Population Health Informatics Can Advance Interoperability: National Program of Cancer Registries Electronic Pathology Reporting Project

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PURPOSE Given the reach, breadth, and volume of data collected from multiple clinical settings and systems, US central cancer registries (CCRs) are uniquely positioned to test and advance cancer health information exchange. This article describes a current Centers for Disease Control and Prevention (CDC) National Program of Cancer Registries (NPCR) cancer informatics data exchange initiative.

METHODS CDC is using an established cloud-based platform developed by the Association of Public Health Laboratories (APHL) for national notifiable disease reporting to enable direct transmission of standardized electronic pathology (ePath) data from laboratories to CCRs in multiple states.

RESULTS The APHL Informatics Messaging Services (AIMS) Platform provides an infrastructure to enable a large national laboratory to submit data to a single platform. State health departments receive data from the AIMS Platform through a secure portal, eliminating separate data exchange routes with each CCR.

CONCLUSION Key factors enabling ePath data exchange from laboratories to CCRs are having established cancer registry data standards and using a single platform/portal to reduce data streams. NPCR plans to expand this approach in alignment with ongoing cancer informatics efforts in clinical settings. The 50 CCRs supported by NPCR provide a variety of scenarios to develop and disseminate cancer data informatics initiatives and have tremendous potential to increase the implementation of cancer data exchange.

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BACKGROUND

The core function of cancer surveillance depends on moving cancer information from points of care, such as hospitals, offices, and laboratories, into a central cancer registry environment where data are exchanged and made available. Central cancer registries (CCRs) in each US state and territory have an important role in data exchange between clinical settings, CCRs, and federal agencies (Appendix Table A1 lists acronyms used in this article). To accomplish population-based cancer surveillance, data reporters use highly standardized cancer data definitions and codes to collect information on patients, cancer type, stage, and treatment from multiple sources, and CCRs consolidate these data to ultimately provide community and national cancer statistics.¹ Health planners, researchers, decision makers, and the public, in turn, use these data to inform prevention efforts and monitor cancer trends. The Centers for Disease Control and Prevention (CDC) understands that data exchange

and interoperability can directly benefit the availability of data and, in turn, affect decisions and lives.

In this article, we provide an overview of CDC cancer informatics initiatives and Public Health Information Network Messaging System (PHINMS), which are being leveraged to enable direct transmission of pathology data to CCRs. We describe how cancer data are currently being exchanged from a single laboratory data source to multiple CCRs using electronic reporting through a cloud-based computing platform. Finally, we discuss how such CDC projects and other initiatives can contribute to advancing data interoperability and information exchange.

CANCER AND PUBLIC HEALTH SURVEILLANCE AND INFORMATICS AT CDC

National Program of Cancer Registries

CDC's National Program of Cancer Registries (NPCR) supports CCRs in 46 states, the District of Columbia, Puerto Rico, the Virgin Islands, and the US Pacific

ASSOCIATED CONTENT

Appendix

Author affiliations and support information (if applicable) appear at the end of this article.

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CONTEXT

Key Objective

How can data be transferred from pathology laboratories into a national population-based surveillance cancer system?

Knowledge Generated

Data standards and structured data capture enable data exchange into state central cancer registries using an established, secure public health information messaging service.

Relevance

The advancement in information exchange could enable collection of national cancer data in near real-time and be used to inform clinical and public health activities to improve cancer prevention and control.

Island jurisdictions.² The program was established by Congress through the Cancer Registries Amendment Act in 1992 and has grown to become one of CDC's largest population-based surveillance systems.³ The Cancer Registries Amendment Act authorized CDC to make grants to States to support population-based, statewide cancer registries to enable state and local health departments to understand cancer trends and patterns unique to their jurisdiction to direct cancer control programs, including those focused on prevention and early detection.³ Before NPCR was established, 10 states had no cancer registry, and most states with registries lacked the resources and legislative support they needed to gather complete data.² Together with the National Cancer Institute's SEER Program, CDC collects data on the entire US population, reflecting 1.7 million newly diagnosed (incident) cancer cases annually. The congressionally mandated authority for national cancer surveillance is unique to NPCR and supports registries to collect cancer site, histology, stage at diagnosis and associated demographic and geographic information.³ Cancer counts in US Cancer Statistics are based on direct reporting rather than derived by estimation or modeling.⁴ The congressionally mandated authority for national cancer surveillance is unique to NPCR and supports registries to collect demographic information, date of diagnosis, and cancer, including the cancer site, pathologic type, stage of disease, and initial treatment.³

