Health Clinic Oak Harbor, Bremerton Naval Hospital, and other Puget Sound military and Coast Guard facilities.

The effort to collate and transmit the data occurred monthly and required an hour for each iteration. This effort was unidirectional. There was no employed method for consolidated data retrieval and incorporation into the military medical record. While this method provided state public health officials a means to evaluate overall immunization rate, the same population assessment ability did not natively exist at the local military installation level. To include data held in the WAIIS, individual user accounts allowed access and manual import of immunization data from WAIIS into the DoD EHR. This required the individual, usually an RN or LPN, to access the WAIIS through an internet browser, search for the patient in question then manually type the information as a historical entry into the DoD EHR immunizations module. Such transcription is not without error.

Cessation of data sharing activities carries a degradation in data quality and decision-making validity for both parties. COVID-19 restrictions lead to a severe reduction in face-to-face visits, and a presumed reduction in vaccination rates among children as a result. Investigation of this theory demonstrated overall fully immunized status of 50% of children younger than 18 currently enrolled to MAMC. This analysis carried a hopeful assumption of incomplete data with a true immunization rate higher than evident. Investigation of methods to resume data sharing led to the creation of this described project.

Combining data sources from community healthcare organizations and MTFs provides a more complete model of immunization status, allowing better informed decision- and policymaking at the state and national level. Involved stakeholders in this effort include the informatics staff at MAMC, the Defense Health Agency, the Primary Care Clinical Community,

the Washington Chapter of the American Academy of Pediatrics Vaccine Committee, and the MAMC Commander (CEO). Additional stakeholders include the individuals and families with reported data, clinicians throughout WA providing care for these individuals, and the Public Health officials in receipt of the data.

Total planned time for the project was nine months. Project definition and planning, including IRB approval of data usage, occurs during the first 3 months. The execution phase, including data model development and validation, messaging interface development, validation, and implementation, and governance development occur over the following 3 months. Governance and policy adjustments will take considerable time, with the closing 3 months allocated for complex stakeholder management in pursuit of product implementation. Criteria for success in the project include only the development of models. Beyond simple project completion, the desire for improved care drives the desire for implementation.

2. Background

In 2019, Tricare enrolled 1.82 million Family Members and Retirees to MTF Primary Care Managers with an additional 1.47 million enrolled to PCMs outside MTFs.[7] These numbers include 800,765 and 650,010 patients aged 0-17 enrolled to MTF PCMs and non-MTF PCMs, respectively, with an additional 33,558 not enrolled and eligible for direct care.[7] There were 348,284 total Tricare beneficiaries in Washington State, accounting for about 3.6% of the total Tricare enrolled population world-wide. Military treatment facilities provided 38.3 million outpatient encounters, including specialty visits, while non-MTF facilities provided an additional 71.6 million encounters.[7] Notably, this data does not include encounters at sites using MHS GENESIS as the EHR, as data inclusion is not yet fully validated. This lack of validation three

years after initially implementing MHS GENESIS foreshadows the difficulties encountered in data validation and policy navigation with this project.

In Tricare, beneficiaries are eligible for care based qualifying military service. The individual providing this military service is the sponsor. The Defense Enrollment Eligibility Reporting System (DEERS) provides the definitive record of eligibility.[9] The Tricare benefits number ends in a -00 for sponsors, with sequential increase in the number for dependents. For children with dual military parents, DEERS identifies one parent as the sponsor for benefits, which may change over time. Recognizing this relationship aids in assessing care delivery within the MHS.

Determining the immunization status for vaccines with multiple doses in the series presents a moderately complex challenge. In vaccination series with more than one dose administration there are time interval requirements to ensure maximal immunologic response. This holds true for booster immunizations as well, with waning immunity improved after a pre-determined interval. Processing vaccination records programmatically allows time interval-based validity determination. Simply counting the number of received vaccinations offers a simplistic approach at the cost of potentially overestimating the number of inadequately immunized individuals. Review of vaccination records at the time of administration mitigates this risk, ensuring the appropriateness of administered vaccinations; however it is not a complete solution.

