Multisite Evaluation Report

Digital Bridge electronic case reporting (eCR) implementations

November 2019

digital bridge

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Acronyms

AIMS: APHL Informatics Messaging Services platform
APHL: Association of Public Health Laboratories
ASTHO: Association of State and Territorial Health Officials
CDA: Clinical Document Architecture
CDC: Centers for Disease Control and Prevention
CSTE: Council of State and Territorial Epidemiologists
eCR: Electronic case reporting
EHR: Electronic health record
eICR: Electronic initial case report
ELR: Electronic laboratory report/reporting
HL7: Health Level Seven
ICD: International Statistical Classification of Diseases and Related Health Problems
IT: Information Technology
LOINC: Logical Observation Identifiers Names and Codes
MAC-ELISA: Immunoglobulin M antibody capture enzyme-linked immunosorbent assay
NACCHO: National Association of County and City Health Officials
NND: National Notifiable Disease
ONC: Office of the National Coordinator for Health Information Technology
PCR: Polymerase chain reaction
PHII: Public Health Informatics Institute
RCKMS: Reportable Conditions Knowledge Management System
RCTC: Reportable conditions trigger codes
ROI: Return on investment
RR: Reportability response
SNOMED: Systematized Nomenclature of Medicine
UDOH: Utah Department of Health
XML: Extensible Markup Language
XPath: XML Path Language

Executive Summary

Background

Digital Bridge is a collaborative of decision-makers in healthcare, public health, and health information technology (IT) who come together to address information exchange challenges. A governance body formed in fall 2016 to lead this effort. For their first project, Digital Bridge participants designed a multi-jurisdictional, national approach to electronic case reporting (eCR). In public health and allied fields, case reporting refers to healthcare providers submitting information with personal identifiers about patients to a designated public health authority, as required by law, for specific diseases and conditions (Council for State and Territorial Epidemiologists, 2016). Historically, health departments rely on paper reports or internet-based report entries. This manual process can be slow, incomplete, and burdensome for healthcare and public health personnel. eCR aims to automate transmission of case reports from electronic health records (EHR) to public health agencies and establish bidirectional, or two-way, information exchange between the two. eCR can result in more accurate, complete, and timely data to support public health action. More timely detection of health-related conditions or events of public concern can result in rapid intervention and lowered disease transmission (MacKenzie et al., 2016).

Beginning in 2017, eight demonstration sites joined Digital Bridge to effectively test this new eCR infrastructure: California, Houston, Kansas, Massachusetts, Michigan, New York State, New York City and Utah. Each demonstration site includes a public health agency, a healthcare organization, and a health IT developer. The sites tested the eCR approach with patient data originating in the healthcare organization's EHR system related to five conditions: pertussis, gonorrhea, chlamydia, salmonellosis, and Zika virus infection.

In early 2017, the governance body established the Digital Bridge evaluation committee to complete a multisite evaluation on eCR success in these demonstration sites. The committee included professionals from state and local health departments, federal and non-governmental organizations, and the private sector. The multisite evaluation aimed to produce knowledge that would inform future projects that automate case reporting. This report is designed to address the evaluation goals articulated by the governance body, and provide reliable information to support decision-making related to the continued development and implementation of eCR in jurisdictions nationwide.

There are four evaluation goals:

1. Identify and describe the processes by which sites initiated and implemented eCR and the factors that influenced these processes
2. Determine eCR functioning and performance in terms of system functionality and case report quality (i.e., accuracy, completeness, and timeliness)
3. Identify the resources needed to initiate and implement an eCR system
4. Identify the potential value and benefits of eCR to stakeholders

This report contains results from both qualitative and quantitative analyses of aspects of eCR initiation and implementation. It begins with programmatic information about the demonstration sites followed by the methods used for data collection and analyses. Findings and conclusions are presented for the

ten evaluation questions identified in the evaluation plan. The final section includes recommendations for action that can be used in eCR planning, implementation, and evaluation in the immediate and longer-term future.

Methods

The evaluation entailed de-centralized data collection and extraction, centralized analysis, and de-centralized interpretation across the implementation sites. This evaluation included seven types and sources of data, both qualitative and quantitative:

- Key informant interviews with site-based personnel
- Information extracted from the health IT product in each site
- Information provided to healthcare sites from the APHL Informatics Messaging System (AIMS) platform
- Information extracted from the reportable conditions knowledge management system (RCKMS), maintained by the Council of State and Territorial Epidemiologists (CSTE)
- Data from the public health surveillance system in each site
- Information on site-specific costs
- Site characteristics from document review

Personnel in all eight demonstration sites were instrumental to data collection processes. For example, site-based personnel completed all extraction of information from the health IT systems and applications, public health surveillance systems, and more. These personnel also completed cost data analysis instruments and participated in key informant interviews. The Digital Bridge evaluation committee oversaw and advised evaluators throughout the execution of the eCR demonstration projects. The Public Health Informatics Institute, a program of the Task Force for Global Health, an affiliate of Emory University, led and managed evaluation activities day to day. PHII validated site-specific findings and conclusions with key personnel in each location. Together with representatives of the evaluation committee, they conducted a virtual data interpretation exercise that included participants from all sites. Evaluation committee members and site participants reviewed a draft report and provided comments that were incorporated in the final report.

Key Findings

Demonstration site representatives participated in key informant interviews and provided important perspectives on several aspects of eCR initiation and implementation. In these sites, electronic initial case reports (eICRs) were transmitted to the public health agency successfully, and bidirectional data exchange was achieved as patient data were sent to the public health agency and back to the healthcare facility as intended. These sites noted that effective communication, programmatic and technical expertise, and adequate IT infrastructure facilitated eCR implementation. At the same time, these sites noted that unanticipated obstacles in coordination among contributors, availability of resources (human and fiscal), and insufficient technical guidance inhibited initiation and implementation. Hence, the IT components of eCR were well-supported by the Digital Bridge project team; however, better support of other workflow aspects, such as communication among the collaborators and resource allocation, may have accelerated initiation and implementation.

Overall, the reportable condition concepts were well represented in the reportable conditions trigger codes (RCTC). Analysis of RCTC data from two sites found that only a small proportion of local codes needed to be mapped to RCTC during implementation. Many of the codes already existed in the EHR system or were added as new codes. Two specific issues were identified for a Zika test, and chlamydia species lab tests were missing in RCTC, causing issues with implementation as the sites proceeded. The concepts in the RCTC reflect the codes needed to trigger the generation of an eICR for transmission to the decision support intermediary (DSI) for additional analysis.

Findings are organized around the core components of the Digital Bridge approach to eCR. Two sites were able to successfully develop and implement the core components of the Digital Bridge eCR approach. As implementation continues, eICRs may add valuable information to cases in the public health surveillance system, building potential to produce sustainable change and improve surveillance. As sites and jurisdictions continue implementation, additional improvements in the completeness, accuracy, and timeliness of reportable conditions is anticipated.

In relation to cost, the initial analysis showed striking variation among sites notably due to experiential differences in IT system adoption. Costs were dependent on existing IT infrastructure, in-house expertise, and human resources available. eCR adoption is complex and challenging for early adopters; however, the demonstrations revealed that implementation tasks became more routinized and less complex for subsequent sites. We anticipate identified barriers to implementation becoming easier as more sites implement eCR.

Recommendations

Based on the evidence gathered throughout the evaluation process, contributors formed recommendations to inform future eCR implementation. The evaluation committee urges implementers, operators, and evaluators to consider executing these recommendations when planning eCR implementation and enhancements. Jurisdictions and sites refer to the public health agency, health IT, and healthcare provider teams that implement eCR.

eCR Readiness and Resources

1. Jurisdictions or sites should conduct an eCR readiness assessment prior to implementation.
2. Jurisdictions or sites should confirm that vendor solutions and capabilities match their specific business requirements before implementation.
3. Jurisdictions or sites should secure supplemental training and technical assistance to support the information technology requirements associated with implementation.

Communications and Collaboration

4. Jurisdictions or sites should ensure that relevant leaders in key organizations are well-informed and support eCR implementation (e.g., to ensure that adequate human and fiscal resources are available).
5. Jurisdictions or sites should confirm how specific organizations will contribute to eCR implementations and discuss roles and expectations prior to implementation.
6. Jurisdictions or sites should establish a shared platform for technical collaboration among contributors to eCR.

7. Jurisdictions or sites should establish communication early to engage appropriate reporting staff.

Technology and Process Alignment

8. Jurisdictions or sites should document clinical and patient care workflows and trigger code configuration early in implementation to support transmission of complete eICRs.

Future Evaluation Efforts

9. Jurisdictions and relevant stakeholders should assess the most appropriate method to document and analyze eCR-related costs in preparation for future evaluation activities.
10. Jurisdictions and relevant stakeholders should engage supporting organizations (i.e., partner organizations or contributors not located in the site or working across sites to provide technical assistance, for example) in the evaluation to a greater degree.
11. Include diverse workgroups (e.g., site representatives, partner organizations) to contribute to evaluation planning, implementation, and use (using the Digital Bridge evaluation committee as a model).
12. Future evaluation activities must account for variations in site maturity and implementation, and the evaluation questions and methods must evolve to address this crucial finding.
13. Intended users of this evaluation should collaborate on, determine, and use a minimum set of indicators.

Introduction

Digital Bridge is a collaborative of decision-makers in healthcare, public health, and health information technology (IT) who come together to address information exchange challenges. A governance body formed in fall 2016 to lead this effort. For their first project, Digital Bridge participants designed a multi-jurisdictional, national approach to electronic case reporting (eCR).

This report describes an evaluation of the Digital Bridge eCR pilot that took place within eight public health jurisdictions around the country. The report includes background information about the Digital Bridge approach to eCR and the evaluation, an overview of the evaluation methods, the evaluation results, and recommendations for future implementations of eCR.

Digital Bridge eCR Background

In public health and allied fields, case reporting refers to healthcare providers submitting information with personal identifiers about patients to a designated public health authority, as required by law for specific diseases and conditions (CSTE, 2016). Historically, health departments rely on paper reports or internet-based report entries. This manual process can be slow, incomplete, and burdensome for healthcare and public health personnel (Lee et al., 2010). eCR aims to automate transmission of case reports from electronic health records (EHR) to public health agencies and establish bidirectional, or two-way, information exchange between the two. eCR can result in more accurate, complete, and timely data to support public health action. More timely detection of health-related conditions or events of public concern can result in rapid intervention and lowered disease transmission (Mac Kenzie et al., 2016).

Beginning in 2017, eight demonstration sites joined Digital Bridge to test this new eCR infrastructure: California, Houston, Kansas, Massachusetts, Michigan, New York State, New York City, and Utah. Each demonstration site includes a public health agency, a healthcare organization, and a health IT partner. These sites implemented eCR with patient data from the healthcare organization's EHR system for five conditions: pertussis, gonorrhea, chlamydia, salmonellosis, and Zika virus infection. In each of these sites, partners worked to automate transmission of information from EHRs in the healthcare organization to the public health agency in near real-time. In addition to site-based resources, Digital Bridge partners provided administrative support to connect and enable communication across sites and provide technical assistance as needed.

The Digital Bridge approach to eCR aims to change the status quo of point-to-point data connections between healthcare and public health entities. The approach uses existing EHRs to automatically flag potentially reportable disease cases and create an initial case report. In the eCR approach, after a healthcare clinician enters patient visit details into an EHR, data that meet specific criteria generate an eICR to automatically send information about a reportable condition to public health authorities in demonstration sites (Digital Bridge, 2017). The central decision support service determines whether the case is reportable to public health. If the case is reportable, the report is forwarded to appropriate public health agencies. The central decision support service eliminates confusion regarding where to send the case report and alleviates burdensome manual reporting processes for healthcare professionals. This real-time, automated process is designed to be available in any health care IT product and adoptable by any size organization and data provider.

The decision support service runs on the APHL Informatics Messaging Service (AIMS), a secure, cloud-based platform developed by the Association of Public Health Laboratories (APHL). Case reports are evaluated against public health reporting criteria by the Reportable Conditions Knowledge Management System (RCKMS), developed by CSTE (CSTE, n.d.).

The infographic in Figure 1 depicts how data are entered into the EHR, sent to the decision support intermediary, adjudicated based on reportability rules, and sent on to a public health authority.

Figure 1: A Visual Representation of the eCR Process (based on Digital Bridge, 2017)

1	2	3	4	5
Provider Enters Information	Health Technology Sends Information	Reportability is Determined	Cases are Analyzed and Evaluated	Additional Feedback is Shared with Provider
Healthcare provider documents patient visit information into electronic health record as part of regular workflow.	Criteria in health records trigger an electronic initial case report (eICR) to automatically send.	Case report is validated and if reportable, is forwarded to the appropriate agency. Healthcare provider is notified if disease case is submitted.	Public health professionals receive the disease case for analysis and evaluation.	The provider can choose to receive guidance on patient care and outbreak response from public health.

Evaluation Background

In early 2017, the governance body established the Digital Bridge evaluation committee that included professionals from state and local health departments, federal and non-governmental organizations, and the private sector. In collaboration with key stakeholders, the committee developed and released a multisite evaluation plan approved by the governance body in early 2018 (Digital Bridge, 2018).

The plan included ten evaluation questions that address eCR planning, implementation, and selected outcomes. All eight demonstration sites participated in data collection, but not every site participated in all aspects of the multisite evaluation.[1]

The evaluation plan was designed to produce knowledge that would inform future projects that attempt to automate case reporting (Digital Bridge, 2018). This report addresses the evaluation goals and provides the governance body, as well as others interested in eCR implementation, with information to inform decision-making related to the continued development of the Digital Bridge eCR approach.

The Robert Wood Johnson Foundation grant 75243 provided fiscal resources to implement this evaluation. In 2017, the Centers for Disease Control and Prevention (CDC) provided resources to the MITRE Corporation and Battelle Memorial Institute to work with the Digital Bridge evaluation committee and demonstration sites to co-create the comprehensive evaluation plan.

Purpose

Stakeholders identified the purposes of this evaluation in terms of four goal statements:

1. Identify and describe the processes by which sites initiated and implemented eCR and the factors that influenced these processes
2. Determine eCR functioning and performance in terms of system functionality and case report quality (i.e., accuracy, completeness, and timeliness).
3. Identify the resources needed to initiate and implement an eCR system.
4. Identify the potential value and benefits of eCR to stakeholders.

These purposes were translated into ten evaluation questions presented in Table 1. Evaluation questions "define precisely which aspects of the program will be addressed" (MacDonald, 2013, p. 3). These questions focus on the merit, worth, or significance of a program and help to define the boundaries of an evaluation (Wingate & Schroeter, 2017).

[1] Multisite evaluations examine a program (i.e., an activity, intervention, or project) that operates in more than one location and includes cross-site evaluation activities (Straw & Herrell, 2002). In multisite evaluations, the program can be implemented in the same way in all sites or differently from site to site.