Given the reach, breadth, and volume of data handled by NPCR cancer registries, CDC is uniquely positioned to test, demonstrate, and disseminate new approaches to exchanging cancer information spanning multiple settings and systems. In addition, NPCR benefits from the infrastructure and experience of CDC's other national surveillance systems for both infectious and noninfectious diseases. Thus, NPCR can be both an example and a learning laboratory to examine how to best collect and share structured cancer data among individual facilities and geographic jurisdictions.

CDC/NPCR Registry Plus Software

In addition to providing technical support and funding to CCRs, CDC/NPCR provides informatics solutions to enable

data collection and transmission from providers (eg, hospitals, outpatient physicians, laboratories) to CCRs and, ultimately, into national surveillance systems including NPCR, SEER, and the Commission on Cancer National Cancer Database. The Informatics, Data Science, and Applications Team within NPCR develops multiple software programs and tools for hospitals, outpatient facilities, and laboratories to report and registries to process cancer data. These software programs, collectively known as Registry Plus, are publicly available and compliant with the North American Association of Central Cancer Registries (NAACCR) standards.⁵ All national cancer surveillance systems in the United States and Canada contribute to and use NAACCR data standards to collect, prepare, and exchange data.⁶

Even though cancer data standards are highly developed, cancer surveillance still depends heavily on manual record abstraction and data entry by cancer registrars at the facility level. This process is labor intensive and can take > 24 months for complete data to be available for informing and evaluating cancer prevention and care. Direct data capture from sources like pathology laboratories and healthcare provider electronic health records (EHRs) would improve data flow and timeliness into cancer registries and, ultimately, availability to data users. One of the CDC's Registry Plus software tools, Electronic Mapping, Reporting, and Coding (eMaRC) Plus, was designed for CCRs to receive Health Level Seven International (HL7) version 2.3.1, version 2.5.1, and Clinical Document Architecture (CDA) reports from pathology laboratories and physician offices.⁷ To support eMaRC Plus, CDC works closely with CCRs to provide technical assistance with validation and testing of reports, as well as with EHR and Laboratory Information System (LIS) vendors to ensure efficient data exchange with their specific systems and identify needs or solutions. In 2020, eMaRC Plus is used by 45 CCRs to receive electronic reports in the CDA format from EHRs. Currently, there is no CDA format for reporting cancer pathology data. However, > 40 CCRs receive electronic pathology (ePath) reports in the HL7 message format from LISs. The College of American Pathologists (CAP) has used experts from across the country to develop standardized

cancer checklists with codes for each question and answer, allowing the computer to read the form without any human intervention. The pathologist completes the form, then clicks submit to automatically create a computer-readable Structured Data Capture (SDC) Extensible Markup Language (XML) formatted report for processing by the receiving system (ie, cancer registry or EHR).⁸ An expansion is planned to enhance eMaRC Plus to receive and process the Integrating the Healthcare Enterprise SDC XML forms available to pathologists in the United States and Canada.