The policies governing integration of Federal data into a State information system are predictably complex. Under the authority of the Under Secretary of Defense for Personnel and Readiness, the Director of the DHA is responsible for the management of the DoD Immunization Program.[10] Among other requirements, the Director has the regulatory mandate to maintain "a single, standardized DoD immunization registry" and "[coordinate] health information exchange with state and territorial immunization registries."[10] This requirement aligns with state trends

authorizing immunization information systems (IIS), with 66% of states having statutory authorization for an IIS in 2011.[11]

This project focuses on the pediatric population to avoid exposing data which might be operationally sensitive. Vaccine preventable diseases include many diseases not routinely encountered in the United States, and thus not part of the routine immunization profile for adults or children.

The DoD has used electronic systems to provide and record medical and patient documentation since 1968.[8] Most recently, three systems provided the majority of inpatient and outpatient documentation capabilities for the DoD: CHCS, AHLTA, and Essentris. The Composite Health Care System (CHCS) was based on the Regenstrief medical records system and provided coding, orders, and intra-system communication between medical professionals. As a text-based, non-graphical user interface system, CHCS continues to form the backbone for laboratory and pharmacy orders for facilities not yet transitioned to MHS GENESIS. Each CHCS instance is facility-specific and archives data across regionally situated servers which further integrate data into the central Clinical Data Repository.

Originally developed as an upgrade to CHCS and including a graphical user interface, the Armed Forces Health Longitudinal Technology Application (AHLTA, originally known as CHCS II) remains in use for a majority of MTFs across the world. Often cited as difficult to use, may users preferred alternate ways to enter immunizations, preferring the streamlined interfaces of the readiness systems to use of AHLTA;s immunization module, especially in the Air Force.[12]

The military readiness systems are data warehouses providing entry and reporting portals on medical readiness of the force. There are multiple readiness systems, with Figure 2 demonstrating the many data sources, warehouses, and partners with the DoD information space,

including the separate Service Medical Readiness Systems. Under the MHS Information Platform (MIP), legacy data warehouses, such as the Clinical Data Repository (CDR) and MHS Data Repository (MDR) provide data access and drive analytic efforts.[13]

The Power Insight Enterprise Data Warehouse (PIEDW) provides data extracts from the Millenium Database underlying MHS GENESIS, with a 1–3-day update lag. More modern capabilities in the HealtheIntent Enterprise Data Warehouse (HIEDW) moves towards availability nearly four years after initial EHR go-live.

Initial data exploration in available data warehouses demonstrates numerous data quality issues including data segregation, duplication, validation, and access. Human network establishment is the identification and engagement with individuals involved in governance, access, and data utilization across the MHS. System access is an ongoing effort which progresses with bureaucratic speed and efficiency.

The importance of immunization programs within the military continues to support a system separate from the medical record. Each military service, Army, Navy, and Air Force, maintains its own readiness system, all of which communicate at multiple points with each other and the health record, comprising both legacy systems and the new DoD EHR, MHS GENESIS. In general, data flow is unidirectional from the health record to the readiness systems. This unidirectional configuration limits data spillage and unwanted dissemination of medical intelligence. The Air Force's Aeromedical Services Information Management System (ASIMS) provides the simplest and most widely utilized interface for immunizations recording. In Air Force treatment facilities, individuals administering immunizations also utilize this interface to record beneficiary immunizations. This non-EHR documentation occurs due to its ease of use as compared with the legacy EHR. Compiling accurate data for beneficiary immunizations recorded