Table 1: Multisite Evaluation of Digital Bridge Electronic Case Reporting (eCR) Demonstration Projects – Evaluation Goals and Questions

Evaluation Goal	Evaluation Question
Identify and describe the processes by which sites initiated and implemented eCR and the factors that influenced these processes	1. How were the core components of eCR initiated and implemented in participating sites? 2. What were the facilitating and inhibiting factors related to initiation and implementation? 3. How did sites address inhibiting factors?
Determine eCR functioning and performance in terms of system functionality and case report quality (i.e., accuracy, completeness, and timeliness)	4. To what extent were sites able to develop and implement the core components of the Digital Bridge approach to eCR successfully? 5. To what extent are electronic case reports accurate, complete, and timely? 6. To what extent is the information in the electronic initial case report (eICR) complete and accurate?
Identify the resources needed to initiate and implement an eCR system	7. What were the costs associated with initiation and implementation of eCR in sites?
Identify the potential value and benefits of eCR to stakeholders	8. To what extent did eCR improve (or hinder) surveillance functions in sites? 9. What are the strengths and weaknesses of the Digital Bridge approach to eCR for digital information exchange and use? 10. To what extent does eCR add value to healthcare and public health practice in sites?

Intended Users and Uses

As presented in Table 2, there are three categories of primary intended users[2] of the Digital Bridge eCR evaluation and a series of diverse uses that have already occurred or are likely to occur in the near future.

[2] Evaluation users are individuals who are in a position to make decisions or take action based on evaluation results. Evaluation use refers to the actions or learning that occurs among evaluation users or other stakeholders based on the evaluation (CDC, 1999). There are three main types of evaluation use. (1) *Conceptual use* takes place when the evaluation findings help program personnel or other stakeholders understand the program in a different or new way (Fleisher & Christie, 2009). (2) *Instrumental use* refers to the use of evaluation findings to adjust or modify the program (Fleisher & Christie, 2009). (3) *Process use* includes "the cognitive, behavioral, program, and organizational changes resulting, either directly or indirectly, from engagement in the evaluation process and learning to think evaluatively" (Patton, 2008, p. 109).

Table 2: Multisite Evaluation of Digital Bridge Electronic Case Reporting (eCR) Demonstration Projects – Intended Users and Uses

Intended Users	Current and Anticipated Uses
Current and future implementation sites	• Individual sites have used site-specific data to document and communicate the status of eCR implementation (or aspects of implementation) to personnel and other stakeholders. • Evaluation committee representatives, PHII, and two implementation sites shared initial data at a national public health conference to communicate the status of eCR implementation in these sites and early lessons learned (i.e., about the program and its evaluation). • Sites have used data to support operations and technical decisions specific to eCR implementation (e.g., allocation of resources in preparation for production). • Sites can use the findings to determine needs and priority areas for investment of resources at multiple points in eCR planning and implementation. • Sites not currently participating in the Digital Bridge project have reviewed data collection instruments with PHII personnel to aid in evaluation planning in their own site. • Personnel in sites not yet sending electronic case reports have reviewed data collection instruments to lay out and prepare for evaluation activities as they implement eCR in the months ahead. • Participating sites can use the evaluation report as a starting point to discuss recommended improvements to instruments, data collection procedures, and other aspects of the evaluation. • As a group, representatives of current sites used analyzed data to articulate recommendations for action to improve technical planning (e.g., related to trigger codes).
Digital Bridge Governance Body	• The governance body can use evaluation findings to better understand opportunities and needs as eCR activities transition to other organizations and include additional sites. • The governance body can add the evaluation report to the archive of materials intended to support ongoing development of eCR activities nationwide. • The governance body and key stakeholders can determine whether the evaluation should be continued as is or modified to address additional aspects of the program.
Current and Future Partner Organizations (government and non-government)	• Partners can use the data and recommendations to identify technical assistance needs in sites and contribute human or fiscal resources to meet these needs. • Partners can use the evaluation report to better understand common operational and technical challenges across sites. • Partners can use the evaluation report to identify additional tools or job aids needed to improve eCR implementation in current and new sites.

Evaluation Personnel and their Roles

PHII, a program of the Task Force for Global Health, an affiliate of Emory University, led and managed evaluation activities day to day. PHII personnel provided initial drafts of evaluation instruments, collected or compiled evaluation data, analyzed evaluation data, and documented the findings and conclusions to prepare evaluation committee deliverables.

The Digital Bridge evaluation committee oversaw and advised evaluators throughout the execution of the eCR demonstration projects. Jeff Engel, MD, CSTE, and Goldie MacDonald, PhD, Centers for Disease Control and Prevention, chaired the evaluation committee. The Digital Bridge governance body appointed professionals from public health, health IT, and healthcare with expertise and interest in the committee's charge as committee members. Evaluation committee members came from the Association of State and Territorial Health Officials (ASTHO), the Office of the National Coordinator (ONC), Intermountain Healthcare, Utah Department of Health (UDOH), and the National Association of County and City Health Officials (NACCHO). ASTHO representatives assisted in the evaluation as they reached out to the state health officials in a few public health agencies and also participated in introductory calls to review the purpose of the Digital Bridge evaluation and secure buy-in.

PHII personnel consulted with the evaluation committee to

- identify which components of the evaluation plan would be implemented,
- further operationalize indicators listed in the evaluation plan,
- develop a matrix of evaluation questions, indicators, and data to be collected for each indicator,
- develop data collection instruments and participant consent forms,
- determine how to pilot test instruments with implementation sites,
- examine options to collect and store data securely,
- articulate data collection roles and responsibilities across contributors (e.g., PHII personnel and site-based personnel),
- communicate with implementation sites and other stakeholders at crucial points throughout the evaluation process,
- review analysis plans for qualitative and quantitative data,
- develop and implement a participatory data interpretation activity with implementation sites,
- prepare and submit conference abstracts to share information about the evaluation with a wider audience, and
- outline and prepare portions of the evaluation report.

Personnel in all eight demonstration sites were instrumental to data collection processes. For example, site-based personnel completed all extraction of information from the health IT systems and applications, public health surveillance systems, and more. These personnel also completed cost data analysis instruments and participated in key informant interviews. PHII personnel worked directly with implementation sites to collect, clean, and analyze data. PHII validated site-specific findings and conclusions with key personnel in each location. Together with evaluation committee representatives, site personnel contributed to interpreting the evaluation results and developing recommendations. This evaluation would not be possible without the participation and contributions of healthcare IT staff from Intermountain Healthcare and Houston Methodist Hospital, the IT vendor staff from Epic, and public health agency staff from the California Department of Public Health, Houston Health Department, Kansas Department of Health and Environment, Massachusetts Department of Public Health, Michigan

Department of Health and Human Services, New York City Department of Health and Mental Hygiene, New York State Department of Health, and UDOH.

Evaluation Methods

The evaluation entailed de-centralized data collection and extraction, centralized analysis, and de-centralized interpretation across the implementation sites. This section of the report describes the various types and sources of data used in the evaluation and how those were gathered; procedures followed for instrument development, data collection, and human subject protections; processes used for data interpretation; and limitations of the evaluation that affected data quality and quantity.

Data Types and Sources

This evaluation included seven types and sources of data, both qualitative and quantitative:

1. Key informant interviews with site-based personnel
2. Information extracted from the health IT product in each site
3. Information provided to healthcare sites from the AIMS platform
4. Information extracted from RCKMS, maintained by CSTE
5. Data from the public health surveillance system in each site
6. Information on site-specific costs
7. Site characteristics from document review

Table 3 indicates the (a) eCR implementation status of each of the sites at the point in time when the writing of this report started and (b) the status of each site's participation in each of the various streams of data collection. Sites' participation in data collection was largely determined by their implementation status. For example, sites that were not in production did not have the necessary data in AIMS, the public health surveillance system, or RCKMS. The sections that follow explain each of the streams of data collection in more detail.

Table 3: Sites' Implementation Status and Participation in Each Stream of Data Collection

Data Collection Activity	Demonstration Sites							
	UT	Houston	NYC	NY State	KS	CA	MI	MA
Digital Bridge eCR Implementation Status as of June 2019	●	●	◒	◒	◒	◒	◒	◒
Key Informant Interviews	●	●	◒	○	◒	○	○	◒
Extract from health IT product	●	●	○	○	○	○	○	○
Extract from RCKMS data	●	●	●	●	●	●	●	●
Extract from public health surveillance system	●	○	○	○	○	○	○	○
Data on costs	◒	◒	●	○	●	◒	●	●
Information on site characteristics extracted from key document review	●	●	●	●	●	●	●	●

Legend: ● *Completed* ◒ *Partially Complete* ○ *Not Initiated*

Key Informant Interviews with Personnel in Demonstration Sites

In this evaluation, key informant interviews[3] were used to document and explore how site partners initiated and implemented eCR. These data provided important contextual information to better understand quantitative data collected on key aspects of eCR functionality and performance. In addition, these interviews revealed important challenges and lessons learned from the perspective of site-based personnel.

The interview guide addressed eCR planning and implementation processes and included questions about factors that facilitated or inhibited initiation of eCR core components. PHII developed the interview questions in consultation with members of the evaluation committee and tested the content with a participant working in Houston. PHII completed six semi-structured interviews across two demonstration sites: four in Houston and two in Utah. These small-group interviews included a total 14 participants: six from public health organizations, six from healthcare organizations, and two from

[3] Key informant interviews involve those with first-hand, in-depth knowledge about an aspect of the program in question. These interviews are loosely structured and allow for important ideas, information, or observations to emerge in conversation (USAID, 1996).

health IT organizations. PHII conducted three of the interviews in person at the Houston Health Department, UDOH, and Houston Methodist Hospital. The other three interviews were conducted on the phone. Three sites, Kansas Department of Health, New York City Department of Health, and California Department of Health, participated in abbreviated interviews to address the status of their implementation, but those discussions are not included in this report.

Each participant had an instrumental role in eCR initiation or implementation in their site and provided written and verbal consent to participate. The interviews were recorded, transcribed, and maintained in a secure environment. The evaluation team recorded phone interviews via GoToMeeting and used a digital recorder for in-person interviews. All interviews were transcribed using SpeechPad. The evaluation team compared each transcript to audio recordings and revised the transcripts where necessary. All of the audio recordings are stored and have been archived by PHII.

PHII personnel completed a cursory review of the transcripts and presented initial themes to the evaluation committee, demonstration site representatives, and other key stakeholders in January 2019. Personnel from Deloitte Consulting, LLC conducted a comprehensive analysis of the qualitative information collected. A senior consultant developed *a priori* codes based on the interview questions and core components of the Digital Bridge eCR approach defined in the evaluation plan (Digital Bridge, 2018). She analyzed the transcripts to validate these codes and create additional ones based on emergent themes. In consultation with PHII, these codes were revised twice based on careful review of the transcripts and technical information related to aspects of eCR. All transcripts were coded using the revised codes, and narrative excerpts were extracted and organized by site and organization type (i.e., healthcare, health IT, or public health). All of these data were cleaned, managed, and analyzed with Dedoose, a web application for mixed methods research. Personnel from Houston and Utah provided feedback on the initial findings and checked the accuracy of the information used. Finally, representatives from PHII, Deloitte, the evaluation committee, and the Digital Bridge implementation workgroup contributed to interpreting the analyzed data and developing recommendations for action based on the information.

Data from Health IT Product in Demonstration Sites

Data extracted from the health IT product included information on mapping, application of trigger codes, and the number of eICRs and reportability responses (RR) created. Two sites contributed to this component of the evaluation: Utah submitted data for February 12 to March 12, 2019 and March 13 to April 12, 2019, and Houston submitted data for three months: March, April, and May 2019. Healthcare provider staff at Intermountain Healthcare and Houston Methodist Hospital provided data from their health IT systems.

The healthcare provider staff extracted data on standard or local codes in the health IT products and how the codes were mapped (aligned to or matched) to the RCTC list. As explained by Hui and Conn (2016), the RCTC are a set of standardized codes that support the electronic flow of case reports from clinical settings to public health agencies. Maintained by CSTE, these codes are implemented in clinical settings, and, when matched to information in a patient encounter record, spur generation of an eICR. These trigger codes enable identification of encounters that may be associated with reportable conditions (i.e., conditions or diseases that healthcare providers must report to public health authorities) and route them on to the next step in the eCR process. Healthcare provider staff collected data and electronically submitted information from the health IT product to PHII.

To collect these data, PHII developed an Excel spreadsheet with input from subject matter experts that includes fields for information on the four value sets contained in the RCTC. Sites implemented the standard codes for each condition based on the RCTC value sets from the RCTC release version (2017-10-13). The RCTC value sets include codes in four categories:

- **Diagnosis_Problem S1 -** This set of values contains diagnoses or problems that indicate that the patient may have a reportable condition, despite the clinical presentation of the condition. These codes are typically found in the EHR's problem list and are used for billing.
- **Organism_Substance S2** - This set of values contains organism and substance names received in reports of laboratory results that may represent a potentially reportable condition. These are typically Systematized Nomenclature of Medicine (SNOMED) codes.
- **Lab Order Test Name S3** - The set of values that contains the laboratory order test names, as part of a laboratory order for a test, indicating that a patient may have a reportable condition. These are typically Logical Observation Identifiers Names and Codes (LOINC) codes.
- **Lab Obs Test Name S4 -** This set of values contains the lab observation test names that may indicate if a patient has a reportable condition. These are typically LOINC codes.

PHII provided the form, an Excel spreadsheet, to sites and oriented them to the content via a series of conference calls. Sites used the form to extract information from their healthcare IT product application in their facilities from January to June 2019. PHII personnel were available via email and phone to assist with use of the form or clarify the information to be extracted. Upon receipt of data from the sites, PHII combined the information in a single Excel spreadsheet organized by site in order to compare the trigger codes in the RCTC and the trigger code mapping completed by the healthcare providers.

To assess the application of trigger codes, the personnel in healthcare organizations queried the health IT product database to determine the number of eICRs triggered during the evaluation period. These data were based on audit logs (an audit trail of the sequence of activities or events that happen inside the software of the health IT product) that identified which encounter during the study period has a record of at least one associated eICR. For each of these eICRs, information was extracted and recorded. Personnel in one participating healthcare organization were able to extract data from their health IT product by reportable condition (i.e., chlamydia, gonorrhea, pertussis, and salmonellosis). The other healthcare organization provided the number of eICRs triggered for a specified time period but did not report the data by condition.

Healthcare providers also extracted data from the health IT product to determine the number of reportability response documents that were received and consumed by a health IT system. Sites created and ran database queries to generate counts of the number of reportability responses received. These data were submitted electronically to the evaluator via a provided template. PHII compiled the data from the providers and conducted a comparative analysis of the RR and eICR counts. After PHII

completed this analysis, the sites reviewed the findings and presentation of data and replied with clarifications.

Data Extracted from the Reportable Conditions Knowledge Management System (RCKMS) Maintained by the Council of State and Territorial Epidemiologists (CSTE)

At the request of each site, CSTE provided data to the evaluation team about sites' use of the default criteria; default criteria are pre-populated in RCKMS based on the CSTE position statements (RCKMS, n.d.). CSTE provided these data for the public health agencies in all eight sites. CSTE also provided information about the sites' specific refinements to criteria for each condition, code types, and refinement categories. Before the analyses, CSTE staff collated RCKMS default criteria for the five pilot conditions on September 25, 2018. Summary reports for the jurisdictional reporting specifications from the eight sites were provided to PHII following approval via email from participants. Summary reports for Houston and Utah were generated on October 12, 2018, followed by California on February 12, 2019 and Kansas, Michigan, New York City, and New York State on April 10, 2019. The Massachusetts reporting specifications were collated on April 15, 2019.

