

AHRQ Grant Final Progress Report

Title of Project:

Advancing Population and Public health Reporting and Outcomes with Vaccination data Exchange (APPROVE)

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1. Structured Abstract

Purpose: To characterize the enablers and barriers for electronic vaccination exchange, using a novel interoperability tool within public health systems, and using an evolving interoperability tool across public health and clinical care systems.

Scope: This research was conducted in Minnesota using two public health information systems, the Minnesota Electronic Disease Surveillance System (MEDSS) and the Minnesota Immunization Information Connection (MIIC), along with key healthcare systems that report vaccinations to MIIC and access its clinical decision support.

Methods: This study utilized mixed methods, with MIIC providing quantitative data on electronic vaccination exchange. Analysis of user queries to MIIC from clinical sites and from MEDSS provided insights on accessing data for vaccine status assessment. Enablers and barriers were solicited qualitatively by observations of tool use and semi-structured interviews with public health epidemiologists, clinical care providers and technical specialists.

Results: Findings highlighted the utility of both the interoperability tools. The novel MIIC-MEDSS interoperability tool was evaluated with quantitative analysis (user time, clicks, queries) and qualitative review with users. This demonstrated efficiencies in vaccination data access (before: 50 clicks, >2 min; after: 4 clicks, 8 s) translating into staff effort (before: 5 h/week; after: 17 min/week). Expert interviews (n=28) conducted with 12 healthcare systems and public health clinics (n=286 sites) between April - July 2022. Most (83%) had MIIC integration within EHRs, and high EHR queries to MIIC (~6 million/month), but numerous organizational/technical barriers identified including standardization needs and limited resources.

Key Words: Interoperability, standards, immunization information systems, electronic health records, vaccination, disease surveillance

2. Purpose

Objectives of Study: The study aims were to better understand the use of two interoperability tools, a novel one between two public health information systems and an evolving interoperability tool used between electronic health records in healthcare and a public health information system.

- **Specific Aim 1:** The enablers and barriers to the use of a novel interoperability tool for electronic vaccination data exchange within public health systems was characterized using a mixed methods approach. Data on number of individuals reached for vaccine status assessment was obtained through analysis of queries to MIIC. Data on enablers and barriers was collected by structured observations of tool use and semi-structured interviews with public health epidemiologists and technical specialists.
- **Specific Aim 2:** The use of an evolving interoperability tool for electronic vaccination data exchange across public health and healthcare systems was evaluated using mixed methods. Data on EHRs across health systems and their electronic exchange status for vaccinations was obtained from MIIC. Analysis of user queries to MIIC provided insights on number of individuals reached for vaccine status assessment. Structured observations of tool use and semi-structured interviews with care providers and technical specialists provided usage details.

3. Scope

Background

Disease surveillance and population vaccination coverage are foundational public health services¹ and proven to be key success factors for the decline of many infectious diseases^{2, 3}. The power of vaccinations was evident in context of COVID-19 pandemic. Surveillance of reportable infectious diseases (including COVID-19) and corresponding vaccination coverage are coordinated endeavors in public health but known to be complex due to the quagmire of information systems. There is a critical need for better infectious disease surveillance and a transformative opportunity to leverage electronic data exchange across the health information systems (HIT) for disease surveillance, vaccinations and clinical care. This presented a strong motivation and scientific premise for the proposed research.

The overarching goal of this work is to enhance data-driven decision-making by facilitating data exchange between HIT systems within public health and across public health and clinical care, with the principal objective of better healthcare quality. As current health reform efforts emphasize data exchange and interoperability^{4,5}, it is critical to evaluate and understand implications of increasing exchange of data across stakeholders. Though national standards are recommended⁵, there is paucity of research on its adoption and effects of interoperability⁶. There is a growing need for research around HIT in the public health context. This study addresses this gap by examining two key state public health information systems and evaluating novel data exchange across these systems and between a public health information system and electronic health records (EHRs).