Public Health Information Network Messaging System

CDC supports Public Health Information Network Messaging System (PHINMS), a secure data exchange software that enables bidirectional information exchange of data between clinical and public health systems. CDC has used PHINMS since 2005 to implement and maintain standardized ePath reporting from national and large regional laboratory systems to CCRs. Through PHINMS, authenticated users can send and receive encrypted data with data exchange confirmations.⁹ Messages composed of standardized vocabulary can be implemented in a range of formats (eg, HL7, XML, image files, and comma-separated values). Since 2008, the Association of Public Health Laboratories (APHL) used the PHINMS to use CDC as an intermediary server (Route-not-Read hub) that ensures the Sender is able to send an outbound message and the CDC's Receiver successfully receives the message. To expand on this capability, APHL developed the APHL Informatics Messaging Services (AIMS) Platform. The AIMS Platform routes electronic messages between the CDC, partner laboratories, and public health agencies, and handles reporting on infectious diseases, including HIV, vaccine-preventable diseases, flu, and resistant bacterial testing. In 2016, a secure, cloud-based environment was created for the AIMS Platform to provide shared services that aid in the identification, validation, translation, transformation, and routing of electronic data.¹⁰ Table 1 shows how the AIMS Platform has been enhanced compared with the PHINMS. Business and data-sharing agreements are already in place to cover data exchange between APHL and state Departments of Health. Given that the AIMS Platform was designed to exchange health information on a national scale and has a proven infrastructure, NPCR is leveraging it to enable electronic reporting of cancer data to CCRs.

ePATH REPORTING INTO CANCER REGISTRIES

Standards and Process

Pathology reports from laboratories were chosen as the first data source to demonstrate automated, electronic capture and reporting of cancer registry data to CCRs, because the diagnosis of nearly all cancers in the United States relies on pathology. A long-standing partnership between CDC, the CAP, laboratories, and CCRs collectively laid the groundwork by developing national standards for ePath reporting and data exchange.¹¹ National standards for reporting

cancer pathology data to CCRs were first documented by NAACCR in 2002. From 2005, the standards and business rules for reporting have been defined as NAACCR Pathology Laboratory Electronic Reporting Volume V.¹² Cancer registries are able to receive and process the HL7 ePath data from laboratories into their main cancer surveillance database using the previously described eMaRC Plus software. The registries can receive ePath data through either manual upload, accessing a dedicated folder, or through an automated electronic exchange method like PHINMS. When possible, CCRs coordinate with state Departments of Health to implement a PHINMS server to receive state public health data for multiple domains.

Of note, CCRs still must consolidate multiple reports on a single case and append the incoming laboratory data with other cancer data into a single record in the cancer registry surveillance system. As reports are sent electronically, the CCR must determine if it is a new tumor, a tumor already in the database, or a multiple primary. This is accomplished by software with linkage logic that uses key demographic variables to score the incoming record. If there is no other record of the tumor in the database, the system creates a new record. When there are specific data items from two or more linked records or from multiple reporting sources, consolidation rules define how data are evaluated to determine the best value. These rules can be as simple as *known over unknown* or *most recent over older dates*; in complex cases, consolidation requires manual review by a subject matter expert. The application of consolidation rules can be automated, manual, or a combination of the two. Values determined through automated consolidation can be updated manually, if a better value is determined with additional information. Many CCR directors report that consolidation is the most time-consuming component of cancer surveillance. As more data are submitted electronically from various sources, the work of deduplication and consolidation is expected to increase rather than decrease.

Cloud-Based Centralized Data Exchange for ePath

A challenge, however, is that when national or regional laboratories serve more than one state, it is a burden for them to maintain individual connectivity points to exchange ePath data with multiple CCRs. A more efficient approach could be for the laboratory to submit cancer data to a single platform for distribution to the appropriate CCR. To address this issue, in October 2018, NPCR began working with APHL and a large national laboratory, Quest Diagnostics (Secaucus, NJ), to report ePath data directly to CCRs using the AIMS Platform, without the use of PHINMS, bypassing the need for record abstraction. Quest Diagnostics developed and implemented a standardized LIS with the ability to create ePath messages that are HL7 version 2.5.1 Observation Results compliant, based on version 5.0 of the NAACCR Volume V Pathology Laboratory Electronic Reporting specification.¹² CDC worked directly with Quest

TABLE 1. Comparison of Requirements and Supported Transport Protocols of PHINMS to APHL AIMS Platform

Features		PHINMS	APHL AIMS
Laboratory requirements	Establish and maintain connections to all 50 public health agencies		Establish and maintain a single connection to the AIMS Platform
Public health agency requirements	Establish and maintain connections to multiple regional/national reporting laboratories		Establish and maintain a single connection to the AIMS Platform
Transport protocols supported	Electronic Business using eXtensible Markup Language	PHINMS	
		Direct	
		Integrating the Healthcare Enterprise	
		Cross-Enterprise Document Reliable Interchange	
		Nationwide Health Information Network	
		Clinical Data Repository	
		Web Services	
		Amazon Web Services S3	
		SSH File Transfer Protocol	
		Virtual Private Network	
Additional services	Not applicable		Validation, translation, and transformation services available

Abbreviations: AIMS, APHL Informatics Messaging Services; APHL, Association of Public Health Laboratories; PHINMS, Public Health Information Network Messaging System; SSH, Secure Shell.