Evaluation staff compiled all of this information in a single spreadsheet to determine (a) the number of default criteria used in each site, (b) if and how they modified these criteria, and (c) what additional criteria they used.

Data Extracted from the Public Health Surveillance System in Demonstration Sites

Two types of data were extracted from the public health surveillance system: (1) the number of eICRs received by the public health system and (2) the completeness of the eICRs in terms of their data elements included in the eICR. The process for collecting these types of data is described below.

Site personnel were asked to complete a spreadsheet to report **the number of eICRs received by the public health surveillance system**. This spreadsheet was developed by PHII staff, reviewed by the evaluation committee, and then piloted by members of the evaluation committee who tested it at UDOH. The public health surveillance personnel developed queries to pull data from the surveillance system database. Public health staff ran the queries to determine the number of eICRs and RRs consumed. Only one site participated in this component of the evaluation.

Public health agency personnel were asked to review a sample of eICRs from all five pilot conditions and determine the **completeness of data elements used in the eICRs** for a 30-day period. The data elements were derived from the mapping of CSTE-identified data elements in the implementation guide for eCR (Health Level Seven International (HL7), 2017). This completeness instrument was developed by PHII, reviewed by the evaluation committee, and then piloted by Utah Department of Health. The public health agency surveillance system audit trails provided documentation for these details on completeness of data elements. The completeness data required multiple iterations of data element review to ensure consistency across the XML Path Language (Xpath) queries the public health agency used. This required collaboration, by phone and email, between public health personnel and the healthcare provider personnel to ensure that the queries were structured to pull the data from the correct location in the eICR. Once the data from public health agencies were collected by public health staff, it was populated into the evaluation instrument for public health indicators (described above). UDOH reviewed 8,341 eICRs from February 12 to March 12, 2019 and provided the results to PHII for inclusion in the evaluation.

Information on Site-Specific Costs and Expenditures

Public health agencies, healthcare organizations, and health IT vendors tracked the number of hours used to configure each task in an evaluation instrument provided to each organization. A review of the ASTHO Return on Investment (ROI) web-based tool informed the development of the eCR cost data collection instrument used for this purpose (ASTHO, 2016). After conversations with the evaluation committee, instruments were developed to capture the costs of activities, infrastructure, and personnel time and the ASTHO ROI tool was not used. This instrument was drafted by PHII, reviewed and modified by the evaluation committee, and then piloted by a public health agency before distribution to sites. PHII staff conducted conference calls with public health agency and healthcare partners to review the instrument and answer any questions about the request for data collection. PHII combined all submitted data in a spreadsheet for comparison by site and by implementation and initiation periods. Analysis was done to translate numbers for comparison across sites, i.e., four weeks was equal to one month. PHII staff summed labor costs to calculate the total cost per week and total cost per year of initiation and implementation. These data were used to calculate the total cost of the project by site for the two phases of eCR: initiation and implementation.

Public health agencies provided cost information for discrete periods of time during initiation and implementation. One public health agency and one healthcare provider submitted their cost data after the specified deadline, so their data are not reflected in the findings. In collected cost data, there was great variation in the responses received. Some sites responded with an implementation time period of three weeks compared with another site that included two years' worth of costs for implementation. One public health agency did not use the instrument provided and developed their own instrument to track hours and costs of eCR implementation. Epic was the only healthcare IT representative invited to participate in this data collection since they were the only one at the production stage. They declined to provide cost data because pricing estimates for new interfaces like eCR can vary between customers; therefore, they recommended that information on cost data be gathered directly from the healthcare provider. Person hours and related technology costs were also requested.

Site Characteristics Data from Document Review

Site characteristics provide context to the findings of this evaluation. PHII obtained information about site characteristics from Digital Bridge site applications as well as notes from implementation site calls led by the Digital Bridge project management office. This information was compiled in a spreadsheet, which was then reviewed by the personnel at the project management office and sent to the public health agencies involved in eCR demonstrations for their review. Each implementation site provided comments, and PHII staff made revisions accordingly.

Evaluation Procedures

Instrument Development

All evaluation materials, including questionnaires and instruments, were developed in English, and all interviews were conducted in English. PHII led the development of the instruments, and site personnel and the evaluation committee had opportunities to review the instruments and provide input to increase their clarity, relevance, and usability.

Data Transmittal, Storage, and Analysis

With the exception of interviews, data for the evaluation were recorded in various Excel spreadsheets by site personnel, transmitted via email to evaluation staff, and stored in a secure cloud drive. Quantitative analyses were performed in Excel.

Research Determination and Human Subjects Protections

The Emory University Institutional Review Board (IRB) determined that this evaluation did not constitute research because the systematic collection or analysis of data is not intended to be generalizable. PHII was not required to submit a complete proposal for IRB review. All participants who participated in the evaluation signed consent to participate or verbally consented to interviews.

Data Interpretation

After data collection and analyses were completed, the evaluation committee hosted a webinar to engage the implementation sites in a collaborative process to interpret the findings, develop answers to the evaluation questions, and reach overall conclusions about the value of the Digital Bridge eCR approach. Attendees included 28 participants from eight demonstration sites. These participants represented healthcare care organizations, public health agencies and health IT vendors or personnel. Members of the evaluation committee and decision support intermediary team also participated. They presented and reviewed data and shared recommendations for action. In addition, this process surfaced new information about sites' experiences with the eCR approach, which are addressed in relevant parts of this report.

Limitations

In this multisite evaluation, there were four main limitations:[4] (a) the quantity and quality of data collected across sites varied due to where they were in the implementation process at the time; (b) some data could not be accessed due to legal agreements not well-understood prior to data collection; (c) documentation of costs was hindered by methodological and practical challenges in some sites; and (d) available resources (e.g., funds, personnel, time) influenced the scope of the evaluation in important ways.

The findings of this evaluation reflect the unique perspectives and experiences of the individual respondents and sites represented. At the time of data collection, these sites were at different points in eCR initiation and implementation. At least in part, this practicality dictated the information available for evaluation purposes, as reflected in Table 3. The two sites that were in parallel production (i.e., manual and electronic reporting at the same time until information quality can be confirmed) were the only ones that contributed data for all of the evaluation questions. Other sites participated to varying degrees, depending on how far along they were in the eCR initiation or implementation process. It will be important to add data from additional sites in production to fully understand these aspects of eCR. It is worthwhile to note that all eight sites participated in several aspects of the evaluation (i.e., data

[4] The Program Evaluation Standards recommend complete description of the limitations of an evaluation (Yarbrough, Shulha, & Hopson, 2011). These limitations can relate to methodological concerns, sources of data, potential biases relevant to the evaluation or its findings, and more (Miron, 2004). Limitations can hinder application or use of findings and can include unanticipated challenges that surfaced during the process (Price & Murnan, 2004).

collection on site characteristics, costs, and RCKMS). The initial inquiry on completeness was limited to one site, and more information is needed from other sites.

The evaluation plan called for extraction of information from the AIMS platform to identify eICRs with formatting errors and the number of eICRs sent to the public health agency. APHL could not provide these data because the business associate agreement for these demonstration projects prohibited disclosure of protected health information to third parties for evaluation purposes. As a result, personnel in the healthcare organizations provided information about eICRs for use in this evaluation. This adjustment to data source and method provided usable information, but it is important to continue to explore options to secure robust data on eICRs for future evaluation activities.

The evaluation plan recommended documenting and recording labor and technology cost data at each site using the ASTHO ROI tool. The tool was not used in this portion of the evaluation, and the plan was amended to be more feasible given resources available across the evaluation, including human resource availability at PHII and demonstration sites. In addition, public health agency staff turnover at some demonstration sites limited data collection as new project staff did not have the information on the costs of eCR initiation and implementation. Of the two sites in production, one healthcare provider submitted cost data and the other healthcare provider submitted cost data in July 2019; therefore, it is not included in this analysis. The EHR vendor declined to share cost data as that data is considered proprietary.

The evaluation plan included far more data collection than was practicable. Stakeholders worked collaboratively to narrow down data collection to match the resources available. For example, PHII and the evaluation committee limited the number of key informant interviews in favor of other data collection activities. PHII personnel provided regular updates to the Digital Bridge governance body about the data collection process and status. Like many multisite evaluations, stakeholders had to prioritize data collection activities, and some of these decisions were made as the evaluation unfolded. As a result, not all data were collected as planned or in all demonstration sites. For example, the perspectives of personnel in demonstration sites that did not reach parallel production were not included in the qualitative data collection. It will be crucial to examine the most useful data in this report, but users need to identify what should be added to future inquiries, too. In addition, the availability and accessibility of audit logs for trigger codes and eICR transactions in some vended products limited data collection.

Prioritization of data collection activities was an active conversation between PHII, the evaluation committee, implementation sites, and the governance body. The conclusions presented in this report were made with full consideration of the evaluation's limitations.

Results

This section of the report presents the results from both qualitative and quantitative analyses of evaluation data about eCR initiation and implementation. The findings are organized by the ten evaluation questions (see Table 1) identified in the original evaluation plan.

Evaluation Question 1: How were the core elements of eCR initiated and implemented in participating sites?

Findings

Demonstration Site Details

The following types of site characteristics are especially relevant to this evaluation: Health IT product names, end user types, service delivery, prior experience with eCR infrastructure and standards, and legal status. The demonstration sites included six state health departments and two local health departments: California Department of Public Health, Houston Health Department, Kansas Department of Health and Environment, Massachusetts Department of Public Health, Michigan Department of Health and Human Services, New York City Department of Health and Mental Hygiene, New York State Department of Health, and UDOH. The health IT vendors included Epic, Cerner, NetSmart and the Michigan Health Information Network (MiHIN). The healthcare providers included large facilities like Intermountain Healthcare in Utah and smaller facilities like the clinics that serve the Institutes of Family Health in New York City, or a public health clinic in Michigan.

Each public health agency in these demonstration sites had a surveillance system for reportable conditions. Vendors for the surveillance system included Maven Disease Surveillance Outbreak Management System (Maven), EpiTrax Disease Reporting System (EpiTrax), New York City's Interactive Health Data (EpiQuery), and custom, state-supported systems like the California Reportable Disease Information Exchange (CalREDIE). Four sites used Amazon Web Services S3 (AWS S3) over secure socket layers, and three sites used the Public Health Information Network Messaging System (PHINMS) software package to connect with AIMS. One site used RESTful service over a Virtual Private Network (VPN) for the transport mechanism with AIMS. At the time of this report, Massachusetts did not have a healthcare provider involved in their implementation, therefore the transport mechanism is unknown. Six sites had a prior existing AIMS interface, and Massachusetts and Utah had previous eCR experience. Utah had prior eCR experience exchanging sexually transmitted disease electronic case reports and Massachusetts exchanged case reports with the implementation of electronic medical record support for public health. All sites had experience with using standardized codes for reportable conditions and experience with Clinical Document Architecture (CDA) documents. Site characteristics are summarized in Table 4.

Table 4: Characteristics of Digital Bridge eCR Demonstration Sites

Digital Bridge eCR Demonstration Sites

Site Characteristics	California Department of Public Health	Houston Health Department	Kansas Department of Health and Environment	Massachusetts Department of Public Health	Michigan Department of Health and Human Services	New York City Department of Health and Mental Hygiene	New York State Department of Health	Utah Department of Health
Type of Jurisdiction	STATE	LOCAL	STATE	STATE	STATE	LOCAL	STATE	STATE
Public Health Surveillance System	CalREDIE	MAVEN	EpiTrax	MAVEN	CUSTOM SYSTEM	CUSTOM SYSTEM	CUSTOM SYSTEM	EpiTrax
EHR Vendor	EPIC	EPIC	CERNER	EPIC	NETSMART/ HIE-MiHIN	EPIC	EPIC	CERNER
Transport mechanism with AIMS platform	AWS S3	PHINMS	PHINMS	To be determined	RESTFUL + VPN	AWS S3	AWS S3	AWS S3
Experience Using CDA Documents in Public Health Surveillance System	✓	✓	✓	✓	✓	✓	✓	✓
Prior Experience Using RCTC or Standardized Codes for Reportable Conditions	✓	✓	✓	✓	✓	✓	✓	✓
Existing AIMS Interface	⊗	✓	✓	✓	✓	✓	⊗	✓
Prior ECR Experience	⊗	unknown	unknown	✓	unknown	unknown	unknown	✓
Healthcare Facility is Outpatient ( ) or Inpatient ( )	☀ ☾	☀ ☾	☀ ☾	To be determined	☀	☀	☀ ☾	☀ ☾

PHII and other contributors used data from key informant interviews to address this evaluation question. As a reminder, these interviews included participants from the Houston Health Department, UDOH, Houston Methodist Hospital, Intermountain Healthcare, and Epic, a health IT company. The interviews focused on six core components of the Digital Bridge approach to eCR: trigger code mapping, application of trigger codes, creation of the eICR, reporting criteria analysis and authoring, adjudication of case reports using jurisdiction-specific rules, and consumption of the eCR and RR by the public health organization. This section of the evaluation report includes a summary of findings from these interviews; more detailed information and excerpts from the interviews are in Appendix 1. Findings refer to statements about a program, or aspects of a program, based on evidence (i.e., the qualitative data from key informants). These findings can include statements or visual representations of the data but do not address interpretations, judgments, or conclusions about what the information means or implies (USAID, 2009).

Personnel in two sites provided information about their experiences with eCR initiation and implementation:

a) **Representatives of the public health organizations conveyed that RCKMS personnel (CSTE staff members) assisted as sites authored reporting criteria, and the interface was easy to use to refine jurisdictional criteria.**
   - Subject matter experts (e.g., laboratory and microbiology terminologists) assisted with mapping trigger codes in the EHR for the five conditions.

b) **Both sites generated eICRs from trigger codes but experienced initial challenges with the timing and versioning of eICRs.**
   - Both sites noted that personnel with eICR expertise and healthcare facilities with existing infrastructure to support eCR facilitated the process of sending and receiving eICRs.
   - Both sites explained that personnel from the health IT vendor, healthcare providers, CDC, and the public health surveillance system contributed to overcoming challenges and ultimately the successful transmission of messages.

c) **Both sites were able to automate transmission of eICRs from the clinical setting to the public health agency while in parallel production (i.e., manual and electronic reporting at the same time until information quality can be confirmed).**
   - Both sites routed eICRs through interface engines en route to public health surveillance systems: Mirth Connect (i.e., NextGen Connect) and Orion Health Rhapsody.
   - In parallel production, one of the public health agencies had to conduct additional validation and mapping to review and parse data appropriately.

Conclusions

Diverse stakeholders contributed to dialogue regarding what these findings mean and any conclusions that can be drawn from the two streams of qualitative information presented in this section of the report. The information on site characteristics revealed the relevance of previous experience with reportable conditions surveillance to initiate and implement eCR. While only two sites reported previous experience with eCR, all eight sites had surveillance-related experience that translates to eCR directly. It will be important to emphasize the applicability and value of this experience to jurisdictions as they consider whether to implement eCR in the months and years ahead. Bidirectional data exchange occurred in the demonstrations, and eICRs were submitted to public health agencies successfully, indicating that core components were successfully implemented. The data also revealed that there is no one-way to initiate and implement eCR—no two sites were configured in exactly the same way in terms of types of facilities, information transport and connection to AIMS, or vendors used. These data hint at how important it is to understand jurisdictional context, needs, and requirements throughout work on eCR.