Context

The study was conducted in Minnesota with the potential to have a state-wide and ultimately broader national impact. The Minnesota Department of Health (MDH)⁷ has a stellar reputation as a strong public health agency. The Minnesota Electronic Disease Surveillance System (MEDSS)⁸ and Minnesota Immunization Information Connection (MIIC)⁹ systems are hosted at MDH, and these two systems together with EHRs in clinical care were the focus of this research.

Based on Minnesota eHealth profile in 2019 conducted by the MN e-Health Initiative, the state has high EHR adoption rates (hospitals 100%, clinics 99%)¹⁰. But the statistics on data exchange were low with only one third of clinics indicating needed data available electronically and majority of exchange driven by proprietary vendor-based solutions¹⁰. The data exchange scenario in public health is rudimentary, with the main HIT systems not interoperable with each other and with limited standards-based exchanges with EHRs.

Settings

MEDSS receives case reports of reportable infectious conditions and electronic laboratory reports for supporting case management, contact tracing and outbreak investigations. MEDSS was implemented in 2009 and contains 5,097,887 events (as of December 2020)⁸. The system has users across state programs, local public health agencies, and clinical partners with varying access and roles. In 2017, ~71,995 cases were reported and an additional 73,181 cases were reported in 2018. With the COVID-19 pandemic, ~ 5.5 million tests on estimated 3 million people (as of December 2020) were reported to MEDSS. A novel interoperability tool using nationally recommended standards^{11,12} across MEDSS and MIIC implemented in 03/2021 was focus of study Aim #1.

MIIC serves as a central repository for vaccination data for the State of Minnesota. MIIC has been operational since 2004 and currently holds data for approximately 110 million immunizations

for 6.5 million individuals (as of September 2022). MIIC has a wide user-base with 5,867 organizations as registered users ranging from primary care clinics, specialty providers, nursing homes, long term care facilities, retail pharmacies and hospitals, a majority of which submit data or run reports for their client population. This study focused on users who utilized standards-based bidirectional exchange^{11,12} to query MIIC for vaccination history and clinical decision support for immunizations (CDSi) from electronic health records¹³ in Aim #2 of the proposed research.

Participants

Quantitative (Aims 1 and 2): Data on number of individuals reached for vaccine status assessment was obtained through MIIC queries from MEDSS users for Aim #1. Data from MIIC helped to enumerate the proportion of clinics with interoperability tool implementation, interoperability approach (asynchronous/static view/dynamic view), their EHR platform and volume of queries by organization (use of tool) for Aim #2.

Qualitative (Aims 1 and 2): Nine public health professionals, including an interoperability specialist were interviewed for Aim #1. Semi-structured interviews were conducted with 28 experts across 12 healthcare systems and public health clinics for Aim #2. The experts included public health epidemiologists, clinical care providers and technical specialists, and assisted in enumeration of various enablers and barriers to the use of both the interoperability tools.

4. Methods

Study Design

The study employed mixed methods to evaluate the novel interoperability tool within public health systems, and the evolving interoperability tool across public health and clinical care. The study used observational and quasi-experimental design and was guided by Glasgow's RE-AIM framework representing Reach, Effectiveness, Adoption, Implementation, and Maintenance¹⁴.

Data Sources/Collection

Aim 1 (Novel Interoperability tool)

Quantitative: Data on number of individuals reached for vaccine status assessment was obtained through MIIC queries. This yielded one of the measures of interoperability tool use, which is to assess the number/percent of individuals impacted (Reach metric of RE-AIM).

Qualitative: Semi-structured interviews with nine professionals including public health epidemiologists and an interoperability specialist, along with structured observations of tool use provided data on Effectiveness, Implementation and Maintenance of the RE-AIM metrics. This process also elucidated barriers and enablers to use of the tool and needed on-going maintenance.

Aim 2 (Evolving Interoperability tool)

Quantitative: Data from MIIC helped to enumerate the proportion of clinics with interoperability tool implementation, interoperability approach (asynchronous/static view/dynamic view), their EHR platform and volume of queries by organization (use of tool). This analysis yielded insights on RE-AIM metrics: number of individuals reached for vaccination evaluation (Reach) and entity profiles (Adoption).