Diagnostics to test and finalize this HL7 data structure . Cancer registries, in turn, use eMaRC Plus or a similar tool to receive and process the pathology data that Quest Diagnostics transmits using the AIMS Platform. To ensure that reportable cancer cases were identified, nonreportable cases were filtered out based on the standard list of reportable International Classification of Diseases, 10th Revision, Clinical Modification diagnosis codes assigned by the pathologist. If the pathologist does not code the cases, then CDC asks the laboratories to identify a flag for the pathologist to indicate a reportable cancer case. The reliability of this method varies by laboratory, but validity of this approach has not yet been formally tested. With ePath reporting standards established and implemented, Quest Diagnostics is now able to submit national ePath data from > 35 regional Quest laboratories to the AIMS Platform. The APHL AIMS Platform provides an infrastructure that eliminates setting up separate routes between each laboratory and individual CCRs. The state health departments have one portal with the AIMS Platform to receive the data. This “data exchange highway” reduces the burden on both the laboratories and the states by enabling reporting to multiple public health programs. The CCRs in Louisiana, Nevada, and California are currently pilot testing this new approach to receive relevant ePath cancer data through this cloud service and process the incoming data using eMaRC Plus or a similar tool (Fig 1). Key success factors of this ePath project are having already established data standards that laid the foundation for direct data exchange and using a single platform/portal to reduce data streams.

FIG 1. Diagram of National Program on Cancer Registries electronic pathology (ePath) reporting to population-based central cancer registries through the Association of Public Health Laboratories Informatics Messaging Services (APHL AIMS) Platform. Solid line indicates current pilot; dashed line indicate future stage. Central cancer registries process the incoming data using Electronic Mapping, Reporting, and Coding (eMaRC) Plus or a similar tool. LIS, Laboratory Information System.

FUTURE DIRECTIONS

The ePath pilot project is part of CDC's larger plan to modernize cancer surveillance. NPCR is working to make data exchange and processing from medical facilities and laboratories to CCRs more efficient through a dedicated Cancer Surveillance Cloud-Based Computing Platform (CBCP). The establishment of connectivity between laboratories and CBCP for electronic exchange of pathology reports is the first phase. The AIMS Platform will contribute data to this CBCP by being one of many sources to exchange data with the CBCP. In future phases, NPCR aims to use the CBCP to host Registry Plus software, securely host patient data received directly from healthcare providers, and provide data access and management dashboards to authenticated data reporters and CCRs (Jones DE, et al: manuscript submitted for publication).

Population-based cancer surveillance systems can accelerate cancer data exchange on a national scale by developing processes to securely move data from clinical providers into CCRs across the United States. Furthermore, NPCR seeks to align cancer surveillance standards with Health Information Technology standards. Emerging standards, such as HL7 Fast Healthcare Interoperability Resources (FHIR), are positioned to improve interoperability and ease implementation of patient health data exchange across systems.¹³ NPCR is exploring how FHIR can enable data exchange between clinical workflows and CCRs. Common Oncology Data Elements eXtensions (CodeX) is a new FHIR Accelerator started in late 2019 to develop, test, and implement methods for interoperable exchange of information for cancer care and research.¹⁴ CodeX builds on the minimal Common Oncology Data Elements (mCODE) FHIR specification, which provides a standard for a core set of data elements for oncology EHRs.¹⁴ The mCODE initiative is a collaborative effort between ASCO and the MITRE Corporation.¹⁵ NPCR is participating in the CodeX Cancer Registry Reporting Use Case by testing mCODE and FHIR for reporting cancer treatment data from cancer centers to CCRs. NPCR is also participating in the Making EHR Data More Available for Public Health (MedMorph) project led by CDC and funded by the Patient-Centered Outcomes Research Trust Fund.¹⁶ MedMorph aims to create a reliable, scalable, generalizable, configurable, and interoperable method for obtaining EHR data for multiple public health and research use cases. Reporting cancer data from healthcare provider EHRs to CCRs is one of three use cases being fully developed in the MedMorph initiative.¹⁷