in this manner is difficult as it is not completely accessible within the MIP, based on input methods.
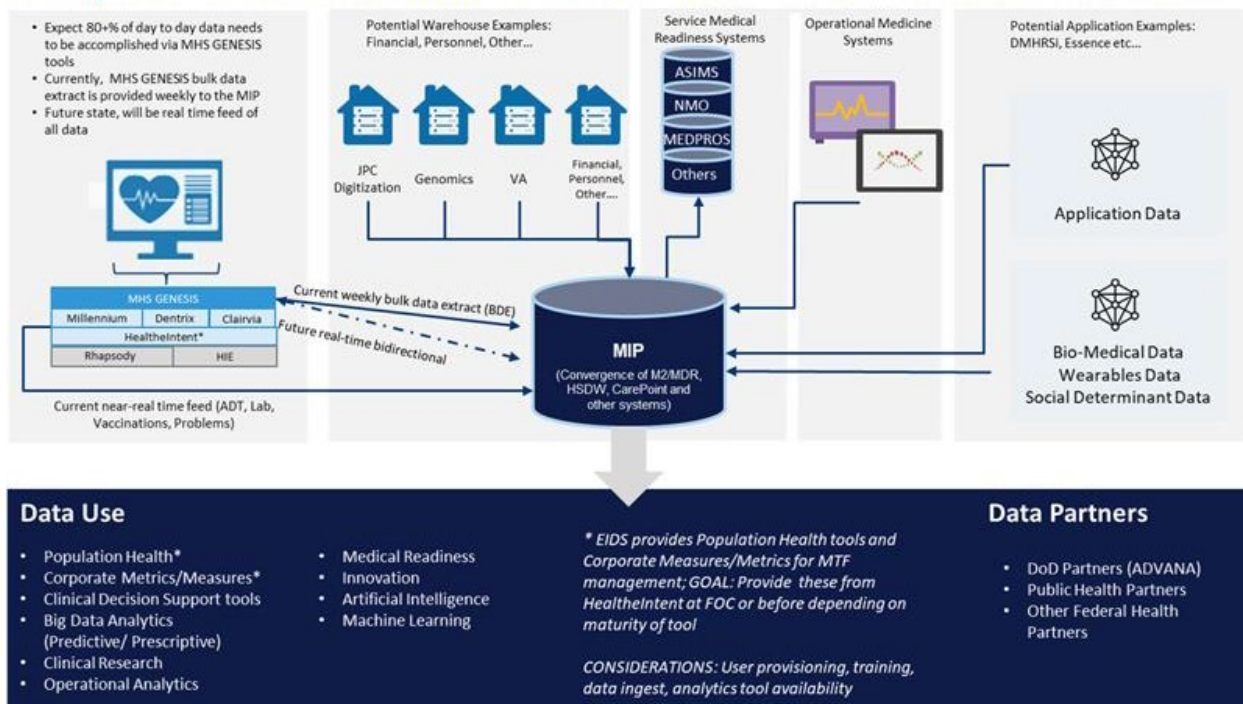

Figure 2. Proposed Defense Health Agency Future-State: MIP Data Flow and Use. (David Alt, MD, email communication, SEP20)

With the transition to MHS GENESIS, the MIP should provide access to the HL7 messages sent from GENESIS, with the hope of leveraging those messages for ease of transformation into a feed to the WAIIS. Use of the HL7 standard facilitates clear data transfer and limits ambiguity as to the vaccine administered and data transmitted.

Vaccine identification supports accurate status assessment. Vaccine formulations change over time and may have different doses and schedules to confer immunity. The use of standardized universal identifiers decreases the potential for misidentification. CVX codes provide standardized means of identifying immunization. With the legacy CHCS and AHLTA data provide to the WAIIS via flat file upload, Madigan did not transmit CVX codes. Instead,

Common Procedural Terminology (CPT) billing codes provided the means of vaccination identification. The codes for vaccine products are separate from that of administration.[14] Incorrect or incomplete coding, which is not automatically generated within AHLTA, carries the potential for transmitting inaccuracies. Additionally, data entered through a readiness system does not carry billing codes, limiting the integration of this data into the WAIIS. Policy can further limit the completeness of transmitted data.