Qualitative: Structured interviews were conducted with 28 experts across 12 healthcare systems and public health clinics (n=286 sites) between April and July 2022. These experts (providers, clinic administrators, technical specialists) helped to identify the enablers and barriers and provided data on Effectiveness, Implementation and Maintenance for RE-AIM metrics.

Data Analysis

Aim 1 (Novel Interoperability tool)

Quantitative: Quantitative methods involved analysis of staff time and clicks for both pre- and post-implementation provided by a lead epidemiologist who tracked the time and clicks for vaccination data access from MIIC. This analysis was conducted on a non-COVID reportable condition and is based on analysis done for pertussis, a reportable infectious disease. The use of the tool was evaluated by review of MIIC data access from MEDSS through SQL queries of the MIIC database to access MIIC log data.

Qualitative: Qualitative methods involved input from epidemiologists (n=9) who lead select infectious disease surveillance programs and are informed users of the interoperability tool. The feedback was collected through semi-structured discussions in Microsoft Team meetings (n=3) with notetaking and transcription done by the lead researcher with support of an informatician from the MEDSS program team. Dedoose v9 (Los Angeles, CA) was used for managing and analyzing the qualitative data and themes were identified by research team including current tool feedback and needed future enhancements and were reviewed by the study epidemiologists (n=9).

Aim 2 (Evolving Interoperability tool)

Quantitative: Data on MIIC electronic exchange was obtained through SQL queries to the MIIC data lake from 2019 through 2021 to capture the pre and post-pandemic timeframe. Data was collected for both electronic reporting to MIIC and mode of reporting (HL7 standards-based, formatted text files), along with queries to MIIC and their modality (HL7 standards-based, MIIC developed bulk query).

Qualitative: The interview comprised of 25 questions across six subject areas (background, awareness and use of MIIC data, value of MIIC CDSi, value of MIIC data and reports, technical issues/troubleshooting and closing). The questionnaire was shared ahead of time with SMEs to help prepare and invite colleagues, as needed. Data was collected over Zoom meetings from April - July 2022 by two study members with detailed note-taking and audio recordings. Verbal consent was obtained prior to the structured interview, which lasted for approximately 45 minutes. The responses to structured questions were analyzed using descriptive statistics. A thematic qualitative analysis was performed to identify the main organizational and technical barriers and facilitators.

Limitations

Aim #1: Development and implementation of this interoperability tool requires significant informatics workforce expertise and may pose a limitation for some public health departments. The tool needed to be iteratively designed and tested with end-users and getting time from epidemiologists in midst of the COVID pandemic and monkeypox outbreaks was challenging.

Aim #2: This study focuses on a single state IIS (MIIC in MN). The study was designed to represent three-fourths of clinical settings due to the integrated healthcare delivery dominance in Minnesota. Sites also utilized the dominant EHR in this market (Epic®) for clinical care and the two main EHRs in public health in Minnesota (PH-Doc and Champs). The study did not capture all the EHRs or settings, but as noted above, it was set up to have generalizability of results.

Ethics

Approval from the Institutional Review Board (IRB) at the University of Minnesota was obtained. All data was kept on secure drives accessible only to study team personnel.

5. Results

Principal Findings

The study results pointed to high adoption and use of the novel interoperability tool in Aim #1 and the evolving interoperability tool in Aim #2.

Aim #1 (Novel Interoperability Tool)