Recommendations

Similarities of eCR implementations point to needs to (a) engage subject matter experts early in the process to facilitate the mapping of codes and to (b) identify the appropriate human resources to assist in implementation. The implementation of eCR can be complex, and having experts available to assist with implementation would allow jurisdictions or sites to expedite implementation and resolve technical issues as they arise. Sites also identified the need for validation and mapping exercises to ensure data quality. Early on in the implementation, sites should review clinical workflows to establish what in the patient's health record will trigger the eICR. This conversation would subsequently ensure the triggers are generating from the correct location in the EHR and pulling the most complete data needed for an eICR. The identification of timing and the location of the trigger code in the health IT product is crucial to a successful implementation from the health IT product to the public health authority. In addition to identification of trigger code timing, public health agency staff and healthcare providers could assess their existing infrastructure as part of a readiness assessment before starting to implement eCR. While timing and versioning issues were cited, both sites were able to work through the issues and receive eICRs. With the anticipated improvements in data quality, and an expected increase in workload, sites should determine human and technical resources and develop a readiness assessment to decide how best to implement eCR at their site. This preparation would assist in the ease of implementation.

Evaluation Questions 2 and 3: What were the facilitating and inhibiting factors related to initiation and implementation? How did sites address inhibiting factors?

For the purpose of this evaluation, factors that facilitate or inhibit eCR activities refer to technical, social, organizational, and economic conditions that affected the initiation and implementation processes (Digital Bridge, 2018). PHII personnel and other contributors used data from key informant interviews with personnel in two sites to address these questions.

Findings

Factors that facilitate eCR initiation or implementation

a) **Communication within and across sites**: Personnel from both sites noted that communication was the most important factor that facilitated implementation. For example, active communication among personnel in a single organization and across organizations improved transparency and trust and contributed to prompt troubleshooting. Regular and robust communication was seen as crucial for understanding initiation and implementation processes and making necessary decisions in real time. Participants in both sites noted that peer-to-peer information exchange across sites was valuable. The Digital Bridge governance body established an implementation workgroup that provided a forum for regular interaction with personnel in other jurisdictions; participation in these web-based meetings was seen as helpful and contributed to on-the-job learning.

b) **Access to Expertise:** Participants noted that access to professionals with eCR expertise improved their ability to implement eCR. For example, participants explained that having someone in-house with expertise in CDA was useful at key points in eCR implementation. Other participants talked about the important role that external subject matter experts served to facilitate and support eCR implementation (e.g., professionals from APHL, CDC, and CSTE).

c) **Leadership Support:** Participants noted that explicit support from leadership in the healthcare setting was important and helpful in eCR initiation and implementation, especially with regard to priority setting and resource allocation.

Factors that inhibited eCR initiation and implementation

a) **Resource Constraints:** Participants explained that limitations to human and fiscal resources inhibited initiation and implementation. For example, they cited inadequate server space—and lack of funds to purchase more—as a barrier to adequately test eCR functionality. In one public health agency, personnel-related barriers included inconsistent access to personnel with adequate knowledge and experience, lack of dedicated time to work on eCR, and turnover in key positions.

b) **Limited Guidance Documentation:** Participants reported that eCR documentation (e.g., implementation guides) did not adequately alert them to potential roadblocks they might experience during implementation. For example, participants requested more detailed technical guidance on application of existing interoperability information and standards.

c) **Integration of Local and Vendor-supplied IT products:** Participants in both sites reported challenges as they integrated homegrown, local IT infrastructures with vendor-supplied IT solutions for eCR (e.g., making modifications to mapping and trigger codes). Time required to address these challenges delayed the implementation process.

Conclusions

PHII and key stakeholders drew conclusions from this qualitative information with caution. It is clear that aspects of communication, programmatic and technical expertise, and IT infrastructure facilitated eCR implementation in these sites. At the same time, participants noted that unanticipated obstacles to

technology integration among contributors, availability of resources, and insufficient technical guidance inhibited initiation and implementation.

Recommendations

Stakeholders who interpreted these data noted that the emphasis on IT-related components of eCR is important and necessary. However, there are other areas of work that can accelerate and ease eCR initiation and implementation that received far less attention in terms of technical assistance provided by Digital Bridge contributors or other partner organizations. For example, assistance could be provided to enhance communication and collaboration internal to sites as the project unfolds or for assessment of key assets or resources needed pre-implementation. Further, despite challenges throughout the demonstration project, these participants continued to acknowledge the potential benefits of eCR and how the activity can evolve over time. No one in either site indicated that the investment of human or fiscal resources outweighed the actual or anticipated benefits of eCR. In discussion of these data, key stakeholders noted that this commitment and enthusiasm for the endeavor should not be overlooked as an asset to eCR implementation in current and future sites.

Evaluation Question 4: To what extent were sites able to develop and implement the core components of the Digital Bridge approach to eCR successfully?

Each demonstration site agreed to implement an approach to eCR that included

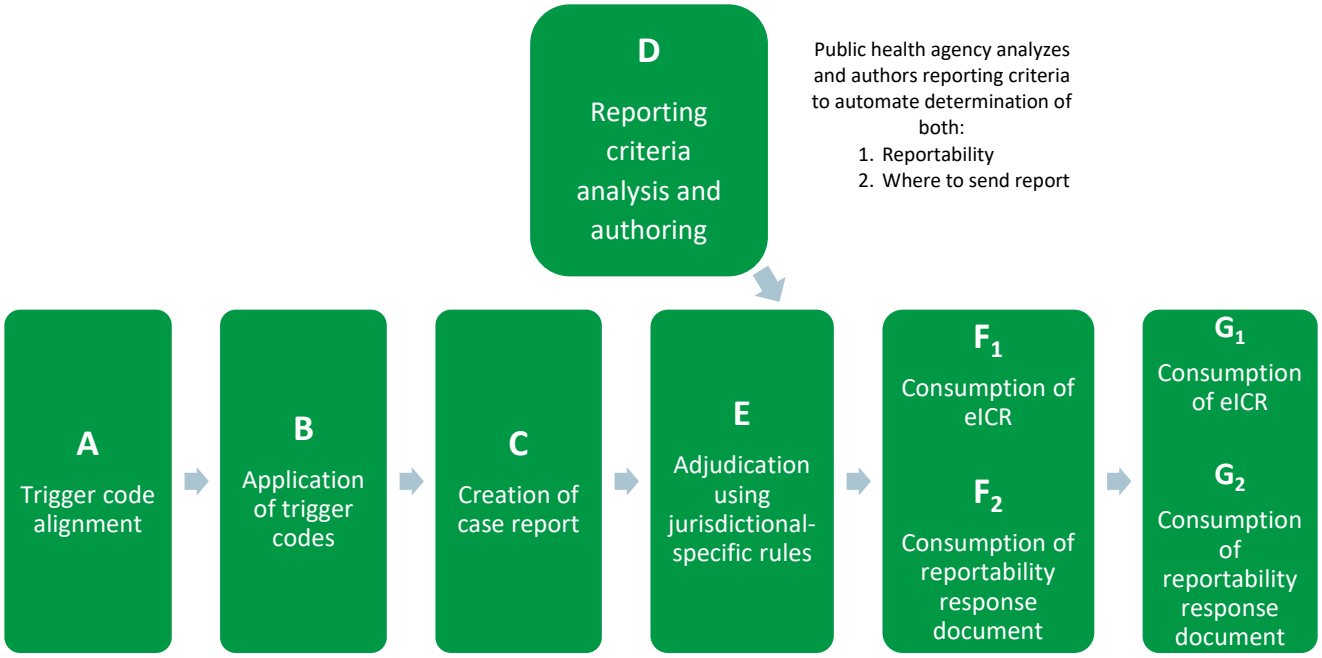
- applying Health Level 7 (HL7) CDA standards for the eICR and RR documents;
- matching local and standard trigger codes in a healthcare organization's EHR platform to those in the RCTC document; and
- using RCKMS to document reporting requirements and adjudicate content in the eICR for reportable conditions.

As summarized in the evaluation plan (Digital Bridge, 2018), the core components of this approach to eCR include a set of related activities:

- health IT staff map (i.e., crosswalk or translation) and align content in the health IT product to standard trigger codes in the RCTC document;
- health IT product applies trigger codes to identify events correctly;
- health IT product creates an eICR when trigger codes activated;
- personnel in the public health agency analyze and author reporting criteria to automate determination of reportability and where to send report;
- decision support tool applies jurisdictional rules to determine whether the case report is routed to a public health agency;
- public health agency receives, consumes (i.e., accepts and processes), and makes the case report and reportability response available for use; and
- health IT product and healthcare organization receive the case report and reportability response for use, too.

The findings for evaluation question 4 are organized around the core components of the Digital Bridge eCR approach. For reference, Figure 2 identifies and shows the relationship among these components.

Figure 2: Core Components of Digital Bridge eCR Approach



Findings

Two sites provided data on the functionality and performance of core components A through D and F_2. Data were not available to evaluate core component E, adjudication using jurisdictional-specific rules, because RCKMS could not provide data for this component of the evaluation. Because sites were not fully exchanging information in production (sites were still testing for quality), this evaluation includes partial findings for core component F_1, consumption of electronic case reports.

Core Component A: Trigger Code Alignment

To implement eCR, the healthcare organization needs to update its EHR to include, or map (crosswalk) local codes to, standard codes in the RCTC. While all sites had to map and align trigger codes as preparatory work for eCR, only Houston Methodist Hospital and Intermountain Healthcare provided data for this core component. The other sites were not yet at a point in implementation to participate in this portion of the evaluation. The RCTC included standard codes for gonorrhea, chlamydia, pertussis, salmonellosis, and Zika. Intermountain used standard codes for all conditions except Zika virus. It used a laboratory test code for immunoglobin M antibody capture enzyme-linked immunosorbent assay (MAC-ELISA) that was not part of the RCTC, resulting in no Zika case reports sent to the health department using the eCR mechanism during the demonstration period. Houston Methodist implemented standard codes for all five pilot conditions.

Both sites mapped standard and jurisdiction-specific trigger codes to those specified in the RCTC inventory but used lab results as triggers for certain conditions (i.e., rather than problem lists or lab orders recorded in the health record). Through the authoring process, both sites realized that Zika virus infection is a reportable condition that should be triggered from a *lab order,* not a *lab result,* to ensure timely awareness and response.

The mapping and aligning of content in the health IT product was done by mapping the standard codes to local codes. Intermountain Healthcare uses an EHR system provided by Cerner Corporation. Although the EHR is maintained by Cerner, Intermountain local codes were maintained in the terminology server, Healthcare Data Dictionary, and these were mapped to standard codes such as LOINC, SNOMED CT, and International Classification of Diseases 10th edition (ICD-10), which are the terminology codes specified in the RCTC. Intermountain created a global code list prior to eCR implementation and used a Cerner tool to compare its own terminology to the RCTC. This comparison helped to elaborate existing mapping for lab result LOINC codes. As presented in Table 5, eight of 3,433 codes needed to be mapped to codes in RCTC. SNOMED CT Organism codes were not in Icentra, and Intermountain IT personnel added them to the Cerner product.

At Houston Methodist, 14 of 903 local codes needed to be mapped to standard codes in RCTC. Houston Methodist used a four-step process to map and align content in their health IT product: (1) review the RCTC spreadsheet of codes, (2) extract all codes for the five pilot reportable conditions to create a global code list, (3) compare codes used at the facility to the global code list (e.g., soft lab staff identify the codes they use), and (4) format codes that do not match the standard codes integrated into their health IT product. In the initial months of this demonstration, personnel at Houston Methodist could not identify the individual codes that triggered an eICR. Houston Methodist engaged a reporting analyst to assess the information and determine which trigger codes generated eICRs.

Electronic case reporting requires trigger codes to generate eICRs from the health IT product. Initially, sites needed to review their existing codes and map codes to match content in the RCTC. In both healthcare organizations, the majority of codes found in the RCTC in EHRs matched content. For local codes that were retained, it is helpful to understand how the concepts represented by the local codes

differed from those in the RCTC. As presented in Table 5, Houston Methodist retained 14 diagnoses and organism codes that differed in content from standard codes in the RCTC. This site used Zika codes from the Notifiable Event Disease Condition (NND) code set, and ICD-10 codes for conjunctivitis, headache, myalgia, pain in joint, and rash and other nonspecific skin eruptions. Notifiable disease cases have voluntary reporting of disease for nationwide aggregation of disease data. Reportable conditions require mandatory reporting when identified by a health provider, hospital, or laboratory (CDC, 2018). Houston Methodist also used seven ICD-10 codes for non-organism Zika results for polymerase chain reaction (PCR), antibody, and neutralization tests.

Table 5: Proportion of Local Codes Mapped to Codes in the RCTC and Explanation of Concepts that Differed from RCTC

Healthcare Organization	Proportion of Local Codes Mapped to Standard Codes in the RCTC	How Local Codes Retained Differed from RCTC
Houston Methodist Hospital	14 of 903	**Diagnoses codes (7)** **Zika codes** from the NND code set; 11,726 (Zika Virus disease) and 11,736 (Zika virus, congenital infection) **ICD-10 codes** for conjunctivitis, headache, myalgia, pain in joint, and rash and other nonspecific skin eruption **Organism Codes** (7) – Seven codes for non-organism Zika results needed for PCR, antibody, neutralization tests

Core Component B: Application of Trigger Codes

To automate transmission of case reports, the health IT products must apply trigger codes to identify events correctly. Data collected on this core component of eCR included: (1) total number of patient encounters for a specific time period; (2) the number of patient encounters for which an eICR was sent to the AIMS platform; (3) the number of eICRs that AIMS received; and (4) the number of eICRs that passed validation in AIMS. As presented in Table 6, Houston Methodist Hospital and Intermountain Healthcare provided these data. However, these two facilities defined a patient encounter differently, and duration of data collection varied by one month. At Houston Methodist Hospital, patient encounters included inpatient admissions, outpatient clinic visits, and laboratory orders only (the ordering of medications, labs and imaging). Intermountain Healthcare defined patient encounters as inpatient visits, office visits, and emergency room visits. Houston Methodist Hospital extracted data on eICRs from March to May 2019. Intermountain Healthcare extracted data on eICRs for two one-month periods from February 12 to April 12, 2019.

Table 6: Healthcare Organizations that Participated in Data Collection on eICRs, how They Defined Patient Encounters, and Data Collection Periods

Healthcare Organizations	Encounter Specifications	Data Collection Period
Houston Methodist Hospital	Inpatient admissions, outpatient clinic visits, lab visits, or emergency room visits	3 months
Intermountain Healthcare	Inpatient admissions, outpatient clinic visits, lab visits, or emergency room visits	2 months

Core Component C: Creation of Case Reports

In two months, Intermountain Healthcare sent 26,683 eICRs to the AIMS platform: 9,725 for chlamydia; 9,584 for gonorrhea; 6,172 for pertussis; and 1,202 for salmonellosis (Table 7). The number of eICRs for gonorrhea and chlamydia are similar because these laboratory tests are ordered as a panel (i.e., group of tests ordered together). For February 12 to March 12, 2019, 43.8 percent of patient encounters resulted in one eICR, 53.6 percent produced two eICRs, and 2.3 percent created three or more eICRs. While Intermountain sent 26,683 eICRs to the AIMS platform, the UDOH received 9,063 eICRs for gonorrhea; 9,226 for chlamydia; 186 for pertussis; and 22 for salmonellosis. This jurisdiction requires facilities to report both positive and negative (or non-positive) test results for chlamydia and gonorrhea. This requirement can result in more eICRs received than in jurisdictions without this requirement. For a three-month period, Houston Methodist Hospital sent 13,436 eICRs to the AIMS platform: 4,191 in March; 4,680 in April; and 4,565 in May 2019 (Table 8). Personnel in this facility did not provide the number of eICRs by condition but shared the number of eICRs with reportable conditions transmitted to the Houston Department of Health from the AIMS platform: 98 in March, 151 in April, and 160 in May.