Federal installations located within State jurisdictional borders, as is the case with Military Treatment facilities, fall subject to numerous statues, regulations, and policies. Add the complexity of leased clinics outside the military installation, joint VA/DoD facilities, and overseas locations, and the requirements for enacting any program increase dramatically. These complexities require the most time to arrange; they distinguish this effort as an informatics process requiring coordination of information systems and technology, the health system, and clinical care itself.[15]

3. Objectives

The intent of this project is to facilitate information sharing between MHS GENESIS (the Department of Defense (DoD) Electronic Health Record (EHR)) and the Washington State Immunization Information System (WAIIS) for childhood immunizations administered to Tricare beneficiaries less than seventeen years of age at Military Treatment Facilities (MTFs) located within Washington State. Ideally, this takes the form of a bi-directional HL7 interface. Barriers to this implementation include interface development costs and prioritization as well as regulatory approval through the Defense Health Agency (DHA).[9] As a point of reference, IISs within the United States are enmeshed within a complex network of more than 984 federal, state,

and local statues, regulations, and policies.[5, 16] DHA is responsible to manage a single, standardized DoD immunization registry and to coordinate "health information exchange with state and territorial immunization registries."[10]

4. Methods

The primary requirement at a high level is connecting to the Washington State Immunizations Information System (WAIIS). This requirement contains implicit tasks to gain authorization to connect and the technical connection details. Authorization to connect is a task governed externally to the MTF and the DHA by the Washington Department of Health, and internally by the organization and the Defense Health Agency. WAIIS connection documents contain a standard data sharing agreement, providing the basis for the governance instrument used in this project. Federal government agreements with any state government require acknowledgement of federal supremacy, driving a need to modify the base document. Changes to standard agreements must clear legal reviews on both sides. An additional local requirement required agreement clearance of privacy review to ensure compliance with applicable regulations. The Oregon Health & Science University Institutional Review Board reviewed this project with a determination as 'not human research.'

As a (relatively) quick method of assessing immunization status for the MAMC enrolled pediatric population, we assessed the CDC childhood immunization schedules to create expected received vaccination doses by age and vaccination groups. Using this information as a benchmark, we combined individual vaccination records of pediatric beneficiaries enrolled to Madigan, obtained from the Military Health System Management, Analysis, and Reporting Tool

(MHS MART (M2)), to count recorded doses. Data obtained from M2 provides about a two-week lag from live data, with data updated weekly.

To account for this reporting lag as well as an administrative lag in scheduling and receiving vaccinations, we evaluated vaccination status using three categories: Current, Due, and Overdue. Current implies receiving at least the number of expected vaccination doses by age cohort, including not receiving any doses if not yet due. Due indicates having reached the age where an additional dose is due, up to and including 6 weeks from that age, and not yet having the needed number of doses. Overdue denotes an age greater than 6 weeks from dose expectation with less than the expected number of doses for a given vaccination. We included individuals older than the approved age for a given vaccination in the Current category, computed against 0 doses expected at that age.

Our findings generated an initial concern for inadequate immunization of children, especially less than one year of age. The care delivery restrictions imposed as a result of the COIVD-19 pandemic were especially concerning in limiting the number of immunizations received. While a potential cause for the observed decrease was the receipt of immunizations outside the MTF, without a connection to the WAIIS, this postulate was difficult to verify. Re-establishing a connection to the WAIIS, given the change in organizational control of data repositories with the shift to MHS GENESIS, required significant policy coordination.

The original data sharing agreement signed in 2007 did not have an expiration date or validation provision. With no superseding agreement, the state continued to use the original as basis for account maintenance and new request issuance. Organizational end-user utilization of the WAIIS data occurred through logging on to WAIIS website and querying individual records as needed. One such use case is immunization records reconciliation for individuals reporting

immunizations received outside the organization. As previously mentioned, prior to the MHS GENESIS go-live in 2017, Madigan shared data through a monthly flat file upload through a secure FTP site. At the lowest level, project success criteria include reestablishing this capability.