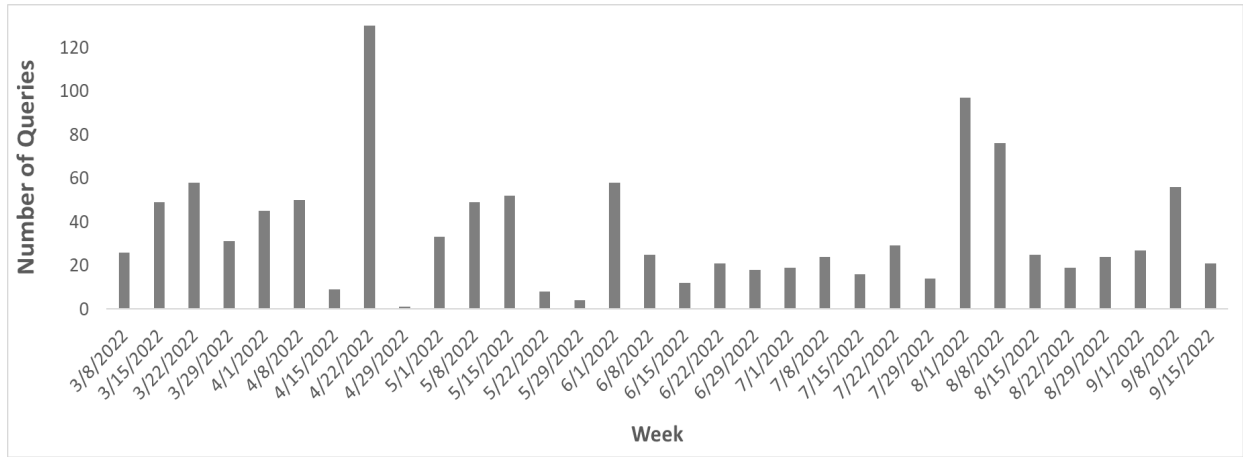
The interoperability tool for data exchange from MIIC to MEDSS was implemented in March 2022. Table 1 presents the evaluation of the interoperability tool with assessment of metrics related to time estimates, number of clicks for data retrieval, estimation of data errors, and staff effort with manual processes. Prior to implementing the interoperability tool, it took 50 clicks and 134 s (2 min, 14 s) to access an individual’s vaccination data based on user input. After implementation, only 4 clicks and 8 s were required to access an individual’s vaccination data. During weeks with high volume of MIIC access, the staff time was reduced from 5 h/week to ~17 min/week.

Table 1. Comparison of Metrics Pre and Post Interoperability Tool Implementation

Metrics	Pre-Interoperability Tool Implementation	Post-Interoperability Tool Implementation
Time estimate for retrieval of an individual vaccination record	134 seconds (2 minutes, 14 seconds)	8 seconds
Average number of clicks to complete process of getting vaccination data from MIIC and entering data into MEDSS	50 clicks	4 clicks
Estimate of data entry errors	~300 errors to fix annually	Eliminates data entry and imports MIIC data
Estimated staff time per week of work for non-COVID conditions	5 hours	~17 minutes
Staff effort for manual process	1 epidemiologist, 2-3 student workers for every year	No specific staff assigned; data accessed as needed with interoperability tool

Assessment of tool use conducted by analysis of MEDSS to MIIC query data using logs of MIIC queries since implementation (March 2022–September 2022), pointed to use by epidemiologists with ~130 queries/week for individual vaccination data access during high use (Figure 1). This implies the number of times an individual vaccination record from MIIC was needed and accessed through the interoperability tool related to public health reportable conditions in MEDSS. Representative end-users were satisfied with this interoperability tool with one of the epidemiologist’s evaluation noting “MIIC-MEDSS exchange is the best”. This demonstrates the utility of the electronic exchange of vaccination data and storage of this data in MEDSS to support case management and disease surveillance.

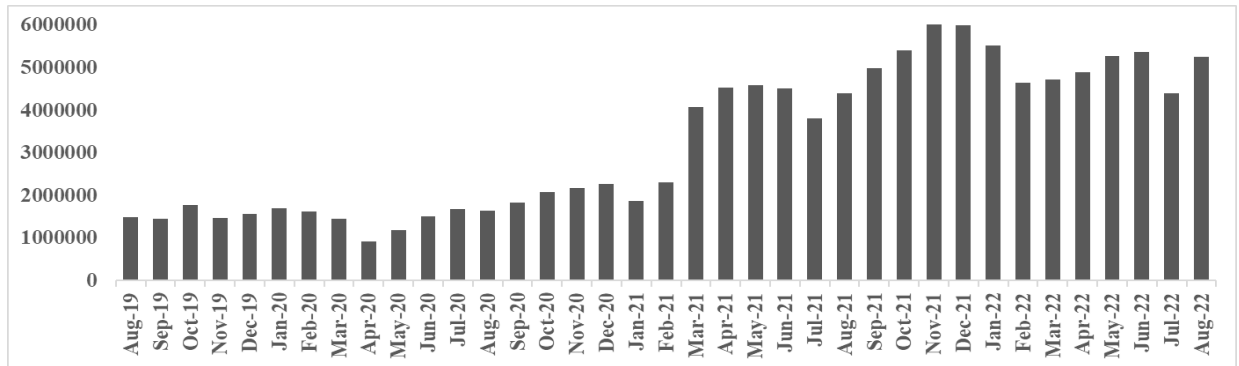
Figure 1. Queries from MEDSS to MIIC Using the Interoperability Tool



