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## Research and Applications

# Enabling health information exchange at a US Poison Control Center

Mollie R. Cummins <sup>1</sup>, Guilherme Del Fiol <sup>2</sup>, Barbara I. Crouch,<sup>3</sup>  
Pallavi Ranade-Kharkar,<sup>4</sup> Aly Khalifa,<sup>2</sup> Andrew Iskander,<sup>2</sup> Darren Mann,<sup>4</sup>  
Matt Hoffman,<sup>5</sup> Sid Thornton,<sup>4</sup> Todd L. Allen,<sup>4</sup> and Heather Bennett<sup>6</sup>

<sup>1</sup>University of Utah College of Nursing, Salt Lake City, Utah, USA, <sup>2</sup>Department of Biomedical Informatics, University of Utah, Salt Lake City, Utah, USA, <sup>3</sup>Utah Poison Control Center, University of Utah, Salt Lake City, Utah, USA, <sup>4</sup>Intermountain Healthcare, Salt Lake City, Utah, USA, <sup>5</sup>Medical Informatics, Utah Health Information Network, Murray, Utah, USA, and <sup>6</sup>Utah Poison Control Center, University of Utah, Salt Lake City, Utah, USA

Corresponding Author: Mollie R. Cummins, PhD, RN, FAAN, FACMI, University of Utah College of Nursing, Annette Poulson Cumming Building, 10 South 2000 East, Room 5345, Salt Lake City, UT 84112, USA (mollie.cummins@utah.edu)

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### ABSTRACT

**Objective:** The objective of this project was to enable poison control center (PCC) participation in standards-based health information exchange (HIE). Previously, PCC participation was not possible due to software non-compliance with HIE standards, lack of informatics infrastructure, and the need to integrate HIE processes into workflow.

**Materials and Methods:** We adapted the Health Level Seven Consolidated Clinical Document Architecture (C-CDA) consultation note for the PCC use case. We used rapid prototyping to determine requirements for an HIE dashboard for use by PCCs and developed software called SNOWHITE that enables poison center HIE in tandem with a poisoning information system.

**Results:** We successfully implemented the process and software at the PCC and began sending outbound C-CDAs from the Utah PCC on February 15, 2017; we began receiving inbound C-CDAs on October 30, 2018.

**Discussion:** With the creation of SNOWHITE and initiation of an HIE process for sending outgoing C-CDA consultation notes from the Utah Poison Control Center, we accomplished the first participation of PCCs in standards-based HIE in the US. We faced several challenges that are also likely to be present at PCCs in other states, including the lack of a robust set of patient identifiers to support automated patient identity matching, challenges in emergency department computerized workflow integration, and the need to build HIE software for PCCs.

**Conclusion:** As a multi-disciplinary, multi-organizational team, we successfully developed both a process and the informatics tools necessary to enable PCC participation in standards-based HIE and implemented the process at the Utah PCC.

**Key words:** Health information exchange, poison control centers, workflow, health information interoperability, patient care

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## INTRODUCTION

Poisonings are the leading cause of unintentional injury and death in the United States.<sup>1</sup> The death rate from unintentional poisoning, particularly drug overdose involving opioids, has continually increased

over the past 22 decades.<sup>1</sup> The growing epidemic of poisoning, which includes drug overdoses, is apparent in US emergency departments (EDs). The rate of opioid-related ED use more than doubled between 2009 and 2016.<sup>2</sup> In 2017, US poison control centers (PCCs) recorded

656 235 cases of unintentional poisoning, included drug overdoses, managed in US health care facilities, and the Centers for Disease Control & Prevention reported 70 237 drug overdose deaths.<sup>3,4</sup>