DISCUSSION

The NPCR ePath project demonstrates the evolution from abstraction-based data collection to electronic reporting directly from the sources that created the data, pathology laboratories, and EHRs. This project sets the stage for reporting sources to provide data directly to registries,

easing some of the burden of reviewing reports and enabling CCRs to focus on the consolidation, verification, and completeness of data. Through this and other cancer registry informatics efforts, national surveillance systems can advance progress and uptake of cancer information data interoperability through developing and testing data exchange processes. Looking to the future, we recognize the potential benefit for registries to use FHIR to bring together data from varying EHR system workflows as well as the different vocabularies, coding systems, and data collection methods in each system.

Technological solutions to improve cancer data collection are promising, but there are many factors outside of data standards and data flow architecture that determine success. A recent feasibility assessment of electronic reporting and readiness of NPCR registries highlighted the need for IT expertise and infrastructure, management support, and staff positions in informatics, programming, quality assurance, and data processing (Tangka FB, et al: unpublished manuscript). In addition, external factors that affect the ability of CCRs to participate in cancer data exchange include state-level legislation, the capacity and quality of reporting sources, funding availability, the volume of cases received, and informatics support to access an interstate data exchange platform. Each year, CCRs collect data on more incident cancer cases while at the same time facing challenges such as level or decreasing funding, workforce instability (retention, an aging workforce), and, most recently, redirection and furloughs due to COVID-19.¹⁸ Although data exchange may eventually offer some relief through streamlining the availability and collection of the data, many registries would like to see clear benefits and

have informatics support to take on innovative projects or new practices. Equally important, registrars and CCRs are more likely to support population-health surveillance informatics projects if they show results and job relevance for registrars or the benefit to the CCR mission, because perceived usefulness and perceived ease of use are underlying factors in an individual's or organization's intention to use and eventually adopt new technology.¹⁹ To overcome these concerns, partnerships are critical for NPCR to learn together with organizations that provide cancer data to CCRs.

In conclusion, an infrastructure for data exchange is already available through established population-based surveillance programs. Direct reporting of infectious diseases to state public health agencies through the PHINMS and AIMS Platform informed this NPCR ePath reporting project. Building on this experience, NPCR is developing a CBCP to further expand direct collection and exchange of cancer data while also exploring how to capitalize on FHIR and other industry standards that promote interoperability. The national reach of our population-based surveillance program positions NPCR as an influential partner to bring together multiple initiatives to pilot and expand cancer data exchange. The fifty CCRs supported by NPCR provide a variety of scenarios to test, develop, and disseminate cancer data informatics initiatives. The registries, however, seek assurance that informatics projects will increase efficiency of data collection, provide reliable data, address privacy and confidentiality, and contribute to understanding cancer and outcomes in their jurisdiction. Despite the acknowledged challenges, informatics solutions that involve NPCR and CCRs have tremendous potential to increase the implementation of cancer data exchange.

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DISCLAIMER

The findings and conclusions are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