Aim #2 (Evolving Interoperability Tool)

The volume of HL7 v2.5.1 standards-based queries from EHRs to MIIC (Figure 2) increased markedly in 2021 coinciding with the availability of COVID-19 vaccines, including ~6 million queries in November and December 2021).

Figure 2. HL7 v2.5.1 standard-based queries to MIIC from EHRs to access MIIC Data



All organizations (100%) acknowledged the high use of MIIC during the pandemic, were aware of the functionalities and accessed MIIC on site to look up data and imported data from MIIC to EHRs (Figure 3). The MIIC-EHR integration was appreciated by the respondents as it saved time from separate log-ins and eliminated the burden of duplicate data entries and data entry errors. Almost all (11 of 12, 92%) reported data to MIIC using HL7 v2.5.1 standards. All except two (83%) had MIIC access integrated within EHR and used the HL7 v2.5.1 standards-based query functionality to look up MIIC data. Though all interviewees (100%) used MIIC to look up vaccination history, only a third used MIIC CDSi or the MIIC reports, and the rest used the features available in their EHRs. This difference was due to organization type (with all public health entities using and the rest not). MIIC was mainly used by nurses, clinic assistants and care support staff (e.g., scheduling, billing) in all the organizations (12 of 12, 100%) and had limited access or use by providers (e.g., physicians).

Figure 3. MIIC Data: Standards-based reporting, query, awareness, access and use

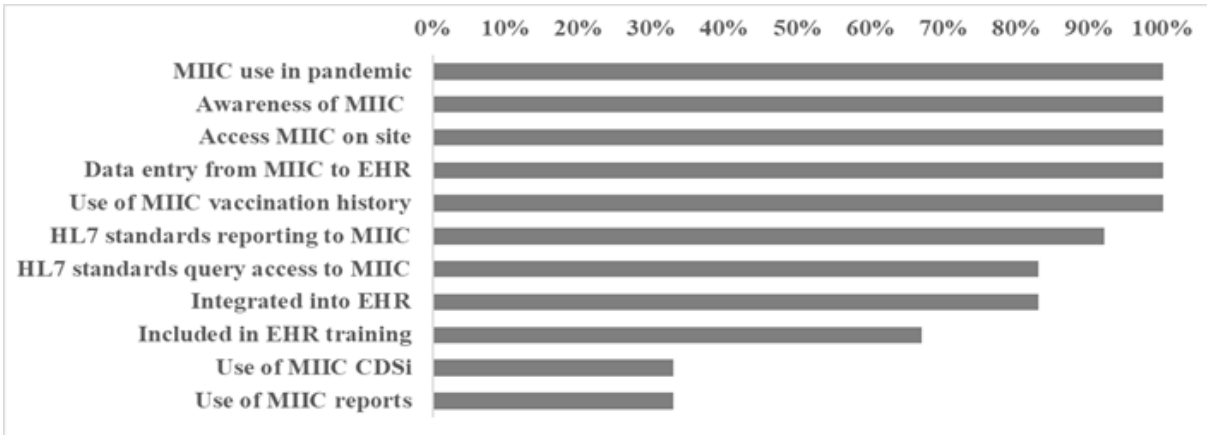


Table 2 presents the identified organizational and technical facilitators and barriers. Standards for exchange (HL7 standard, v2.5.1 in use) and for representation (vaccine codes) along with increased awareness due to pandemic have been facilitators. The need for standardized vaccine naming/labels across entities to address data quality issues and varying user interfaces to access history/CDSi are barriers along with need for training, informatics-savvy workforce and resources.