Navigating the relationship space for this project is the most complex and challenging aspect, with a variety of priorities, imperatives, and authorities. Multiple communities of interest exist within the domain of pediatric immunizations. Briefly, coordination efforts between the MHS Primary Care clinical community committee, Functional Leads, hospital departments, and myself comprise a complex intersection of operational requirements, policy development, and requirements generation. Requirements generation and functional implementation rely on successful integration of these interests. On another front, system access is similarly complex. Figure 2 provides a visual depiction of one system access point.

Gaining access to the data proved to be difficult. Difficulty in this endeavor stemmed from both bureaucratic and technical barriers. Bureaucratic delays in processing system access request to the MIP occurred as a result of changes in organizational structure. A large number of new users added to the system generated a backlog of system access requests, resulting in more than 3 months spent gaining access to the system. Efforts to speed this process included daily to weekly phone calls and emails to organizational access personnel. Poorly formed access request queries also slowed the process, with an incomplete understanding of my purpose as an informatics fellow which fell outside the usual organizational approval routes. Once gaining system access, it took an additional month to gain access to the data source.

During initial efforts to gain access to the MIP, the MIP did not possess the HL7 messages to enable a streamlined process. MIP access to HL7 CVX messages started in December 2020, to support COVID-19 tracking efforts within the Department of Defense.

COVID-19 immunization data was the primary target, with the COVID-19 data used for supporting Operation Warp Speed and associated efforts. At the time, the only queryable tables were the truncated data set of COVID vaccination data. While present in the MIP, the employed management strategy normalized HL7 messages in tables not accessible directly for end users. Processing filtered the COIVD-19 vaccination data into separate tables. As the population of interest was not eligible for vaccination during this time, the provided tables did not support this project. MIP system administrators required additional weeks to generate table views and provide direct access to the HL7 messages.

Working in parallel with the efforts to gain access to the MIP, we explored using M2 and PIEDW as data sources. The GENESIS data in M2 updates weekly from the MILLENIUM Bulk Data Extract. We judged this data source as unsuitable for the project when, comparing data with the PIEDW source, M2 did not include the administration status information. Data from AHLTA and CHCS, providing the baseline for the data structure of M2, only had information for administered vaccinations. AHLTA and CHCS do not record unadministered vaccines. This structure is distinct from GENESIS records, which records immunizations as administered or not given, along with a reason for lack of administration. Without awareness of this field, initial warehouse inclusion of GENESIS data treated all vaccination statuses as record of administration.

Further efforts to differentiate administered from historical vaccinations, as well as definitively identify the product used, required adjustment of the query strategy in PIEDW. Initial efforts worked on identifying the drug names to create a crosswalk to CVX codes. Generic representations of drug names, such as rotavirus vaccine, limited efforts to ensure complete analysis of the drug name. The naming conventions are changeable and fell outside the scope of

the project. The alternative strategy located the National Drug Codes (NDCs) and used these standardized elements in identifying the appropriate CVX codes.

PIEDW also provides next of kin information, required by the WAIIS for patients less than 18.[17] Nearly 80% of next of kin data is incomplete, based on analysis of query results, requiring an alternative strategy. Recognizing the relationship of Tricare benefits numbers, we obtained military sponsor information as a surrogate for recorded next of kin information. This strategy produced complete records for more than 97% of immunization records. The residual incomplete records are attributable to the ongoing MHS GENESIS deployment with some individuals not yet included. Once fully deployed in 2025, this data should be complete.

A Python script utilizing the pandas package processed the retrieved data from PIEDW.[18] This process allowed implementation of data cleaning and throughput analysis. Leveraging automatic processing decreased the time needed to manually process the data with each upload. System restrictions do require the manual download of data, although recurrent query scheduling results in a need for less than 15 minutes of human processing time per upload instance.