US PCCs play a critical role in both emergency treatment and surveillance of poison exposures. These largely publicly funded call centers are primarily staffed by registered nurses and pharmacists with specialized education in toxicology. They assess poison exposures via telephone and provide specific advice to callers, whether the caller is the patient, a bystander, or a health care provider. In the most recent published data from the National Poison Data System, 31% of all US human poison exposures were managed in a health care facility—typically an ED.<sup>3</sup> For the cases managed in a health care facility, the PCC acts as a consultant to the bedside health care providers, providing information and recommendations for treatment. While PCC consultation is essential to quality care, the current process of ED–PCC collaboration is highly dependent upon synchronous and asynchronous telephone communication resulting in workflow interruption for the ED, poor data quality and capture, and unreliable processes for sharing information among team members who are caring for the patient. In prior work, we studied the typical telephone-based communication process and found a number of inefficiencies and safety vulnerabilities in the ED–PCC collaboration process.<sup>5</sup>

## OBJECTIVE

The objective of this project was to enable PCC participation in standards-based health information exchange (HIE), leveraging existing exchange networks and participation agreements. US PCCs have an immediate need to innovate the process by which they collaborate with health care providers, especially EDs, in order to improve efficiency and optimize patient outcomes. Previously, PCC participation in standards-based HIE was not possible due to proprietary software not compliant with HIE standards, a lack of informatics tools and the need to integrate HIE processes into the workflow of PCCs.

## MATERIALS AND METHODS

In this study, we aimed to enable a standards-based HIE process and software infrastructure to improve poison control communication with EDs. In prior work, we determined the information requirements for HIE between PCCs and EDs.<sup>6</sup> We also ascertained the perspective and opinion of thought leaders in emergency medicine, poison control, and informatics about PCC engagement in HIE.<sup>7</sup> Subsequently, we adapted an existing clinical document standard, the Health Level Seven (HL7) Consolidated Clinical Document Architecture (C-CDA) consultation note for the PCC use case.<sup>8</sup> We used a process of rapid prototyping to detail requirements for an HIE dashboard for use by PCCs.<sup>9</sup> We repurposed and extended the existing standards-compliant network connections between the sending and receiving organizations.

### Process development

When we embarked upon this project, there was no health information exchange occurring between the PCC and any external organizations. Communication with hospitals and EDs about poisoning cases occurred via telephone. At times, the Utah PCC used secure e-mail to communicate with public health authorities about specific cases. The Utah PCC also granted the state health department direct

access to its clinical data. The process of HIE was envisioned and developed by a multi-disciplinary team of collaborators representing University of Utah, the Utah Poison Control Center, the Utah Health Information Network (UHIN, Utah's state-wide HIE), and Intermountain Healthcare (Utah's largest health delivery network). During a series of design meetings and based upon our preliminary studies, we partnered with stakeholders and end users to envision a new process of collaboration to be supported by HIE. We collaborated with the Utah Health Information Network and HIE experts from Intermountain Healthcare to plan the system architecture. Governance and organizational priority were resolved through longstanding interoperability goals of the community and established through the state health information technology plan as administered by the Utah Digital Health Services Commission, which convenes stakeholders under the authority of the Utah legislature. A series of interoperability infrastructure grants have been coordinated previously, including a CMS State Innovation Model planning grant. All of the organizational stakeholders had been previously participating in the larger infrastructure projects for the community which allowed for resources to be assigned for developing the poisoning HIE architecture. Clinical and administrative champions in the ED and PCC settings were also critical in enabling and planning this work.

Collaboration and planning addressed a wide range of opportunities and concerns. We sought to establish common ground in relation to fundamental legality, security, and privacy issues detailed in McDonald et al.<sup>10</sup> We discussed and considered use cases ranging from case reporting to ED–PCC bidirectional HIE in support of poisoning emergencies. We considered numerous scenarios and approaches from each stakeholder perspective, focusing particularly on bidirectional HIE processes that would be enabled by poison control participation in HIE. As an example, some stakeholders advocated for universal case notification: using automated triggers within a hospital EHR, to notify the PCC about all poisoning cases, regardless of severity or perceived need for consultation. This was the initial preference of some ED clinicians who felt that more frequent and consistent collaboration with PCCs would result in improved care, as well as PCC users who wished to strengthen case reporting. However, in considering this approach, a workflow concern was raised concerning whether this approach would flood the PCC with referrals for routine cases such as alcohol detoxification. Through system dynamics modeling, we estimated that the overall impact on PCC workflow, especially given an initial trial with just 2 local EDs, would be acceptable, and we decided to proceed with this approach on a trial basis.<sup>11</sup>