Table 2. Technical and organizational facilitators and barriers for interoperability (% respondents)

Technical Facilitator	Technical Barrier
Standards for vaccination data exchange (100%)	Lack of standard vaccine labeling (varying naming in EHRs across entities) (100%)
Standards for representing vaccines (100%)	Need QR code for vaccine history (100%)
Some public health EHRs act as collaboratives to share costs and enhancements (100%)	Low app literacy in some stakeholders to access MIIC data via Docket (100%)
Bi-directional exchanges (report/query) are getting well established (83%)	Fix access issues to Docket app (multiple records access) (100%)
Integration of vaccine ordering in MIIC (33%)	Different EHR user interfaces to access MIIC vaccination history and CDSi (50%)
Standardized MIIC data in dashboards (33%)	No CDSi in few public health EHRs (33%)
	Need for robust CDSi for non-standard vaccine series (e.g., immigrants) (33%)
Organizational Facilitator	Organizational Barrier
COVID-19 pandemic increased appreciation of public health immunization registries (100%)	Lack of resources for interoperability enhancements (100%)
Prior successful MIIC collaborations (100%)	Training on key MIIC features (100%)
Public health clinics have more MIIC awareness (33%)	Data quality issues due to potential duplicate creation in EHRs and guidance for better use of data from MIIC query (100%)
MIIC is promoted in new client package by public health clinics (33%)	Need to increase collaboration for better use of bi-directionality (100%)
	Less public health informatics staff (33%)

Outcomes

Evaluation of both the interoperability tools using quantitative and qualitative approaches and elucidating the enablers and barriers to tool use were the anticipated outcomes and was fulfilled.

Discussion

The Building Back Better report¹⁵ funded by the Robert Wood Johnson Foundation and a recent U.S. Government Accountability Office (GAO)¹⁶ report emphasize the need to transform the US public health system to protect health and achieve health equity. These reports highlight the deficient data infrastructure and identify the lack of interoperability as one of the main challenges. With this novel interoperability tool between a disease surveillance system (MEDSS) and an immunization information system (MIIC), the efficiencies gained have been demonstrated. The data access burden for an individual vaccination record was decreased to 8 seconds, and overall effort reduced from 5 hours/week to ~17 minutes/week with cost savings due to less staff time. It is better to be able to import and update current vaccine data and save it within MEDSS to support case management activities performed by epidemiologists.

The interoperability tool decreased the number of processes/clicks to retrieve data along with elimination of manual data entry and resultant data errors. The query is generated in MEDSS based on an existing case of a reported infectious disease to public health. The quality of demographics in MEDSS and MIIC and their matching is foundational to data exchange using the interoperability tool. Future tool enhancements will depend on user consensus regarding needs, evaluating the impact on data quality across systems with increasing data exchange driven by interoperability enhancements, and exploring the applicability of the FHIR standard for IIS data access¹⁷. Engaging with end-users (epidemiologists) during the design phase of the from the start ensured that the project had buy-in and also delivered a product (interoperability tool) which met user expectations. This case study also addresses the paucity of research around HIT in the public health context.

Development and implementation of this interoperability tool required significant informatics workforce expertise and may pose a limitation for some public health departments. Collaboration with other public health agencies and adopting/adapting existing solutions will be helpful. Partnerships with academia and workforce programs funded by the Office of the National Coordinator for HIT (ONC)¹⁸ will assist in building an informatics-savvy workforce. The tool needed to be iteratively designed and tested with end-users and getting time from epidemiologists in midst of the COVID pandemic and monkeypox outbreaks was challenging.

The updated assessment of IIS-EHR interoperability (evolving interoperability tool) in Minnesota highlights the increasing use of standards-based^{11,12} bi-directional exchange. This is attributed to MIIC having a consolidated history of vaccinations by collating data feeds from various vaccine providers (e.g., clinics, mass vaccination sites) and over time. Most of the participating entities (83%) had access to MIIC embedded within care delivery. But there is variation in MIIC use between health systems and public health clinics with all entities utilizing the vaccination history, but only the public health sites using CDSi and reports. This is due to public health being low resourced and MIIC providing better functionalities than their EHRs. The different user interfaces to access MIIC history and CDSi in some EHRs needs to be addressed for better interoperability.