5. Results

Contractual requirements surrounding MIP interface generation moved use of the HL7 messages out of scope for the project. Though sustainability is a concern, use of PIEDW downloads and flat file WAIIS uploads bridge the capability gap. Completion of the project generated 282,044 cleaned immunization records for upload into the WAIIS. Providing this data to the state fostered public partnerships and enabled a greater accuracy in assessing infectious disease threats.

Complete immunization data for all enrolled individuals is currently not feasible. Theoretically, analysis of vaccination patterns could provide advance information regarding troop deployments. While unlikely, avoidance of any spillage through population exclusion streamlines the policy effort for interface approval. Specifically, limiting the population of interest to pediatric patients avoids the required five-step DoD Operations Security Program (OPSEC) requirements.[19] In general, there is universal acceptance of the public health benefit of childhood immunizations and near universal requirement of records for administrative purposes, such as public-school attendance. An alternative method of providing operational security would be the exclusion of non-routine vaccinations. This method incurs more potential risk, however, in illustrating potential vulnerabilities of diseases prevented through routine vaccination. For these reasons, we limited project scope to pediatric patients only. Ensuring the exclusion of data outside project scope is not straightforward. The structure of immunization data repositories used within the military complicates the segregation of data.

Adult immunizations are of current particular concern due to COVID-19, especially the lack of inclusion of military member immunizations.[20] To meet the request to share data, as well as our OPSEC requirements as dictated by DoDD 5205.02E, one potential approach is the provision of deidentified data to the state for the military beneficiary adult population. This approach includes generating a pseudo-record number and maintaining an identification database on military servers. The state receives immunization data with individually identifying characteristics aggregated to year of birth, a single contact address per zip code/county combination, and a single name.

The method currently in place bypasses the WAIIS in providing data directly to the county public health offices with aggregated numbers. This approach meets a need for shared data at the

county level of aggregation. This approach limits the utility of the WAIIS in providing long term research data and contributes to vaccination underreporting.[21]

From a policy perspective, project completion set the conditions for a fully-functioning bi-directional interface, providing capability for integration into MHS GENESIS and continued improvements in care assessment and resource allocation. On a larger scale, such conditions are a model for nation-wide integration between MTFs and hosting states. Such integration may further drive the successful implementation of a nationwide IIS and support a nationwide Health Information Exchange.

6. Conclusion

Modernization of the MHS EHR provides an opportunity to improve public health efforts through information sharing, which is vital to adequately evaluating healthcare in populations whose members frequently move. While the Tricare benefit provides for direct care in MTFs, the pharmacy benefit which allows vaccination coverage outside these facilities brings the need to ensure inclusion of all treatment data.

From a non-federal perspective, public health awareness of vaccination rates, especially in areas with high concentrations of military beneficiaries, is crucial in evaluating risk and care provision programs.

7. Clinical Relevance

Planning for cross-jurisdictional information sharing is a non-trivial tasking involving multiple stakeholders and potentially conflicting laws and regulations. Meaningful use implementations provide for data portability but do not remove the need for validation and

workflow governance. Integration of policy and data management enable improved understanding at individual and population levels which yields an increased likelihood of coordinated and resourced care delivery.

8. Multiple choice questions

8.1. Immunization Information Systems

    A. are only of use in evaluating immunization information for school registration.

    B. rely on clinic personnel to manually input immunization information.

    C. are federally mandated to receive all immunization information.

    D. provide interoperability of immunization information from different health systems

8.2. The MHS Information Platform

    A. Contains only legacy electronic health record data from CHCS and AHLTA

    B. Is only accessible to military personnel

    C. Is only one of many information sources for healthcare data for the MHS

    D. Removes the need for integration with any non-MHS data platforms or applications

9. Acknowledgements

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