### Informatics tools

#### Standards-based format for messages

We analyzed HL7 C-CDA document types to determine whether and how they could be used to support the information requirements previously established through analysis of call recordings.<sup>6,8</sup> We determined that the HL7 C-CDA Consultation Note best supports information requirements when PCCs communicate case information and management guidance externally to EDs and other agencies. However, while the HL7 C-CDA Consultation Note best supports the capture of data meeting the information requirements, target users indicated that the appearance and organization of the information within the Consultation Note rendered within electronic health record (EHR) systems as a PDF document did not match the cognitive needs of clinicians. In order to address this

concern, we conducted a design meeting with 3 Intermountain Healthcare emergency medicine physicians. The physicians provided input on the organization and formatting of information types within required and optional sections, and we designed the organization and formatting according to their preferences. The organization of the information types is fairly constrained by the standard. However, recipients can choose to display the HL7 C-CDA Consultation Note using the style sheet of their choice.

### Mappings between PCC data and HL7 C-CDA

The Utah PCC, like most US PCCs, uses a proprietary information system called toxiCALL. The Utah PCC poisoning information system supports the collection of both text and coded data describing poisoning cases, including a standard set of data elements required for participation in the National Poison Data System (NPDS), a nationwide poisoning surveillance system. We analyzed the data stored in the Utah PCC poisoning information system for its utility in the communication process and identified additional information elements that would need to be captured in order to send clinically useful documents to ED care providers. Unable to directly modify the Utah PCC's proprietary information system to collect the additional information in coded fields, we implemented a semistructured template that uses XML tags to demarcate distinct pieces of information. As described in Khalifa, Del Fiol, and Cummins, we created computable mappings between the Utah PCC data, including semistructured data collected using the template and the HL7 C-CDA Consultation Note standard.<sup>12</sup> We also used HTML formatting within the C-CDA Consultation Note narrative sections in order to enforce document rendering according to the display format designed with input from poison control and ED domain experts.

### SNOWWHITE

In a process of user-centered design and rapid prototyping, we created an initial interface design for poisoning HIE software.<sup>9</sup> We followed this requirements specification with software development but substantially refined the user interface design in collaboration

with human-computer interaction experts based upon a heuristic usability evaluation. Subsequently, we conducted formal usability testing. The process of user-centered design resulted in an interface that capitalizes upon user familiarity with common conventions of e-mail software. SNOWWHITE (Figure 1) supports the following basic functions: 1) create and send outgoing HL7 C-CDA consultation notes using data collected in a proprietary poisoning information system, 2) receive and view incoming messages from EDs (eg, hospital discharge summaries, progress reports); and 3) search and sort messages. Briefly, PCC staff complete all case documentation within their proprietary poisoning information system, entering additional structured information within a free text field. Then, they additionally locate and select the patient in a regularly updated list within the SNOWWHITE software, click to create, preview, and send the note. Incoming messages, which consist of HL7 C-CDA Referral, Progress, and Discharge Summary Notes, can be located through search and sort functionality.

### Regional and partnered health information exchange University of Utah

University of Utah's Center for High Performance Computing hosts the SNOWWHITE software along with SNOWWHITE's HIE gateway, the component that actually sends and receives messages with outside entities. SNOWWHITE reads data from the Utah PCC poisoning information system hosted by University Healthcare Information Technology Services (ITS) in a separate environment.