This research also pointed to potential user needs/priorities. Training needs were identified and was addressed by the MIIC program through webinar series (Fall 2022) on various functionalities. A key take-away is the need to pay attention to quality of data across systems with increasing bidirectional data exchange across EHRs and MIIC with potential for duplicates and errors propagating across systems, and requirement to implement data quality monitoring protocols/tools. Follow-up study with a focus on smaller providers with less resources (rural/community clinics) are needed to evaluate using equity perspectives and to bridge the digital divide in interoperability.

Conclusions

The pivotal role of public health and need for robust information infrastructure was brought to forefront with the COVID-19 pandemic^{19,20}. It is vital to evaluate the current state of interoperability and standards-based reporting to public health and importantly include the bi-directional exchanges between public health IIS and EHRs.

Significance

Achieving Healthy People 2030²¹ which sets national goals for reducing the infectious disease burden requires efficient electronic data exchange between immunization and disease surveillance systems in public health. Immunization history in MEDSS will facilitate surveillance / follow-up and management of vaccine-preventable diseases. This public health interoperability implementation has facilitated infectious disease surveillance at the state level as MEDSS and MIIC are hosted in the state public health agency, with potential for broader national impact through collaboration.

Implications

With the increasing requirements for electronic data exchanges across public health information systems²², there is a need to implement and assess interoperability. This novel data exchange tool was built using national standards^{11,12} (HL7 standard for query/response, SOAP/web services for data transport, and CVX, MVX and CPT® codes for terminology), a foundation for interoperability. Due to the utilization of national standards for both the interoperability tools, the overall approach in building the tool can be applied to other information systems that respond to queries, generate response and are able to receive standardized data synchronously. Hence the lessons learned from developing/deploying this tool are applicable to other public health interoperability projects. These implementation details are intended to support other public health agencies in their strategy to interoperability due to generalizability of tool design, methodology and findings. This case study demonstrates the potential significant contribution of improving public health systems interoperability, ultimately with the goal of enhanced data-driven decision-making and public health surveillance.

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List of Publications and Products

- Rajamani S, Chakoian H, Bierringer A, Solarz S, White K, Melton G. Designing a Public Health Interoperability Solution across a Statewide Disease Surveillance System and Immunization Information System. AMIA Clinical Informatics Conference (CIC). May 24-26, 2022. Houston, TX.
- Chakoian H, Bieringer A, Lintelmann A, Saupe A, Jeffrey S, Ostadkar R, Grilli G, Polzer M, Schmidt G, Rajamani S, Solarz S. Designing an Interoperability Solution across a Statewide Disease Surveillance System and Immunization Information System for Vaccination Data Exchange. Council of State and Territorial Epidemiologists (CSTE) Annual Conference. June 19-23, 2022. Louisville, KY. Selected for best poster presentation competition.
- Rajamani S, Chakoian H, Bierringer A, Solarz S, White K, Melton G. Designing a Public Health Interoperability Solution across a Statewide Disease Surveillance System and Immunization Information System. University of Minnesota School of Nursing Research Day. April 8, 2022. Minneapolis, MN.
- Bieringer A, Rajamani S, Chakoian H, Solarz S. Designing a Public Health Interoperability Solution across a Statewide Disease Surveillance System and Immunization Information System. American Immunization Registry Annual Conference. April 26-27, 2022. Virtual.
- Rajamani S. Perspectives on the Public Health Informatics Landscape via a Learning Health System Lens. Invited talk at the University of Minnesota Center for Learning Health System Sciences iMPact seminar. August 2, 2022. Invited Talk (virtual).
- Rajamani S, Leeds M, Jiter N, Bieringer A. Evolution of Electronic Exchange of Public Health Vaccination Reporting and Queries in COVID-19 context: Minnesota Immunization Information System. Proceedings of the AMIA Annual Symposium. 2022. 1778.
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