Intermountain Healthcare performed additional analysis to review the trigger codes used to generate eICRs from the health IT product and the number of eICRs per patient encounter. Intermountain Healthcare reported that three trigger codes accounted for more than 90 percent of the eICRs generated. They also found that encounters that resulted in eICRs rarely produced more than two eICRs.

Note that the data in Table 7 for the reportable conditions addressed in the eCR pilot represent only a small fraction of the 1,225,574 patient encounters that occurred during the specified time frame.

Table 7: Electronic Initial Case Reports (eICRs) Sent and Received, Intermountain Healthcare and UDOH, February 12-April 12, 2019

	Intermountain Healthcare	Utah Department of Health
Reportable Condition	eICRs sent to the AIMS platform	eICRs received from the AIMS platform
Non-Reportable	NA	NA
Chlamydia	9,725	9,063
Gonorrhea	9,584	9,226
Pertussis	6,172	186
Salmonellosis	1,202	22
Zika	0	0
Total	26,683	18,497

Table 8: Electronic Initial Case Reports (eICRs) Sent and Received, Houston Methodist Hospital and Houston Department of Health, March-May 2019

		Houston Methodist Hospital	Houston Department of Health
Time Period	Patient encounters	eICRs sent to the AIMS platform	eICRs with a reportable condition received
March 2019	158,244	4,191	98
April 2019	172,210	4,680	151
May 2019	174,222	4,565	160

Core Component D: Personnel in the public health agency analyze and author reporting criteria to automate determination of reportability and where to send report

With support from CDC and key partner organizations, CSTE developed the default criteria for each condition listed in RCKMS based on CSTE position statements for those conditions. Personnel in the public health agency authored jurisdictional reporting specifications through a web portal pre-populated with default reporting specifications (CSTE, n.d.). CSTE personnel provided public health agency staff with default criteria that included summary reports for four sections—logic sets for vital records,

laboratories, providers, and facilities—and suggested links and websites for each of the five conditions. All eight sites provided data on use of these default criteria to implement eCR. For the purposes of this evaluation, we only looked at the provider and facility logic sets. The following analysis includes assessment of the provider and facility reporting logic sets and excludes the logic sets for vital records, laboratory reporting, and reference links and websites.

Figure 3 presents the number of default criteria in RCKMS for each of the five conditions (row 1) and the number of these criteria that were used by the public health agencies (i.e., either as-is or with a modification). While CSTE provided the default criteria, when sites authored RCKMS, they implemented the criteria to match jurisdictional rules. This resulted in variation of the default criteria for each condition except salmonellosis: the only condition for which all sites used all of the default criteria. Pertussis had the most variation in the use of default criteria. For Zika, California, Houston, and Utah implemented all of the default criteria. Seven of the eight sites used all of the default criteria for gonorrhea, and Massachusetts used three of the four criteria. For chlamydia, five of six sites used all of the default criteria, and Massachusetts used three of the four default criteria. However, for chlamydia, Michigan and New York City did not use any of the default criteria.

Figure 3: Number of Default Criteria in RCKMS used by Public Health Agencies to Implement eCR

Demonstration Sites	Chlamydia	Gonorrhea	Pertussis	Salmonellosis	Zika
RCKMS Default Criteria	4	4	12	6	5
California Depart. of Public Health	4	4	0	6	5
Houston Health Department	4	4	4	6	5
Kansas DPHE	4	4	6	6	4
Massachusetts Dept. of Health	3	3	6	6	4
Michigan Dept. of HHS	0	4	0	6	4
New York City Dept. of HMH	0	4	0	6	4
New York State DOH	4	4	6	6	4
Utah Department of Health	4	4	7	6	5

PHII personnel also analyzed information on the use of default criteria in RCKMS to determine when and how demonstration sites modified these criteria. For example, sites can adjust or amend the content, language, or rules to meet jurisdictional needs or requirements. Data on these adjustments can provide additional details regarding the amount and type of work needed to author criteria appropriately. All eight sites were included in analyses of whether the default criteria in RCKMS were used as-is or modified. As summarized in Table 9, all eight sites used all of the default criteria as-is for only one condition: salmonellosis. And, no sites used the default criteria as-is for pertussis. In cases where sites modified the default criteria, modifications were for reporting time frame and additions of clinical and demographic criteria. Table 9 provides examples of how default criteria were modified. Personnel in these sites indicated that LOINC was not available for the Zika lab result at the time they authored the rules in RCKMS.

Table 9: Proportion of Sites using Default Criteria in RCKMS without Modifications

Condition	Proportion of sites using default criteria without modification	Example modifications to default criteria
Chlamydia	5 of 8	• Michigan and New York City: Modified reporting time frame from the default of three days to one day for detection of chlamydia trachomatis antigen by any method in a clinical specimen • Michigan and New York City: Modified reporting time frame from default of seven days to one day for Chlamydial cervicitis, urethritis, and Lymphogranuloma Venereum
Gonorrhea	7 of 8	• Massachusetts: Did not include Gonococcal cervicitis and urethritis as a diagnosis in their criteria
Pertussis	0 of 8	• Houston and Utah: Added clinical (apnea, paroxysmal cough, post-tussive vomiting), and demographic criteria (age <= 2 years) to default criteria
Salmonellosis	8 of 8	• No modifications made to default criteria
Zika	3 of 8	• Kansas, Massachusetts, Michigan, New York City and New York State did not use the default criteria for detection of Zika virus antigen by immuno-histochemical staining method in a tissue specimen

In addition to modifying the default criteria, demonstration sites added new criteria to RCKMS to ensure that the authoring interface met jurisdictional reporting requirements. As presented in Table 10, these additions varied across sites and by condition. Table 10 provides a summary of common additions by category and condition for each demonstration site. Adjustments were made to the days of reporting, reflecting the jurisdictional variance between sites.

Table 10: Adjustments and Modifications to RCKMS Default Criteria by Condition for Eight Sites

Type of Criteria in the Provider/Facility Logic Set	*Chlamydia*	*Gonorrhea*	*Pertussis*	*Salmonellosis*	*Zika*
Adjustments to facility or provider clinical diagnosis criteria	2	2			
Adjustments to lab reporting criteria	3	2	4		6
Adjustments to lab reporting criteria and time-related criteria	6		3		
Adjustments to facility or provider clinical diagnosis criteria and time-related criteria	2				
Adjustments to clinical, demographic, laboratory, and epidemiologic criteria			51		21
Total modifications	13	4	58		27

Sites modified the provider and facility reporting logic sets for chlamydia and gonorrhea to adjust for jurisdictional rules. Analysis of the gonorrhea criteria revealed that Michigan, New York State, and Utah added criteria to RCKMS for the clinical diagnostic criteria and laboratory criteria (Table 11). They each added gonococcal infections excluding cervicitis and urethritis; complications of gonococcal infection, including gonococcal peritonitis and pelvic inflammatory disease; and chronic gonococcal infections (as diagnosis or active problem) as part of the provider/facility reporting diagnosis logic set. Utah also added negative and other non-positive reporting for gonorrhea and chlamydia to accommodate their jurisdictional reporting requirements. Details on the new criteria added to RCKMS can be found for gonorrhea in Table 11 and for chlamydia in Table 12.

Table 11: Number of New Criteria added to RCKMS for Gonorrhea in the Digital Bridge Approach to eCR

Specific Criteria Added	Provider/Facility Logic Set Type of Criteria	Reporting Time Frame	Sites Where Criteria Were Added
Gonococcal conjunctivitis (as diagnosis or active problem)	Clinical Diagnosis Criteria	1 day	Massachusetts, Utah
Gonococcal infections excluding cervicitis and urethritis: and **complications of gonococcal infection**, including gonococcal peritonitis and Pelvic inflammatory disease; and chronic gonococcal infections (as diagnosis or active problem)	Clinical Diagnosis Criteria	1 day	Michigan Utah New York State
Negative and other non-positive reporting of Neisseria gonorrhoeae in nucleic acid or a clinical specimen	Laboratory Reporting Criteria	1 day	Utah

Table 12: Number of New Criteria Added for Chlamydia in the Digital Bridge Approach to eCR

Specific Criteria Added	Provider/Facility Logic Set Type of Criteria	Reporting Time Frame	Sites Where Criteria Were Added
Chlamydial conjunctivitis (as a diagnosis or active problem)	Clinical diagnosis criteria	7 days	Utah and New York State
Chlamydia trachomatis infections excluding cervicitis, urethritis, LGV, trachoma and conjunctivitis; and complications of chlamydial infections including chlamydial peritonitis and pelvic inflammatory disease (as a diagnosis or active problem)	Clinical Diagnosis Criteria	7 days	Utah
Negative and other non-positive reporting for Chlamydia trachomatis antigen by nucleic acid or by organism-specific culture	Laboratory Reporting Criteria	3 days	Utah
Detection of chlamydia species antigen in a clinical specimen by any method	Laboratory Reporting Criteria	1 day	Michigan
Detection of chlamydia species nucleic acid in a clinical specimen by any method	Laboratory Reporting Criteria	1 day	Michigan
Identification of chlamydia species in a clinical specimen by culture method, including identification tests performed on an isolate	Laboratory Reporting Criteria	1 day	Michigan
Trachoma and related disorders (as a diagnosis or active problem)	Clinical Diagnosis Reporting	7 days	New York State

Demonstration sites added the most criteria to RCKMS for pertussis. Houston and Utah added criteria for clinical symptoms including apnea, paroxysmal cough, and post-tussive vomiting with combined demographic and epidemiologic requirements. The epidemiologic requirements (contact with a person with pertussis and member of a risk group as defined by public health authorities during an outbreak) were combined with clinical and demographic requirements for a reporting time frame of three days in Houston and Utah. Added demographic criteria by jurisdiction included age range (e.g., less than or equal to two years, less than 18 months, less than one year). New York State and New York City added four criteria for specific laboratory tests ordered for Bordetella pertussis, with a three-day reporting time frame for New York State and one day for New York City. There was also great variation in the combination of clinical and epidemiological criteria used for this condition. Michigan and New York City added cough and inspiratory whoop as necessary clinical symptoms. They varied by the one-day reporting time frame for pertussis as a diagnosis or active problem and as a lab result.

There were far fewer criteria added to RCKMS for Zika virus infection. Houston and Utah had optional reporting for the laboratory tests ordered for Zika, whereas New York State added sufficient criteria for Zika lab tests ordered. Houston and New York City added demographic and clinical criteria (e.g., travel history, pregnancy information, whether the patient had Guillain Barre syndrome, etc.). New York City implemented optional epidemiologic criteria (e.g., link to a person with laboratory evidence of recent Zika virus infection, postpartum period from delivery to six weeks following delivery, etc.) as part of the provider/facility reporting logic sets.

Core Component F_2: Consumption of reportability response document

For each eICR received, the AIMS platform returns a RR to the facility and public health agency. As presented in Table 13, for gonorrhea and chlamydia, Intermountain Healthcare received 18,137 RRs and UDOH received 18,295 RRs. For these conditions, the RRs were sent for the test panel, not the individual condition. The discrepancy between the number of eICRs and RRs led personnel to examine the jurisdictional rules in RCKMS for these conditions. UDOH used *Chlamydia trachomatis,* and the Intermountain central laboratory sent information on chlamydia species. Both reported that they continue to work through this process to ensure that every eICR results in one RR received. The counts of eICRs and RRs can also vary due to date and time stamp procedures, an issue in reprocessing with eICRs and RRs by AIMS, or other system-related variations, but personnel identified and resolved issues that were known at the time of data collection. The reprocessing issue was the result of a patch deployed to RCKMS in February that created a bug in the software system that caused all submissions to RCKMS to be determined not reportable. Intermountain Healthcare received all RRs as not reportable, and Intermountain Healthcare personnel alerted AIMS staff of a possible issue. After AIMS discovered the bug and resolved it, AIMS reprocessed all case reports sent during that time, resulting in another round of RRs being sent to Intermountain Healthcare. Intermountain Healthcare received 173 RRs for pertussis and 22 for salmonellosis, but UDOH received 185 for pertussis and 22 for salmonellosis. Intermountain Healthcare also received 8,595 RRs that did not contain condition-specific information. RRs for non-reportable conditions are sent in aggregate and not counted by condition. The public health surveillance system will not consume the RRs until eCR implementation is complete. UDOH personnel continue to examine what content in the RR could be relevant to an investigation beyond what is included in the eICR. The Intermountain Healthcare health IT product consumed the RR, but it was not displayed in the electronic health record for clinicians.

Table 13: Reportability Responses (RRs) Sent and Received, Intermountain Healthcare and UDOH, February 12-April 12, 2019

	Intermountain Healthcare	Utah Department of Health
Reportable Condition	Reportability responses received from AIMS platform	Reportability responses received the AIMS platform
Non-Reportable	8,595	NA
Chlamydia Gonorrhea	18,137	18,295
Pertussis	173	185
Salmonellosis	22	22
Zika	0	0
Total	26,927	18,502

Conclusions

Two sites were able to successfully develop and implement the core components of the Digital Bridge eCR approach. Houston and Utah mapped, aligned, and correctly applied trigger codes before passing them through the decision support intermediary. Although only two sites were included in this part of the evaluation, the data show that trigger codes were successfully implemented and sent data from the provider to public health, underscoring the potential to improve reporting for the five conditions.
All of the sites made RCKMS modifications, some more than others, but the default criteria did not prove to be a panacea, in many cases – it is crucial to enter the eCR endeavor with a clear understanding of what the default criteria can and cannot do. These data reveal that expansion to more or other conditions can result in some efficiencies, but certain conditions will require an investment of human resources to address this core component of eCR. The amount and intensity of work on criteria varied by condition. For example, modifications to criteria for pertussis far outpaced the others. These data affirmed that the default criteria are one component of the authoring process, but not the only component to do eCR correctly and meet jurisdiction needs.

This evaluation data show that automation was successful at two healthcare provider sites, thus potentially reducing the burden of reporting and improving the timeliness of the data sent on to the public health agency. Intermountain's results suggest that eICRs are being generated appropriately per patient. Additional analysis needs to continue as the sites move from parallel production to fully live sites, where the public health surveillance system is consuming eICRs. At this point of site implementation, it is not possible to report on the proportions of reportability responses being consumed in the EHRs or public health surveillance systems as sites are still in parallel production.

However, the data provided show discrepancies, and further work needs to be done to assess eCR performance.