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REFERENCES

1. Ryerson AB, Massetti GM: CDC's public health surveillance of cancer. *Prev Chronic Dis* 14:E39, 2017
2. Centers for Disease Control and Prevention: Division of Cancer Prevention and Control: National Program of Cancer Registries (NPCR): About the Program 2020. <https://www.cdc.gov/cancer/npcr/about.htm>
3. Hearing on H.R. 4206 before the House Subcommittee on Health and the Environment: Cancer Registries Amendment Act, 102nd Congress, February 28, 1992. <https://www.congress.gov/bills/102nd-congress/house-bill/4206?s=1&r=8#:~:text=Cancer%20Registries%20Amendment%20Act%20%2D%20Amends,cell%20carcinoma%20of%20the%20skin.>
4. Centers for Disease Control and Prevention: United States cancer statistics: 1999–2017. Cancer incidence and mortality data. Atlanta, GA, US Department of Health and Human Services, CDC. 2020
5. Centers for Disease Control and Prevention: Registry Plus software programs for cancer registries. <https://www.cdc.gov/cancer/npcr/tools/registryplus/index.htm>
6. Sieffert JY, John L Jr: The North American Association of Central Cancer Registries. Dubuque, Iowa, Kendall Hunt Publishing, 1997
7. Division of Cancer Prevention and Control: National Program of Cancer Registries: Software and tools. <https://www.cdc.gov/cancer/npcr/tools/>
8. Torous VF: The College of American Pathologists Cancer Protocols: From optimizing cancer patient care to facilitating interoperable reporting and downstream data use. *JCO Clin Cancer Inform* doi: [10.1200/CCI.20.00104R1](https://doi.org/10.1200/CCI.20.00104R1)
9. Division of Health Informatics and Surveillance: PHIN Messaging System. <https://www.cdc.gov/phinf/tools/phinfms/index.html>
10. Association of Public Health Laboratories: APHL AIMS Platform. https://www.aphl.org/programs/informatics/Pages/aims_platform.aspx
11. Public Health Information Network: Implementation Guide for Transmission of Laboratory-Based Reporting of Public Health Information using Version 2.3.1 of the Health Level Seven (HL7) Standard Protocol 2005. <http://dph.illinois.gov/sites/default/files/publications/cdcelimplementationguidev231.pdf>
12. Jones S, Mazuryk J, Havener L (eds): Standards for Cancer Registries Volume V: Pathology Laboratory Electronic Reporting, Version 5. https://www.naaccr.org/wp-content/uploads/2020/05/NAACCR-Vol-V_20200526.pdf
13. Health Level 7: Introducing HL7 FHIR. <http://hl7.org/fhir/summary.html>
14. Prociuous J: Learn more about CodeX. <https://confluence.hl7.org/display/COD/Learn+More+About+CodeX>
15. HL7 International Clinical Interoperability Council: HL7 FHIR Implementation Guide: minimal Common Oncology Data Elements (mCODE). <http://hl7.org/fhir/us/mcode/>
16. US Department of Health and Human Services, Office of Assistant Secretary for Planning and Evaluation: Making electronic health record (EHR) data more available for research and public health. <https://aspe.hhs.gov/making-electronic-health-record-ehr-data-more-available-research-and-public-health>
17. Center for Surveillance Epidemiology and Laboratory Services: Making EHR Data More Available for Research and Public Health. <https://www.cdc.gov/csels/phio/making-ehr-data-more-available.html>
18. Chapman SA, Mulvihill L, Herrera C: Workload and time management in central cancer registries: Baseline data and implication for registry staffing. *J Registry Manag* 39:178-184, 2012
19. Nadri H, Rahimi B, Lotfnezhad Afshar H, et al: Factors affecting acceptance of hospital information systems based on extended technology acceptance model: A case study in three paraclinical departments. *Appl Clin Inform* 9:238-247, 2018

APPENDIX

Table A1. Acronyms

Acronym	Expansion
AIMS	APHL Informatics Messaging Services
APHL	Association of Public Health Laboratories
CAP	The College of American Pathologists
CBCP	Cloud-Based Computing Platform
CCR	Central cancer registry
CDA	Clinical Document Architecture
CDC	Centers for Disease Control and Prevention
CDR	Clinical Data Repository
CodeX	Common Oncology Data Elements eXtensions
EHR	Electronic health records
eMaRC	Electronic Mapping, Reporting, and Coding
ePath	Electronic pathology
FHIR	Fast Healthcare Interoperability Resources
HL7	Health Level Seven International
LIS	Laboratory information system
mCODE	Minimal Common Oncology Data Elements
MedMorph	Making EHR Data More Available for Public Health
NAACCR	North American Association of Central Cancer Registries
NPCR	National Program of Cancer Registries
PHINMS	Public Health Information Network Messaging System
SDC	Structured Data Capture
XML	eXtensible Markup Language