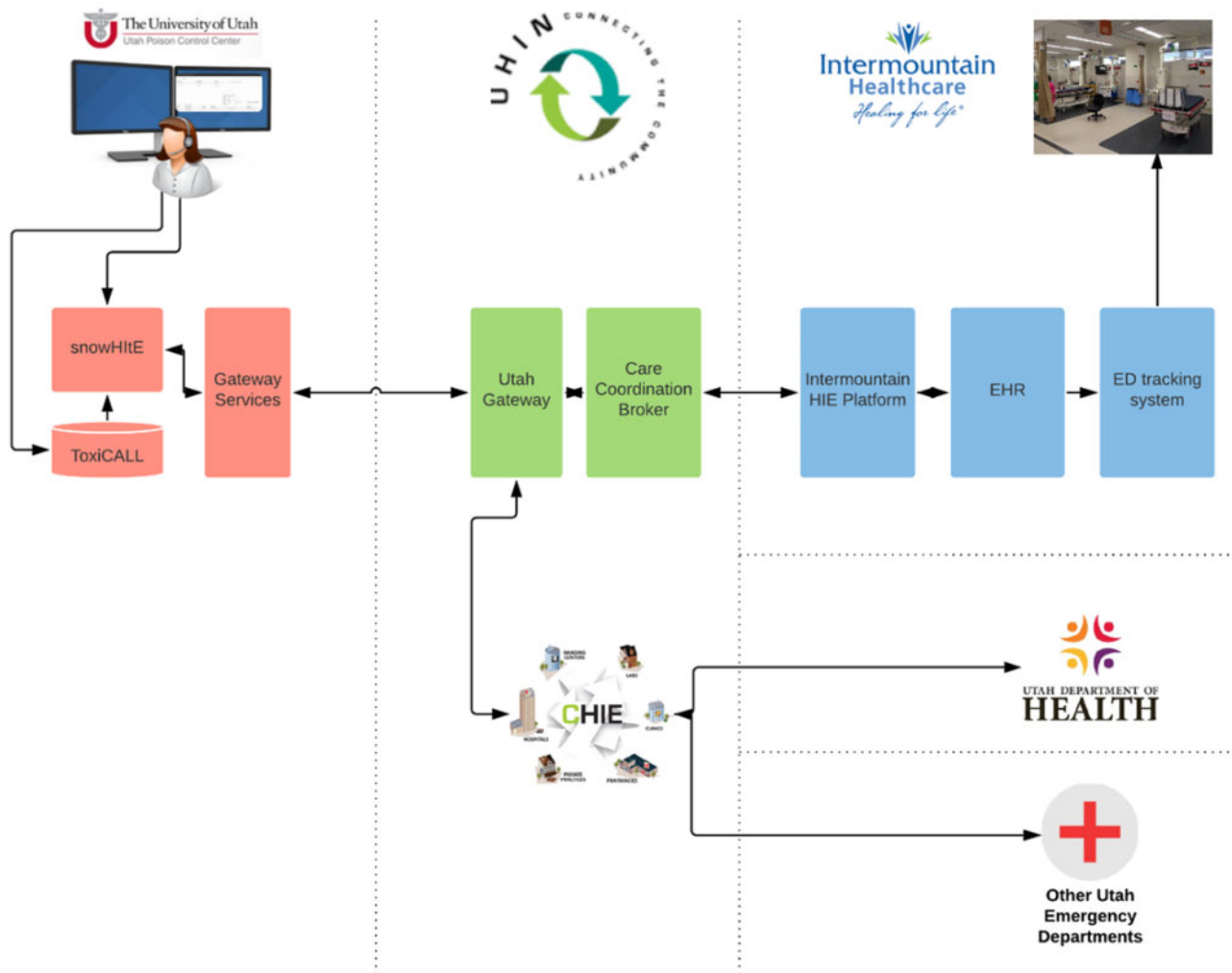
### UWIN

As indicated in Figure 2, Utah's state-wide HIE (UWIN) plays a central role in the poisoning HIE architecture. All information sent and received by Utah PCC is brokered by UWIN. All C-CDA documents are pushed using the Integrating the Healthcare Enterprise (IHE) cross-enterprise Document Reliable Interchange (XDR) profile through UWIN's Care Coordination broker, which routes the messages to the intended recipient(s).<sup>13</sup> C-CDA Consultation Notes are "pushed" from the Utah PCC to UWIN using the IHE XDR profile.