Recommendations

The evaluation findings show that the default criteria met the needs of public health agencies, especially because they had the ability to add additional criteria to address jurisdictional variations. As reported in the key informant interviews, the authoring tools were easy to use, but the review of these data raises the question, should any changes be made to RCKMS to assist authoring future jurisdictions?

Evaluation Question 5: To what extent are electronic case reports accurate, complete, and timely?

Electronic case reporting is generally expected to increase the completeness, accuracy, and timeliness of case findings. Therefore, a low number of false negatives was expected, and UDOH reported no false negatives.

At the writing of this report, the public health surveillance systems were not completely consuming the eICRs; therefore, a detailed review of the completeness and accuracy of case findings was not possible. As sites move from parallel production to eCR-only production, sites will be able to measure the accuracy and completeness of case findings.

Timeliness is defined as receiving the eICR within a jurisdiction's defined regulatory reporting time frame. Timeliness data was obtained for Utah. However, it was determined that the calculations were based on inaccurate event time stamps included in the eICR. UDOH and Intermountain are continuing to review and calculate timeliness to ensure the regulatory reporting requirements are met by eICRs sent from Intermountain Healthcare.

Recommendations

How case reports are measured and best ways to assess accuracy and timeliness should be considered as implementations continue. In addition, once the timeliness queries are established in Utah, they could be incorporated into additional evaluation materials for quality testing.

Evaluation Question 6: To what extent is the information in the electronic initial case report (eICR) complete and accurate?

Data completeness was assessed for 63 selected fields, from the CSTE-identified data elements (Health Level Seven International), using a sample of 8,341 eICRs UDOH received for the five pilot conditions between February 12 to March 12, 2019. UDOH created XPath queries to review the data elements in the extensible markup language (XML) document for completeness.

UDOH staff reviewed each eICR data element and classified them into one of three categories—in use, not in use, or not applicable—depending on if it could be consumed by the public health surveillance system.

Findings

a) Forty-three eICR data elements were in use by the public health surveillance system.

- Of these, 27 data elements were populated with patient data for at least 98 percent of eICRs sampled.
- Four data elements were values for eICR triggering, meaning that the following data elements were populated only in instances where particular trigger logics were satisfied:
  - Ordered lab test code and name
  - Resulted lab test code and name
  - Laboratory result
  - Diagnosis code
- Four data elements have a field in the surveillance system but need mapping from the eICR by the integration engine (middleware that applies business rules to eICR documents):
  - Patient occupation
  - Admission date/time
  - Discharge date/time
  - Date of onset
- Provider email was not included in the analysis because it was initially reported as not in use but is in use by the surveillance system.

b) Seven eICR data elements were not in use by the public health surveillance system.

- Five data elements were not yet in use but were intended for use contingent on future surveillance system development:
  - Travel history start date
  - Travel history end date
  - Text description of travel
  - Travel location code
  - Travel location address
- One data element, provider fax, does not have a corresponding field in the surveillance system and is not currently mapped by the integration engine:
- One data element, date of eICR, is not in use but was populated for 100 percent of the sample:

c) Twelve data elements were determined by the public health department to be not applicable to the public health surveillance system and were not evaluated further:

- Immunization Status – UDOH has no plans to pull this data element from eICRs. Instead, UDOH receives the information from the state immunization information system.
- Death date: Utah has a separate interface with the death registry; therefore, this information will not come from the eICR.
- The remaining data elements classified as not applicable are:
  - Name of sending application
  - Identification code for provider
  - Facility ID number
  - Type of facility providing care
  - Parent/guardian name
  - History of present illness
  - Reason for visit
  - Symptoms list
  - Filler order number
  - Patient class

Of the 56 eICR data elements, 24 were classified as required by epidemiologists to initiate case investigation. Of these 24 required, 18 were populated with patient data for at least 98.7 percent of the sample. The other six data elements were not complete because they may not have triggered that encounter. For example, the *ordered lab test code and name* field would only be populated if that trigger type created the eICR.

Table 14: Completeness of eICR Data Elements in 8,341 eICRs from February 12 to March 12, 2019 - UDOH

Data element required by Epidemiologists to initiate case investigation	Data Element	Percentage of eICRs with Data Element Present
Yes	Date and time of report submission	100%
	Facility Address	100%
	Laboratory Result (Trigger)	99.1%
	Patient Date of Birth (DOB)	100%
	Patient Name	100%
	Provider Address	99.2%
	Provider Name	100%
	Provider Office/Facility Name	100%
	Resulted lab test code and name (Result Observation)	99.5%
	Resulted lab test code and name (Trigger)	99.1%
	Visit Date/Time	100%
	Diagnosis Date	61.8%
	Diagnosis	59.5%
	Laboratory Results	43.8%
	Diagnosis Trigger	1%
	Ordered lab test code and name (Planned Observation)	0%
	Ordered lab test code and name (Trigger)	0%
No	Patient Sex	100%
	Patient ID Number	100%
	Patient Ethnicity	99.6%
	Patient Address	99.2%
	Provider phone number	98.6%
	Patient or Parent/Guardian Phone	98.2%
	Patient Race	91.9%
	Patient or Parent/Guardian Email	54.8%
	Date of Onset	0%
	Facility phone number	0%
	Hospital Unit	0%
	Medications Administered	0%
	Patient Occupation	0%
	Patient Preferred Language	0%
	Pregnancy Status	0%

Conclusion

The majority of the data elements in this analysis were complete, but a critical piece of information was missing. In order for an epidemiologist to initiate a case based on the laboratory information in an eICR, the specimen collection procedure must be identified. This data element was not included in the 2017 version of the HL7 eICR implementation guide but has since been added. Until the specimen collection procedure can be incorporated into the eICRs, UDOH will use the clinical and demographic data received in the eICRs to update cases created based on electronic laboratory reporting (ELR) data, and they will evaluate the process of creating cases based on diagnostic information. In accordance with Utah reporting rules, diagnostic information alone is sufficient to create a pertussis case. The other four pilot conditions require laboratory information to create a case.

Recommendations

As mentioned in the key informant interviews, case reporting directly from EHRs complements the data that may come from ELRs by providing critical clinical and demographic data that may not be included in the laboratory reports, like medications administered, for example. Data on medications administered (e.g., prescriptions and dosage levels) would be helpful to the public health agency, specifically for chlamydia and gonorrhea, although they are not currently available in the Continuity of Care Document (CCD) extract that Intermountain uses to create the eICR. This is a gap that Intermountain and UDOH are resolving.

The eICR completeness analysis required collaboration and communication with the healthcare provider and an understanding of eICR structure. This completeness exercise allowed the public health agency to verify their eICR mappings. Further evaluation needs to continue along with additional data collection from other sites. The lack of data reflects the need to collect additional information from other sites. The benefit of having Utah implement the completeness queries is that the technical queries can be shared with other implementation sites to facilitate data collection on the completeness measure.

Evaluation Question 7: What were the costs associated with the initiation and implementation of eCR in sites?

The evaluation team collected site-specific documentation of costs related to eCR initiation and implementation to address this evaluation question. PHII personnel asked partners in multiple sites to report information about four types of costs:

1. **Initiation labor costs:** Composition of the team working on eCR prior to start-up and associated expenditures for labor (e.g., project planning or kick-off)
2. **Implementation labor costs:** Composition of the team working on eCR during the initial implementation period and associated expenditures for labor (e.g., site development, end-to-end testing)
3. **Labor hours:** Estimated hours dedicated to specific tasks related to eCR initiation and implementation
4. **Total technology costs:** Estimate of the expenditures on IT-related infrastructure and software needed for initiation and implementation

PHII requested and received information from a subset of organizations across eight demonstration sites. Some sites were unable to provide data because either the data were not available, or site representatives did not have access to the data. Some sites shared data, but it was received in July 2019 and was not included in this report. We requested data from eight public health agencies, and six of those responded. We asked one health IT vendor for cost data but the vendor was not able to provide the data. Other health IT vendors were not asked for data as their modules were not in production at the time of data collection. We asked two healthcare providers for data, but only one responded in time for inclusion in this report.

Even with the limited amount of cost data available for analysis, it is clear that costs varied dramatically across sites. As a result of this variability and the limited amount of information collected, we provide key findings for public health agencies, healthcare IT vendors, and healthcare providers.

Public Health Agency Costs

Four public health agencies provided usable data on initiation and implementation costs. Some agencies reported costs in great detail and others responded in general terms. While each site received the same instrument and instructions to document cost information, application of the instrument varied from site to site, as can happen in a multisite evaluation. For example, the California Department of Public Health created a web-based survey that allowed personnel to record hours spent on eCR activities weekly. Alternatively, personnel in the Michigan Department of Health and Human Services reported collective costs associated with eCR initiation and implementation. The estimates included support provided by key contributors like the Michigan Health Information Network, the Altarum Institute, and Netsmart Technology Corporation. All sites reported challenges in extracting the information in their organization. For example, some personnel who were asked to compile the information had not been present since the start of the project, and others were not able to recall initiation-related hours and costs many months later.

Tables 15 and 16 present the data collected for this component of the evaluation. Key findings are organized in three categories: types of personnel and summary of labor costs, costs associated with specific tasks, and technology-related costs. Site names are not specified due to confidentiality concerns of the participants.

Three public health agencies reported that the team working on eCR initiation included diverse personnel: project managers, medical scientists, computer specialists, developers, informatics specialists, epidemiologists, and information technology leads. These agencies also reported that similarly diverse personnel contributed to eCR implementation: informatics analysts, technical leads, project managers, implementation specialists, legal counsel, epidemiologists, terminologists, developers, information technology specialists, and others.

Across the sites, there was a variance in duration of implementation and cost per site for both phases. Each site's reported costs were reflective of their experience and indicative of the type of public health agency they represented—a large, well-established public health agency or a small public health agency. Table 15 presents public health agencies responses to questions about implementation costs and duration. The duration of implementation was reported as three months, five months, and 20 months. The cost for labor during implementation ranged from $3,911 to $23,111 per month. In sites that included a health information exchange as part of eCR initiation and implementation, those staff was included in the calculations. There was variation in the hours per week spent on the project as well as variation in the length of time someone in a specific role spent on the task.

Also shown in Table 15, labor costs varied widely for initiation in these sites. For example, Site 1 reported $852 in initiation costs, and Site 4 reported $478,871. Initiation duration also varied widely across organizations that reported data. Initiation in Site 1 took four weeks, but Site 4 reported two years for initiation.

Public health agencies were asked about establishing connectivity to AIMS, configuring environments to eCR, configuring the receipt of eICRs, authoring RCKMS, and configuring RRs. The estimated number of hours for initiation tasks ranged from 56 to 101. The estimated number of hours for implementation tasks ranged from 125 to 1,789.

Four public health agencies reported the number of hours for the configuration of eICR receipt, parsing capability, and authoring RCKMS criteria. The majority of tasks' hours were spent on configuring the public health agency receipt of the eICR. Participants expressed that they found RCKMS authoring to be straightforward and was completed by an epidemiologist or a surveillance informatics specialist and not especially resource-intensive.

Table 15: Summary of Labor Costs (Money and Time) and the Duration of eCR Initiation and Implementation (not including work by the healthcare IT vendor to map trigger codes)

	Initiation		Implementation	
	Labor Costs	Duration	Labor Costs	Duration
Site 1	$852	4 weeks	$11,732	3 months
Site 2	$8,704	18 months	No data provided	-
Site 3	$60,060	7 months	$148,782	20 months
Site 4	$478,871	2 years	$115,555	5 months

Three public health agencies reported on *technology costs* associated with eCR, including eCR connectivity, existing hardware and software, data center costs, storage networks, and investments in internet infrastructure. Technology costs varied widely, with one site reporting $2,900 for initiation and another site reporting $180,000 in initiation costs. One site reported $190,000 in total technology costs during implementation. These figures reflect the costs of configuring the public health surveillance system to support eCR and building interfaces between systems for bidirectional information exchange.

- Personnel in two demonstration sites reported a significant time investment to acquire the skilled human resources to build the interface that enabled eICRs to reach the surveillance system.
- Personnel in a public health agency reported that they did not incur costs for new technology infrastructure but paid annual fees for maintenance and operation for current systems to support eCR. They also noted that technology costs would be incurred if a jurisdiction does not have adequate infrastructure for initiation and implementation of eCR.
- Personnel in another public health agency reported that they did not have enough resources to purchase adequate server space to establish the technology environments needed for quality assurance testing prior to sending eCR data to the surveillance system.

Table 16: Estimated Technology Costs Related to the Initiation and Implementation of the Digital Bridge Approach to eCR 2017 - 2019

	Initiation	Implementation	Cost Description
Site 2	$2,900	$6,500	This cost includes efforts related to surveillance system configuration changes and building an interface. This site had an interface license, but there was significant time spent acquiring sufficient skills to build an interface that could parse the eCR into a readable format for the surveillance system. No software or hardware was purchased.
Site 3	$180,000	(no data reported)	Current infrastructure costs approximately $180k per year for maintenance and operations. Although the project did not incur costs for new infrastructure, it should be noted that technology costs will be incurred if jurisdictions do not have adequate infrastructure for the initiation and implementation of Digital Bridge. This organization leveraged existing technology and infrastructure.
Site 4	(no data reported)	$190,000	Connectivity costs, existing hardware, existing software, databases, security, data center, storage network, and inbound internet infrastructure.

Healthcare IT Vendor Costs

Epic was the only healthcare IT representative invited to participate in this data collection (because others were not far enough along in the process). They declined to provide cost data because pricing estimates for new interfaces like eCR can vary between customers; therefore, they recommended that information on cost data be gathered directly from the healthcare provider. The affiliated healthcare provider was asked to provide cost data and did participate in the cost analysis (see *Healthcare Provider Costs*). Epic personnel provided the following important contextual information relevant to costs:

- Costs for Houston and other demonstration sites may not be comparable to future costs as the number of sites continues to expand. For example, Epic usually charges by the hour for time spent to establish a new interface. For this demonstration project, Epic established special agreements with sites and waived many fees.
- Participation in the Digital Bridge demonstration projects provided Epic with important insights regarding what is necessary to plan and implement eCR.
- IT-associated costs and time can vary even in sites with well-established infrastructure and resources relevant to eCR. For example, timelines for planning and implementation or the expected role for the vendor influence labor hours and costs.

Healthcare Provider Costs

A single healthcare provider organization participated in this component of the evaluation, but they did not report hours the healthcare IT vendor worked to map trigger codes. Personnel from this organization offered the following insights regarding the costs they incurred:

- Team members in this location included build analysts and an ambulatory architect build analyst.

- Tasks included establishing AIMS connectivity, configuring environments for eCR (e.g., testing, development, etc.), configuring eICR creation, configuring the receipt and processing of the RR, and end-to-end testing of the eCR process.
- Their implementation costs could have been reduced if they had implemented the project using agile project management compared with traditional project management. Agile project management principles are based on the idea that projects iterate over time, including changes to the scope of the project and adjusting to the needs of the end user. Agile project management allows for smaller teams and adaptive leadership and less time for planning, eliminating wasteful activities (White, 2008).
- Identification of necessary resources is critical to the success of eCR implementation, as well as having organizational leaders support the implementation of eCR by participating in project kick-off meetings and allocating staff to participate in eCR implementation.
- Because manual reporting persisted through the production stage, savings associated with switching to the automated reporting mechanism is difficult to assess.

Conclusions

While the data collection on costs associated with eCR initiation and implementation was limited to a just a few sites, the findings revealed substantial variation in every category of cost. Because of the limited number of responses and the variation in the agencies that did respond, findings are limited and do not fully answer the evaluation question. The quantitative information provided—and minimal qualitative information on contextual considerations relevant to costs—indicates that actual costs are linked to several dependent factors: existing eCR infrastructure, availability of skilled personnel, in-house expertise, and access to adequate human and fiscal resources.

In addition, site-based personnel who compiled some of this information or looked at the data carefully noted that many of the contributors to the Digital Bridge demonstration projects were learning throughout the process, and implementation could be more efficient in the future. For example, while Epic personnel did not provide information on site-specific costs, they have considered the level of effort and expenditures and identified what it takes to implement eCR, likely creating an abbreviated process in the future. Participants noted that responding to barriers and challenges with agility and flexibility can contribute to reduced costs over time.

Recommendation

It is important to acknowledge that personnel from multiple organizations that had difficulty with compiling cost data retrospectively shared their concerns regarding the accuracy and completeness of the information submitted. The information from these demonstration sites is not comparable, but it provides a first attempt to document costs associated with eCR across multiple sites simultaneously. Future efforts should refine tools and indicators that collect cost data.

Evaluation Question 8: To what extent did eCR improve (or hinder) surveillance functions in sites?

Two of the eight demonstration sites were in parallel production in fall 2018; therefore, manual reporting persisted while the eCR workflow was implemented. In addition to conducting basic checks to ensure public health agencies received eICRs, both public health agencies are still in testing at the writing of this report. The Houston Health Department and UDOH are still performing quality assurance

checks on the structure, data elements necessary for creating case reports, and data quality. These health departments are continuing to assess the functionality of multiple eICRs on the same patient and eICRs containing multiple conditions.

At this point, participants' perceptions about eCR benefits are limited to *anticipated* benefits, since actual benefits have not been realized yet. eCR has not hindered surveillance functions as the process has not changed for epidemiologists or healthcare providers. Expected benefits of eCR include the following:

- Public health agencies anticipate better data quality and efficiency.
- Practitioners hope that eliminating manual data entry will improve accuracy and completeness as data comes directly from the EHR.
- Public health partners felt that the anticipated efficiency of eCR, including more complete and timely reporting, will allow public health sites to handle the expected increase in case volume and workload. They also felt that this increased workload due to better data quality and efficiency could bring more resources and improve health departments' capacities to measure and respond to public health concerns.
- Providers expect that eCR automation will minimize clinicians' paper-based reporting burden, thereby decreasing disruptions to their other responsibilities.

Furthermore, initial completeness data provide evidence that eICRs have the potential to enhance public health reporting if additional demographic fields are included. As sites continue to assess completeness, a broader picture of implementation and improved data quality will emerge.

Evaluation Question 9: What are the strengths and weaknesses of the Digital Bridge approach to eCR for digital information exchange and use?

Public health personnel shared that a strength of eCR is the potential to provide more accurate and complete data. When the data is created directly from the EHR, the likelihood of mistakes decreases, completeness increases, and security improves. This same transmission improves legal and security compliance, important considerations to healthcare providers. Automation has the potential to remove the need for clinicians to physically report a case and decrease the burden of remembering when to report.

Strengths and Weaknesses

Weaknesses of the Digital Bridge approach include the complex and challenging nature of implementing eCR. Implementation requires continual reviewing and monitoring of data and data feeds. Personnel in sites with human resource constraints, i.e., limited IT staff at the public health agency, felt unprepared for the expansion beyond the five pilot conditions without ongoing support from CDC and Digital Bridge.

a) **Personnel in both sites anticipate improvements in the timeliness and accuracy of case reports when they reach full production.** They expect an increase in cases reported, improvements in data quality, and better identification of cases treated out-of-state via use of the RR.
    - Participants noted that more information is needed regarding how to improve the completeness of the eICR to better enable the public health agency to make decisions based on the document.
    - A site shared an early example of using information from the reportability response document for bi-directional data exchange: a healthcare facility transmitted information

on the reportability of a condition and supplemental information back to the electronic health record.

Public health surveillance-related benefits and challenges

a) Participants explained that they expected eCR would enhance, not change, core surveillance functions. For example, public health personnel noted that eCR will improve efficiency and data quality when eICRs are triggered from problem lists and lab orders.
b) Participants suggested that including additional content in automated case reports in the future would enhance eCR's value to public health: information on patients' relational links (i.e., contact with confirmed cases); and more robust information on symptoms, travel history, and vaccinations, for example.
c) With automation, participants expected to see improvements in terms of the timeliness of sending cases and getting them to the appropriate jurisdictions.
d) Participants noted that as more cases are reported more efficiently, they anticipate an increased workload. They explained that it will be crucial for health department IT staff to collaborate with disease investigators and epidemiologists on any modifications to the surveillance system to ensure the system is equipped to continue to support them in their investigation of disease and patient management, including consistency in the reporting of specific data elements.

Perceived strengths and weaknesses of eCR

a) Public health participants believe that eCR will provide more accurate and complete data than reports by phone call or fax because the information comes directly from the clinical system.
b) Participants reported that automated case reporting removes the need for physical reporting by clinicians and the mental burden of remembering what to report.
c) Participants explained that the transmission of data electronically improves legal and security compliance. For example, one interviewee noted, "nothing is less secure than a fax."
d) Participants reiterated that implementing eCR is complex and challenging, despite the anticipated benefits. For example, eCR requires maintenance that includes reviewing and updating rules annually, monitoring data feeds, and analyzing message quality regularly.
e) Participants in the site with human resource constraints felt unprepared to maintain eCR, or expand beyond the five pilot conditions included in this demonstration project, without ongoing support from the CDC and Digital Bridge.

Table 17: Perceived Strengths and Weaknesses of the Digital Bridge Approach to eCR

Strengths	Weaknesses
Public health shared that case data would be more **accurate and more complete with the use of eCR.** The data comes directly from the clinical system and is often more complete than if a report is shared via a phone call or fax.	Interview participants reiterated that implementing eCR **implementation is complex and challenging,** despite the anticipated benefits. For example, eCR will require maintenance include reviewing and updating rules annually, monitoring data feeds, and analyzing message quality on a regular basis.
Participants explained that the transmission of data electronically **improves legal and security compliance.** For example, one interviewee noted, "nothing is less secure than a fax".	**Personnel in sites with human resource constraints felt unprepared** for maintaining eCR and expanding beyond the five pilot conditions included in this demonstration project without ongoing support from the Centers of Disease Control and Prevention (CDC) and Digital Bridge.
Participants reported that is that **automation of case reporting** removes the need for physical reporting by clinicians but also the mental burden of remembering what to report.	

Conclusion

Because of the state of implementation of the sites, only the perceived strengths and weaknesses for Digital Bridge eCR were captured. However, the perceptions show that the strengths of the Digital Bridge approach to eCR will likely improve security, timeliness, and accuracy of public health reporting in jurisdictions that implement eCR. The weaknesses reinforce the concepts that eCR implementation is time intensive and requires trained staff to implement the processes.

Recommendations

The strengths of eCR should be leveraged as sites continue implementation with messaging to leadership at the jurisdictions or sites that highlights the potential reduction in provider burden as eCR is implemented. The increased security and accuracy of data will improve the management of reportable conditions by the public health authority. While implementation is challenging, public health needs to understand in detail what the healthcare provider is collecting and work with them to make the best of the information provided from the electronic health record.

Evaluation Question 10: To what extent does eCR add value to health care and public health practice in sites?

Implementation sites reported that eCR has the potential to improve public health and the exchange of patient data from care providers to public health. Data exchange is also more secure as data are sent electronically compared to a handwritten form or via a fax. As heard throughout the evaluation, eCR may improve the public health response time to a reportable condition from a healthcare provider. By

improving the response time and the quality of the data provided, there is a potential reduction in the burden of disease of reportable conditions. As more sites participate and join this effort, there will be additional data and opportunities to answer this question.

Overall Recommendations

Based on the evidence gathered throughout the evaluation process, contributors formed recommendations to inform future eCR implementation. This final section of the report summarizes these recommendations for other implementers of eCR as it scales nationwide. The evaluation committee urges implementers, operators, and evaluators to consider these recommendations when planning eCR implementation and enhancements.

While this evaluation's findings contribute to the overall picture of eCR, it would be valuable to continue identifying what processes worked well and what did not work well to determine eCR performance and its potential value to stakeholders.

Technology and Process Alignment

Overall Recommendation	Rationale and Details
Document clinical and patient care workflows and trigger code configuration early in implementation to support transmission of complete eICRs.	• While trigger code mapping and subsequent triggering of eICRs worked in the demonstration implementations, strategies and tools for streamlining this process should be developed to enhance efficiency. • Identifying the source of the trigger codes within the EHR (e.g., patient's problem list or encounter diagnosis) should be completed early in implementation planning and discussed in detail among site stakeholders. Sites should reach consensus on the trigger code configuration and document their decisions. • Additionally, sites noted that documenting the various patient care and clinical workflows that will generate eICRs should be a routine step within eCR implementation. This includes an assessment of how workflows impact the timing and generation of eICRs to ensure completeness.

eCR Readiness and Resources

Overall Recommendation	Rationale and Details
Conduct an eCR readiness assessment prior to implementation	• Collectively, sites' experiences suggest that future sites should complete an eCR readiness assessment to take inventory of existing infrastructure, workforce, processes, and capabilities before initiating the implementation tasks. Equipped with eCR readiness assessment outputs, site decision-makers could better allocate resources, determine timelines, and set expectations. • Up-to-date implementation and technical artifacts should be made available to eCR sites at project kick-off. Partner organizations or technical experts should draw on the knowledge of these implementations to create supporting documents to aid eCR onboarding and adoption (e.g., checklists, roadmaps, job aids, etc.).
Confirm that vendor solutions and capabilities match their specific business requirements before implementation.	• Health IT vendors must ensure that their systems will meet the eCR requirements, underscoring why vendor partners are critical members of any site. eCR teams must ask the health IT vendors: *Will your eCR product meet the needs of the healthcare provider and public health?* • Incorporating the eCR core components into health IT certification programs is one method to incentivize sustained health IT vendor and healthcare provider motivation to implement eCR. As eCR continues to mature, more health IT vendors should be encouraged to build the functionality into their products to limit implementation variation. Participants at one site wondered what the incentive will be for healthcare providers to engage in eCR moving forward--making eCR more available "out of the box" may be one tactic to encourage continued provider adoption.
Secure supplemental training and technical assistance to support the information technology requirements associated with implementation.	• The implementation sites' access to detailed technical guidance may reduce confusion, miscommunication, and time-consuming trial and error. eCR project leaders should identify gaps in knowledge, technical assistance, and guidance materials, and revise guidance materials accordingly. • Additionally, any new tools or guidance should be made available to future implementers, as well as training material for public health agency staff expected to implement eCR. • Orienting staff to eCR and providing them with technical assistance may help sites with limited human resources address their informatics needs.

Communication and Collaboration

Overall Recommendation	Rationale and Details
Ensure that relevant leaders in key organizations are well-informed and support eCR implementation (e.g., to ensure that adequate resources, human and fiscal, are available).	• eCR implementation requires appropriate human and financial resources and sustained commitment. Participants emphasized that organization leaders must be oriented to eCR; buy in to the value proposition; and commit the time, staff, and funding to ensure success. Implementing organizations should consider creating internal processes and artifacts, such as project timelines, executive summaries, project charters, etc., to articulate the details of project engagement.
Confirm how specific organizations will contribute to eCR implementation, and discuss roles and expectations prior to implementation.	• Each site must understand eCR requirements and gauge their internal, technical capacity to implement those requirements. • Site partners must communicate early and often to ensure the appropriate parties are engaged, understand implementation risks and resources, and form shared expectations. • Equally important, stakeholders must understand the limitations of the eCR process and what it *cannot* do (e.g., some level of manual provider reporting may still be necessary post-implementation). • Having clear communication and knowing the technical capacity of each site partner facilitates eCR implementation. Technical capacity includes access to subject matter experts for eCR implementation tasks.
Establish a shared platform for technical collaboration among contributors to eCR.	• Public health agency data requirements to support case investigation must be identified and discussed early in the implementation process to ensure shared understanding between the healthcare provider and agency. This process should include the identification of any data elements deemed mandatory within the eICR standard that are not available within the EHR and develop strategies to address any gaps. • The eCR community should establish and support a consortium that allows implementers to share experiences with their peers.
Establish communication early to engage appropriate reporting staff	• Early communication could increase responses to evaluation questions from public health agencies, healthcare providers and electronic health IT vendors. • Additional discussion on the specificity of queries to support data quality or evaluation would have facilitated the collection of data. For example, in one site, to facilitate data collection on completion, collaboration between the provider and public health agency had to occur before the data could be reviewed.

Future Evaluation Efforts

Overall Recommendation	Rationale and Details

Assess the most appropriate method to document and analyze eCR-related costs in preparation for future evaluation activities.	• Cost analyses may be of minimal value because of the high level of variability between sites; however, if future cost analyses are conducted, follow the following recommendations for accessing how to collect cost data:
	  • To minimize recall bias in future evaluation activities, sites should be provided any cost data collection instruments at the inception of the project.
	  • The instrument and procedures used to extract and compile cost information can be improved for future data collections. The cost data collection instruments should clearly delineate costs for eCR activities, human resources, and infrastructure.
	  • Cost analysis should include costs related to legal activities and other non-technical areas.

Engage supporting organizations (i.e., partner organizations or contributors not located in the site or working across sites to provide technical assistance, for example) in the evaluation to a greater degree.	• Future evaluators are encouraged to be inclusive of supporting organizations involved in eCR roll-out—both in terms of obtaining their perspective and assessing their contributions. For example, this evaluation did not include data collection related to governance body participation or facilitation, project management office effort, communication support, or legal counsel involvement. • Ensure that future eCR implementers understand the expectation for data collection so they allocate human and financial resources for data extraction activities. • Suggest identification of database queries to support data quality and evaluation to facilitate the collection of data. • Engage appropriate reporting staff early to enhance participation in the evaluation. • While this evaluation did assess the RCKMS criteria, future evaluation efforts should also assess how the authoring criteria were applied to each eICR received by the decision support intermediary platform, AIMS. Future analysis should review how the jurisdictional rules determine reportability of every eICR in RCKMS. This could show how the rules each site has implemented work in the decision support intermediary and the impact they have on case investigation. A review of the rules compared to the reportable eICRs could also lead to refinements in the rules a jurisdiction implements. • Invest time in determining how to support and enable use of the evaluation data for communications, planning, and decision-making.

Overall Recommendation	Rationale and Details
Include diverse workgroups (e.g., site representatives, partner organizations) to contribute to evaluation planning, implementation, and use (using the Digital Bridge evaluation committee as a model).	• The diversity and commitment of the evaluation committee contributed to moving this evaluation forward. Future evaluation committees should include a mix of subject matter experts and representatives from federal agencies, partner organizations, public health agencies.
Account for variations in site maturity and implementation, and the evaluation questions and methods must evolve to address these variations.	• Sites in this evaluation were at different stages, which contributed to variability in data collection. A review of the multisite evaluation approach should be undertaken by the evaluation team and supporting evaluation committee in order to accommodate site variations.
Determine and use a minimum set of indicators.	• Intended users of eCR should determine a minimum set of indicators for use in evaluation of eCR, checking for feasibility and usability, and focusing on the most worthwhile and informative indicators. These indicators and related tools (e.g., data collection instruments or protocols) should be available on a public-facing website so they can be reviewed and revised over time as eCR activities evolve.