The screenshot displays the SNOWWHITE interface, which is used for managing C-CDA Consultation Notes. The interface is divided into several sections:

- Top Section:** A header bar with the SNOWWHITE logo and navigation options like Home and Refresh Cases.
- Left Panel:** A sidebar with options for "Sort, search, and display INBOUND C-CDA" and "Sort, search, and select active poison control center cases."
- Main Content Area:** A table displaying a list of C-CDA Consultation Notes. The table has columns for Case #, Datetime, Pat. First, Pat. Last, Facility, and Message Type. Below this table is a section for "Open Cases" with columns for Case #, SPI Assigned, Start Date/Time, Pat. First, Pat. Last, Substance, Pat. Age, Age Units, and Pat. Gender.
- Right Panel:** A preview window titled "Preview Consultation Note" showing a sample of a consultation note with various fields and text.
- Annotations:** Several green callout boxes provide instructions: "View, sort, and display SENT C-CDA Consultation Notes." (pointing to the top right), "Refresh to display current documents, cases." (pointing to the Refresh Cases button), and "Preview and send C-CDA Consultation Note" (pointing to the preview window).

Figure 1. SNOWWHITE interface.



**Figure 2.** Poisoning health information exchange architecture.

HL7 C-CDA documents are pushed from EDs to Utah PCC via UHIN (also using the IHE XDR profile).

#### Intermountain Healthcare

With Intermountain Healthcare, a large health care organization with well-developed IT systems and HIE capabilities, we are pursuing a more workflow-integrated approach. We route the messages with C-CDA consultation notes to specific EDs within Intermountain's 23-hospital system, and, upon receipt, the messages automatically display in Intermountain's ED tracking system, which is part of Intermountain's EHR. In addition, Intermountain has implemented automated triggers within for pushing HL7 C-CDA referral requests, progress reports, and discharge summaries to the Utah PCC via UHIN upon ED admission for poisoning, release of new patient data, and ED discharge, respectively.

#### Community emergency departments and health care providers

To better support communication and information sharing during poison exposure emergencies, the Utah PCC is routing consultation notes to UHIN for storage in the Community Health Information Exchange (CHIE), where health care providers can log in and view the information in a Web portal. In addition, UHIN is capable of

routing the consultation notes to an intended hospital using both the IHE XDR profile and DIRECT, a simpler information exchange protocol based on secure e-mail that is required for EHR certification in the US and has been widely adopted by EHR vendors, including those focused on the small clinical and hospital market.<sup>14,15</sup>

#### Utah Department of Health

We route consultation notes to the Utah Department of Health for surveillance purposes, primarily to support surveillance and reporting related to environmental health exposures.

#### Poison control center HIE messages

##### Outgoing messages

Currently, the Utah PCC is sending HL7 C-CDA consultation notes for all poison exposure cases managed in EDs with consultation and collaboration by the PCC.

##### Incoming messages

Intermountain Healthcare is sending HL7 C-CDA referral request, progress report, and discharge summary documents for ED patients as we prepare to implement a bidirectional HIE process at those sites. The documents are sent automatically according to a set of

EHR triggers as recommended by poison control experts, including abnormal toxicology lab results for referral requests, clinical data updates for progress reports, and hospital discharge events for discharge summaries. Additionally, we are testing a PCC consult order that ED care providers can easily access within the ED tracking system. This order triggers the sending of a referral request from Intermountain to the PCC and provides notification when a PCC consultation note is received in response. These approaches integrate the HIE process with ED workflow and present information within the normal ED workflow without requiring time-consuming logins to separate systems. However, they depend upon additional steps of patient identity matching and required modification by Intermountain Healthcare.

### Implementation

Following software testing, end-to-end transmission testing and formative software usability testing, we implemented workflow modifications and SNOWWHITE 1.0 at the Utah Poison Control Center. During January and February 2017, we conducted group and individual user training on the SNOWWHITE software and subsequently initiated live HIE with 2 super-users. These super-users sent C-CDA consultation notes using SNOWWHITE 1.0 for every poison center case referred to an ED or initiated by an ED. We worked closely with the super-users to identify issues and opportunities for improving SNOWWHITE 1.0. The development team reviewed issues and requests from the super-users and planned development efforts for a subsequent version, SNOWWHITE 1.1, with several usability improvements. In order to maximize user acceptance of the software, we delayed center-wide implementation of SNOWWHITE until the release of version 1.1. We implemented SNOWWHITE v1.1 center-wide on March 29, 2017.

### RESULTS

We successfully implemented the process and software at the Utah PCC and began sending outbound C-CDAs from the Utah PCC on February 15, 2017. On March 29, 2017, the Utah PCC began sending outgoing C-CDA consultation notes during routine operations for all cases referred to or referred by an ED. The Utah PCC began receiving inbound C-CDAs from Intermountain Healthcare on October 30, 2018. Between February 17, 2015 and September 17, 2019, the Utah PCC transmitted 4549 outbound C-CDAs. Between October 30, 2018 and September 17, 2019, the Utah PCC received 922 075 inbound C-CDAs.

### DISCUSSION

Health information exchange is an important disruptive technology with potential to advance the process and reliability of collaboration between PCCs and health care providers, replacing telephone calls placed only for routine information requests or notifications and improving the availability of patient information across all team members at the point of decision-making. HIE could also be used to strengthen the resilience of PCC operations during disaster scenarios, when synchronous telephone communication between overloaded ED and PCC personnel is difficult or impossible. Moreover, the ability to definitively link PCC case data with other health care data could greatly enhance our ability to surveil and study poison exposures and their treatment consistent with a learning health system and enable greater understanding of poisoning morbidity

attributable to prescription drugs, including opioids and individual exposures.

With the creation of SNOWWHITE and initiation of an HIE process for sending outgoing C-CDA consultation notes from the Utah PCC, we have built a system that represents the first participation of a PCC in standards-based HIE in the US. This milestone is an important first step in ensuring that important and timely PCC information and management guidance for poisoning cases is available for decision-making at the point of care in cases of acute poisoning. We route the poison control messages to multiple recipients and for different purposes, including individual patient care during poisoning emergencies and environmental exposure monitoring. The proposed architecture is based on a set of HIE standards that are required for EHR certification in the US, such as HL7 C-CDA, XDR, and DIRECT. Our ultimate goal is bidirectional HIE with *all* Utah EDs. In ongoing collaboration with Intermountain Healthcare, we are working toward live implementation of ED workflow integration that will enable bidirectional, real-time HIE during poison exposure emergencies. This bidirectional HIE process is currently at the pre-implementation, testing stage. The HIE architecture and system is in place and tested, but we have not yet implemented the new process in live patient care operations. While the technical aspects of poison control participation in HIE have been accomplished, further work remains to advance the processes by which the information is shared and used in the context of poisoning emergencies and other use cases. In moving to HIE-supported collaboration between PCCs and EDs, we are implementing a novel case for health information exchange that attempts to integrate external documents into an internal workflow. Given this circumstance, we must take extra care to ensure the process will be durable in the larger EHR environment. Additionally, the ED side integration requires further ED user testing and technical refinement prior to operational use.

We faced several challenges in the implementation of poison control HIE that are also likely to be present at PCCs in other states. In particular, PCCs pose a logical but especially challenging use case for HIE because they typically do not collect a robust set of patient identifiers.<sup>16,17</sup> For example, UHIN has the capability to push HL7 C-CDAs forward to the Utah PCC for all state-wide ED patient encounters that match to PCC consultation notes. We worked together to develop this process, but it has not been implemented because it is dependent upon definitive patient identity matching. We vastly improved patient identity matching for poison control cases through poison control process changes to support this action and the enhancement of HIE with contextual information describing an adjacent ED encounter. As an interim solution, UHIN is working to develop the capacity to review and establish definitive matches in the case of multiple possible matches. In order to fully implement patient identity matching as an automated process, we must identify a sustainable and definitive patient identity matching solution for the poison control use case. In the case of ED-PCC exchange in the context of poisoning emergencies, an ED staff member such as a clerk may feasibly verify matches given the overall volume of these cases and existing workflow.