Appendix 1:

Findings

Evaluation Question 1: How are core elements of eCR initiated and implemented in participating sites?

Table 1. Key Findings about factors on how the core elements of eCR were initiated and implemented in participating sites

Indicator	*Finding*	*Details*
1.1 Trigger code alignment and application process	Despite the predominance of lab result trigger codes in both sites, participants described challenges with aligning trigger codes to reference lab results. Since some labs do not report conditions in a discrete format they cannot trigger from LOINC and SNOMED codes.	Zika is one reportable condition that both sites mentioned should be triggered from a lab order, as it is high-priority and low-incidence. Intermountain uses a different Zika test that was not in the 2017-10-13 release of RCTC. The resulting consequence is UDOH will not receive Zika reports until the RCTC adds that LOINC code.
	Intermountain participants described challenges with triggering from lab orders, as a panel of multiple lab orders may be ordered, but there may be no code for the panel, which is then not triggered.	Houston Health Department participants noted an additional challenge to diagnosis trigger codes: providers do not typically report suspected condition information. Public Health would need to rely on lab orders for that information, but Epic cannot currently trigger from lab orders.
	Public health participants indicated that the value of triggering from diagnosis codes is the information that they might not otherwise receive from an electronic lab report (ELR) (e.g., demographic information, diagnoses, clinical symptoms). At the time of the interview, Houston Health department was not receiving anything triggering off the diagnosis code or problem list.	Intermountain used Cerner prior to the eCR implementation, and Houston Methodist used Epic. Like Intermountain's somewhat automated mapping process using a tool in the Cerner system, Houston Methodist used the pilot's mapping experience to create a script to automate future mapping needs in Epic.
	Both sites used a vendor for the mapping of trigger codes. Both sites described subject matter experts as helpful to mapping	Participants felt that the manual workarounds for trigger codes would make it difficult to scale the mapping

	trigger codes, particularly vendor consultants who provided guidance about how the system worked and other consultants who facilitated the process with the lab. Houston Methodist also referred to the extensive knowledge of lab staff, who know the LOINC codes well and update them consistently. Participants described trigger code mapping challenges related to vendor system functionality, maintenance, and scale. Both sites attributed challenges to vendor system functionality – a result of using vendors' proprietary services versus industry-based standards as well as a dependency on the vendor resulting in time-consuming negotiations. Participants described challenges updating codes and concerns the efforts could be duplicative and cause errors in the system.	process beyond the pilot reportable condition.
1.2 Processes to ensure the health IT products generate electronic case reports when activated by trigger codes	Both sites described core components of their systems' processes for applying trigger codes and identifying events: a lab result or clinician-updated problem list for a patient has an associated trigger code that goes to a main integration point (Houston: AIMS platform, Utah: Pub/Sub), where an algorithm or discern rule compares the code to the RCTC list; the system generates an eICR if there is a match. Participants in both Houston and Utah described that the system is triggering from the codes appropriately, referencing simplicity, reliability, and minimal burden to providers.	The Houston Methodist IT participant described internal confusion about the timing and workflows needed for triggering an eICR, and the Houston Methodist health care participants described challenges pertaining to providers' education about problem lists. Intermountain described that after manually reviewing patient data to identify missed codes, they determined that challenges pertained to code mapping rather than code application. Intermountain participants described challenges related to how information is pulled from other systems to complete the eICRs. Specifically, there are optional fields or unavailable fields in CCDs from Cerner that are mandatory for eICRs (e.g., history, travel history, responsible party for trigger observation).

	Participants in both sites also reported that the system functions properly in generating an eICR, though Intermountain participants explained that they initially implemented an older version of the eICR specifications, which caused issues. The Houston Methodist IT participant described the challenge of triggering a case report too soon and the implication of the AIMS platform not having enough information to make accurate decisions on the document.	
1.3 Process for analyzing and authoring case reporting criteria	Houston Health Department explained that the RCKMS authoring process entailed helpful workgroups that allowed them to learn the rules, ordering process, required customization, and maintenance before seeing the RCKMS interface. Participants consulted subject matter experts and found discussions with other jurisdictions particularly helpful. Participants in both sites found the RCKMS interface to be simple and easily configurable. Houston participants mentioned they would have liked to have assistance in determining how to send eICRs to the appropriate jurisdictions.	Participants from both sites described that they refined RCKMS criteria for Zika, gonorrhea, and chlamydia. UDOH participants explained that they expanded the rule to include all test results (i.e., positive, negative, equivocal, indeterminate), rather than just the negative results.·
1.4 Processes to ensure public health and health IT systems can automatically receive, consume, and make electronic reports available for use	Both sites receive eICRs from AIMS via their PHINMS folders. Houston routes messages through Rhapsody to map to the surveillance system and UDOH routes messages through Mirth Connect to their Electronic Message Staging Area (EMSA) for validation and mapping. In Utah, eICRs with technical issues or missing information are sent to a queue, where a person manually	UDOH participants expressed that ensuring the surveillance system can consume all the information is a challenge that has required the system to be rebuilt or modified multiple times to accommodate updates. UDOH participants expressed that they are less concerned about name discrepancies than they are about other inconsistent information, like pregnancy

reviews and determines where to send them.

Houston Health Department participants described what they analyze eICRs for when conducting quality assurance checks: structure, availability of minimum required elements and any additional elements, frequency of what is populating or not, and data quality. The Houston Health Department also analyzes functionality for multiple messages on the same patient (i.e., whether data are overwritten) and messages containing multiple conditions (i.e., how the system parses out information for different disease model questionnaires).

UDOH participants said they scan for triggerable codes and conduct person-matching to see if the patient already exists in their system, which is person-centric. They explained that they rely on both the system and a person to handle multiple messages on a single patient.
If a message is not successfully matched, a staff member manually reviews that message and determines where to send it.

UDOH participants credited their ability to analyze eICRs with their EMSA system infrastructure, especially because they can process information in house.

Houston Health Department participants described people as helpful to eICR analysis processes, specifically the EHR vendor for troubleshooting assistance, CDC and the surveillance company for system modification support, and status or whether the patient was hospitalized. They currently document the discrepancies in the messages' notes but stated the need for establishing rules to automatically resolve inconsistencies to eliminate the need for investigators to review notes. Participants noted that developing these rules would be challenging. The rules would be field-specific and would need to indicate when to trust the data from one data source versus another (e.g., ELR versus eICR).

	providers for open communication about messages they send.	
1.5 Public health agency staff use of the information from eICRs and reportability response documents	Participants in both sites mentioned that eCR will increase the volume of cases they receive, but that this may not be negative, given the anticipated benefits of efficiency and more complete and timely reporting. With EMSA, UDOH participants felt especially prepared for the volume increase. Participants in both sites felt that eICRs provide data that complement data they can get from other data sources and that eICRs provide information that help determine cases that require investigation. The additional types of information include demographic and provider visit information, like past illnesses and symptoms. The Houston Health Department opted not to receive a copy of the reportability response because they do not have an easy way of consuming the responses and making the information actionable to epidemiologists. At the time of the interview, UDOH was waiting to review the data before making decisions on how to process the report copies and what information to bring into the surveillance system.	UDOH explained their process for excluding irrelevant information: 1) splitting the message by trigger and running each code separately, and 2) excluding treatment information that is not relevant to the triggered condition. Utah felt that some information in reportability responses may be useful for determining whether a case is pertinent to them or should be sent elsewhere (e.g., reason for trigger and reporting jurisdiction). They perceived that the only utility of receiving reportability response copies was to be alerted if a condition would be or would need to be treated out of state

1.6 Health care organization staff use of the information from reportability response documents.	Participants in both sites said that reportability responses are sent to providers through RCKMS. Intermountain participants said they receive reportability responses, but at the time of the interview, they had not yet shared reportability responses with end users so as not to interrupt workflow until they could determine the value and utility for users. Houston Methodist participants said they receive reportability responses via a direct message in XDR format, which clinicians can see as under the patient Care Everywhere tab in Epic. They stated that they receive responses within three to five minutes of sending a trigger.	Participants from both sites described that reportability responses include information on the diagnosis, whether a condition is reportable, and whether the patient is being tracked by the health department. Intermountain participants did not describe how they use the reports, but Houston Methodist participants explained that the primary use is informational for clinicians.

Evaluation Question 2: What were the Facilitating and Inhibiting Factors Related to eCR Initiation and Implementation?

Table 2. Key Findings about the facilitating and inhibiting factors related to initiation and implementation

Indicator	*Finding*	*Details*
2.1 Factors **facilitating** the initiation and implementation of the eCR Core Components	All interview participants considered communication to be the predominant facilitating factor during implementation. Both public health sites described communication in terms of understanding implementation processes and decisions. Both provider sites described communication in the context of transparency and promptness around troubleshooting issues.	Provider sites also explained that communication was the result of good relationships with the health department and CDC, as well as all parties wanting a successful pilot. Houston Methodist participants described their process of gaining beneficial knowledge through implementation, while

	The next most frequently stated facilitating factor was existing or available knowledge or expertise about eCR, technologies and tools, or other content related to eCR implementation. Provider sites discussed knowledge and expertise as it related to their internal capacity. Public health sites described benefits of external resources' or partners' knowledge and expertise. Utah participants mentioned that their technological infrastructure was helpful to facilitating implementation. Only public health sites described the benefits of peer-to-peer sharing during implementation – workgroups or discussions for sharing insights or lessons learned with similar contributors in other jurisdictions Participants in Houston Methodist referenced leadership support as an additional implementation facilitator.	Intermountain participants talked about leveraging their in-house expertise in CDA development, connectivity, and other core components. Participants discussed the benefits of the mixed expertise of all engaged parties (e.g., epidemiology, informatics, IT), and Houston Health Department referenced the support they received from CDC and temporary fellows.
2.2Factors **inhibiting** the initiation and implementation of the eCR Core Components	Inhibiting factors included resource challenges, as described by Houston participants. Houston Health Department participants described technical resource restrictions that caused implementation challenges and raised their concerns about maintenance. Houston's primary resource restrictions, however, pertained to human resources, including staff knowledge, time, and turnover. All sites expressed the need for more and better technical guidance and standards, as existing documentation did not adequately address implementation roadblocks. Participants named several challenges related to insufficient guidance and standards: workflows or triggers that would or would not work, message path to endpoint, CDA format, and interface functionality. Participants	*What we really need is a third environment, which is a development environment, and we don't have it because we don't have the server space. So, just resources like that has hurt us and has slowed down this project.* (Houston, Public Health) Houston Health Department participants explained that information on the Digital Bridge website and current documentation about business processes, data flow, and requirements were relevant for lay audiences but not detailed enough for technical audiences who needed step-by-step guidance on technical specifications. Intermountain participants also referenced miscommunication,

	shared that vague guidance contributed to time-consuming downstream errors and led to miscommunication and misunderstanding among partners. Participants discussed the challenges of integrating their homegrown infrastructure and vended eCR solutions and participants explained that structural changes to eCR versions delayed their ability to implement the core components for which they were responsible. Some participants, however, described the nature of the pilot as an inhibiting factor in and of itself	which resulted from ad hoc communication and information sharing by e-mail versus access to a central repository of information. Participants expressed that they understood that some challenges are due to the nature of a pilot (e.g., coordination and communication inefficiencies, insufficient guidance and standards).
2.3Degree to which received electronic case reports meet the needs of public health staff to initiate an investigation	Houston and Utah surveillance systems were not consuming eICRs into their production surveillance system at the time of the evaluation. Participants responded on how they anticipate eCR to influence public health surveillance. Participants had not yet experienced the benefits of eCR at the time of the interviews as they were still implementing eCR and predominantly triggering from lab results rather than problem lists and/or lab orders.	Participants felt that eCR would not change but, rather, enhance core surveillance functions. UDOH participants also felt that eCR would expand surveillance functionality and would not eliminate traditional communication between providers and public health. They described that eICRs provide important symptom, diagnosis, and treatment information, especially for chlamydia, gonorrhea, and pertussis
2.4 Stakeholder perceptions of improvements or diminishment in surveillance function	Participants described what they would like to see in terms of content, display, and processes. Participants in both sites explained that it was difficult to identify desired content in eICRs, given the status of their implementation. UDOH participants described the difficulty in needing to modify EpiTrax to best consume eCR data, as their staff's workload increases due to changes to how the data look. They said that investigators and epidemiologists were comfortable working with a surveillance system that looked like how they analyze	Both sites articulated their ideal content of eCR: Houston described a desire for information on patients' relational links. UDOH participants stated that their goal was to build out EpiTrax fields for information on symptoms, travel history, and vaccinations, in addition to the current fields on demographic, clinical, diagnostic, and lab information. They expressed concern that this valuable clinical information will not reach UDOH if not packaged with the trigger.

	data, as clinical information was historically translated to public health information at the data entry point before reaching the health department. Houston participants expressed a desire for eICRs to automatically send to the appropriate jurisdictions – something that would differentiate them from ELRs, which currently do not have that functionality. Participants also explained that they would like an automatic feedback loop for addressing data inaccuracies.	
2.5 Site leader identification of **strengths** of each of the Core Components	UDOH participants explained that data would be more accurate because they come directly from a clinical system. Houston Health Department participants described that automatically shared data would be more complete as some information can often be left out if shared by phone call or fax. Public health participants also anticipated that eCR would improve efficiency, especially in handling the expected increase in workload volume. In addition, they anticipate improvements in data quality, efficiency, and legal and security compliance.	Participants in Houston also described potential benefits for legal requirements, as well as relationships with other contributors. Participants explained that automation removes clinicians' physical reporting burdens, as well as the mental burden of remembering what to do and what to report
2.6 Site leader identification of **weaknesses** of each of the Core Components	Participants reiterated that implementing eCR is complex and challenging, despite the anticipated benefits. UDOH participants explained that eCR's usefulness depends on the condition, feed, and who is sending the information	Public health participants described that after implementation, eCR will require annually reviewing and updating rules, monitoring feeds, and analyzing message quality. Sites with human resource constraints felt unprepared for maintaining eCR and expanding beyond the five pilot conditions without ongoing support from CDC and Digital Bridge.

2.7 Site leader's identification of benefits to implementing eCR in health care organizations and public health practice	Due to the timing of interviews, participants could not yet speak to eCR benefits that they had experienced. They could, however, describe their perspectives on what they anticipate benefiting their organizations. Participants predominantly mentioned benefits to data quality and efficiency.

Evaluation Question 3: How were inhibiting factors address?

Table 3. Key Findings about how the inhibiting factors were addressed

Indicator	*Finding*	*Details*
3.1 Strategies and solutions used to address factors inhibiting initiation and implementation of eCR Core Components	Participants described anticipated benefits to efficient and timely data reporting, which could alleviate staff workload burdens. This expectation for benefits encouraged participants during implementation challenges. Intermountain participants described the manual workarounds needed for Cerner's limited functionality.	Intermountain participants felt that the manual workarounds would make it difficult to scale the mapping process beyond the pilot reportable conditions.

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