Additionally, we sought to accomplish HIE, a process inherently tied to individuals and their unique identities, using case-based poison control data collected using a proprietary information system. Without the ability to directly modify the proprietary poisoning information system, it was necessary for us to design and build software that would allow the PCC to create, send, receive, and view HIE documents while preserving the poisoning information system as the single source of truth for documentation of poisoning cases.



While the need for software development was both time- and resource-consuming, it resulted in software that could be adapted for use by most US PCCs. Moreover, we demonstrated the use of a common set of standards-based data, collected in a case-based poisoning information system to support HIE for both individual patient care and public health. However, the use of a separate system for HIE is not optimal for PCC workflow, and, ideally, the information systems used by PCCs would integrate HIE functionality.

Persistent questions relate to the optimal use of PCC engagement in HIE. For example, as a result of collaborative process planning mentioned previously, we implemented ED side triggering strategies that automatically sent documents to the Utah PCC using rules based upon multiple criteria that included time intervals, lab results, and the availability of a discharge summary. However, the sheer volume of incoming documents was viewed as unmanageable by PCC specialists, and we had to request that the triggers be modified substantially to support a manageable volume for both the PCC specialists and the SNOWHITE platform. Certainly, the PCC cannot directly configure and control the volume and nature of the documents it receives because ED-generated documents depend upon configuration actions within the hospital EHR system. However, we adapted our platform to support improved document management, including changes in the way we both display and store documents. These aspects of document management and display will require additional refinement prior to any large-scale integration into clinical processes.

The PCC also cannot directly control the information content of the documents it receives. The HL7 C-CDA standard requires fields, but those fields may or may not be populated, and the value of the information content within those fields may vary. As we advance the use of this architecture, we must continue to assess and optimize the value of the information contained within the documents—documents generated by both PCCs and EDs—and refine our approach so that high-value information is delivered to clinicians at the right point in the workflow and in an appropriate format consistent with generally accepted principles of clinical decision support.<sup>18</sup>

## CONCLUSION

As a multi-disciplinary, multi-organizational team, we successfully developed both a process and the informatics tools necessary to enable PCC participation in standards-based HIE and implemented the process at the Utah PCC in 2017. In order to accomplish PCC participation in standards-based HIE, we 1) adapted the HL7 C-CDA consultation note standard for the poison control use case and created mappings from a PCC information system to the C-CDA consultation note, 2) designed a process and workflow modifications, and 3) developed an HIE dashboard that facilitates poison center HIE. In ongoing work, we are progressing toward implementation of bidirectional workflow-integrated HIE using SNOWHITE.

To support any transition in care among providers, patient information must *move* with the patient. Currently, poisoned patients transition among care providers and care settings, but the patients' data usually remain isolated within institutions. By developing short-term and long-term processes for exchanging poisoning-related information, we make poisoning-related information move in support of patient care. By moving data with the patient to support care transitions and ongoing collaborative care, we shift the focus of information management from provider to patient. However, if the data moves but are not easily accessed or well-integrated into the workflow, they cannot inform decision-making. For information

to *matter*, it must also be readily available to inform decision-making at the point of care. The data needs to be accurate, complete, and relevant to the decision at hand. Data access and use must integrate well with the workflow of ED and PCC care providers. By addressing information availability and workflow integration, we can ensure that exchanged data also *matters*. This shift from unshared, provider-centric data to patient-centered information exchange is critically important for the management of poison exposures, but relevant to *all* provider-to-provider care transitions and collaborations.

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## AUTHOR CONTRIBUTIONS

All authors were involved in the conception, design, or implementation of the described project. All authors contributed to drafting or critically reviewing the content of the manuscript.

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## CONFLICT OF INTEREST STATEMENT

None declared.

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