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Utilizing Standard Data Transactions and Public-Private Partnerships to Support Healthy Weight Within the Community

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ABSTRACT

Context: Obesity is a significant health issue in the United States that both clinical and public health systems struggle to address. Electronic health record data could help support multi-sectoral interventions to address obesity. Standards have been identified and created to support the electronic exchange of weight-related data across many stakeholder groups.

Case Description: The Centers for Disease Control and Prevention initiated a public-private partnership including government, industry, and academic technology partners to develop workflow scenarios and supporting systems to exchange weight-related data through standard transactions. This partnership tested the transmission of data using this newly-defined Healthy Weight (HW) profile at multiple health data interoperability demonstration events.

Findings: Five transaction types were tested by 12 partners who demonstrated how the standards and related systems support end-to-end workflows around managing weight-related issues in the community. The standard transactions were successfully tested at two Integrating the Healthcare Enterprise (IHE) Connectathon events through 86 validated tests encompassing 38 multi-partner transactions.

Discussion: We have successfully demonstrated the transactions defined in the HW profile with a public-private partnership. These tested IT products and HW standards could be used to support a continuum of care around health related issues encompassing both health care and public health functions.

Conclusion: The use of the HW profile, including a set of transactions and identified standards to implement those transactions, in IT products is a helpful first step in leveraging health information technology to address weight-related issues in the United States. Future work is needed to expand the use of these standards and to assess their use in real world settings.

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Introduction

Obesity is a significant problem in the United States. The prevalence of obesity, defined for adults as having a body mass index (BMI) greater than 30 kg/m2 , has increased for the past three decades; almost a third of American adults are estimated to be obese.[1] Research finds that obesity increases the risk of developing numerous medical conditions from diabetes to ischemic heart disease,[2] and that behavioral interventions, including changes to diet and exercise routines, can help with weight loss and maintenance.[3] The U.S. Preventive Services Task Force notes that intensive interventions for obesity may be impractical to implement fully within primary care settings, suggesting that it may be necessary to refer to community-based programs for such services.[4] Research has indicated that interventions delivered in the community may be effective in preventing and managing obesity.[5,6]

Health care providers and public health practitioners face significant barriers in addressing overweight and obesity issues in people and populations. Surveys of health care providers' attitudes around obesity have found that many providers either don't have access to or are unaware of external resources that could help with weight management.[7–9] Public health entities struggle to track the distribution of obesity in their communities. A 2016 survey indicates that, while a majority of local health departments provide prevention services for nutrition, physical activity, and chronic diseases, less than half of local health departments in the US conduct any form of chronic disease or behavioral risk factor surveillance.[10] Fostering linkages between the health care system and outside entities could support community- based delivery of services and inform population-level interventions. Developments in health information technology (HIT) can facilitate integrated, cross-sector collaborations to coordinate care between health care and community-based resources through the sharing of risk factor and chronic disease information. Recent legislation has encouraged the 'meaningful use' of electronic health records (EHRs) and the exchange of clinical information, such as laboratory and syndromic surveillance data, between health care organizations and public health entities.[11] Detailed clinical data from EHRs has the potential to greatly enhance the ability of public health entities to monitor and respond to threats to the public's health.[12–15] If provided by clinicians nationally, data from EHRs could provide important information to support surveillance programs since clinician-measured biometric and disease data tend to be more accurate than self-report data,[16] clinical data can provide longitudinal patient-level information that is more granular than information collected by national surveys such as the National Health and Nutrition Examination Survey,[17] and there is the potential to collect information from a larger, more representative sample population. EHR data can also provide location and time data along with clinical data, which are all necessary to create a population health record that supports public health practice through the continual collection of information on the health of a defined population.[18] While current EHR-based surveillance efforts have focused on communicable diseases, EHR data are currently being used in some states and regions to conduct surveillance, create disease registries, and inform research on metabolic disease.[16,19–25] Experts have also suggested that population-level data could help clinicians better understand the needs and health risks of the communities they serve and better gauge the effectiveness of their work,[27] and ultimately serve an important role in the development of a national "learning health system" where health data are routinely aggregated across many sources for analysis and further use, such as benchmarking the health of a population.[28]

Further work is needed to explore ways to encourage the use of EHR data for chronic diseases such as weight-based conditions. A significant barrier to effectively using EHR data is the heterogeneity in how different EHRs collect and store information. In order for electronic systems to communicate, they must share syntactic "structure" and semantic "vocabulary" standards to understand the formatting and the content of the data being exchanged.[15] Since public health entities need to interact with a wide range of health care providers in the community, the standardization of terminologies and exchange formats could provide valuable support for efforts to use clinical data for surveillance purposes.[18,20] While weight-related concepts such as BMI are standard across multiple EHRs,[20] the representation of behavioral concepts such as diet and physical activity can differ greatly.[29] Stakeholders also need to agree upon the mechanisms that will be used to share information and define appropriate data sharing agreements.

To support the exchange of information related to health issues associated with being overweight or obese federal and international partners collaborated to create and gather a set of both syntactic standards, which are shared structures for formatting and transmitting data, and semantic standards, which are shared data definitions and meanings, to define message content and support the exchange of patient information between multiple stakeholders.[30,31] The result of this collaboration was the Health Weight (HW) profile published by international health data interoperability organization, Integrating the Healthcare Enterprise (IHE). IHE profiles are documents that collect existing data standards and define transactions and use cases to how organizations can use them to integrate health care systems. These profiles utilize semantic medical terminologies such as the Systematized Nomenclature of Medicine (SNOMED), which contains lists of medical terms such as diseases and procedures, and data exchange formats such as the clinical document architecture (CDA) format, which is an XML-based standard that defines the structural format for clinical documents. The HW profile facilitates the exchange of five categories of weight-related content that could be sourced from either EHRs or community service providers: height and weight and demographic assessments; obesity related behaviors; continuity of care information such as medication and intervention histories; the identification of weight-related resources; and patient health plans.[30] The HW Profile and the referenced standards are detailed in implementation guides provided by Health Level Seven (HL7) and IHE. The HL7 implementation guide[32] defines the standards for data transmission. An, HL7 message structured in the Observation Results Unsolicited (ORU) message format can be exchanged between systems to share information such as those related to a patient's weight status and treatment plans. The implementation guide also includes standardized codes that are used to define relevant clinical concepts such as conditions related to variances in weight and dietary behaviors, which are distributed through the Public Health Information Network Vocabulary Access and Distribution System.[33]

IHE defines a multi-step process to create and support the use of international data standards.[34] Two important steps of the IHE process are to engage industry partners such as EHR software vendors to integrate data standards into their products and to test the integration points with other vendors. In this paper we describe the HW Profile data transactions and testing process, data workflow scenarios between HIT systems, data sharing capabilities in multiple systems using the HW Profile, and data visualization. Details of the noted demonstrations and testing scenarios provided here

illustrate how the HW profile can help to support many different stakeholders who promote healthy weight within the community.

Case Description

Healthy Weight Transactions

The IHE Healthy Weight Profile implementation guide defines a standards-based framework for sharing weight-related health information across systems.[35] This profile outlines the technical specifications for five different types of transactions that can be used to transmit HW data between actors who play different defined roles in the exchange of data:

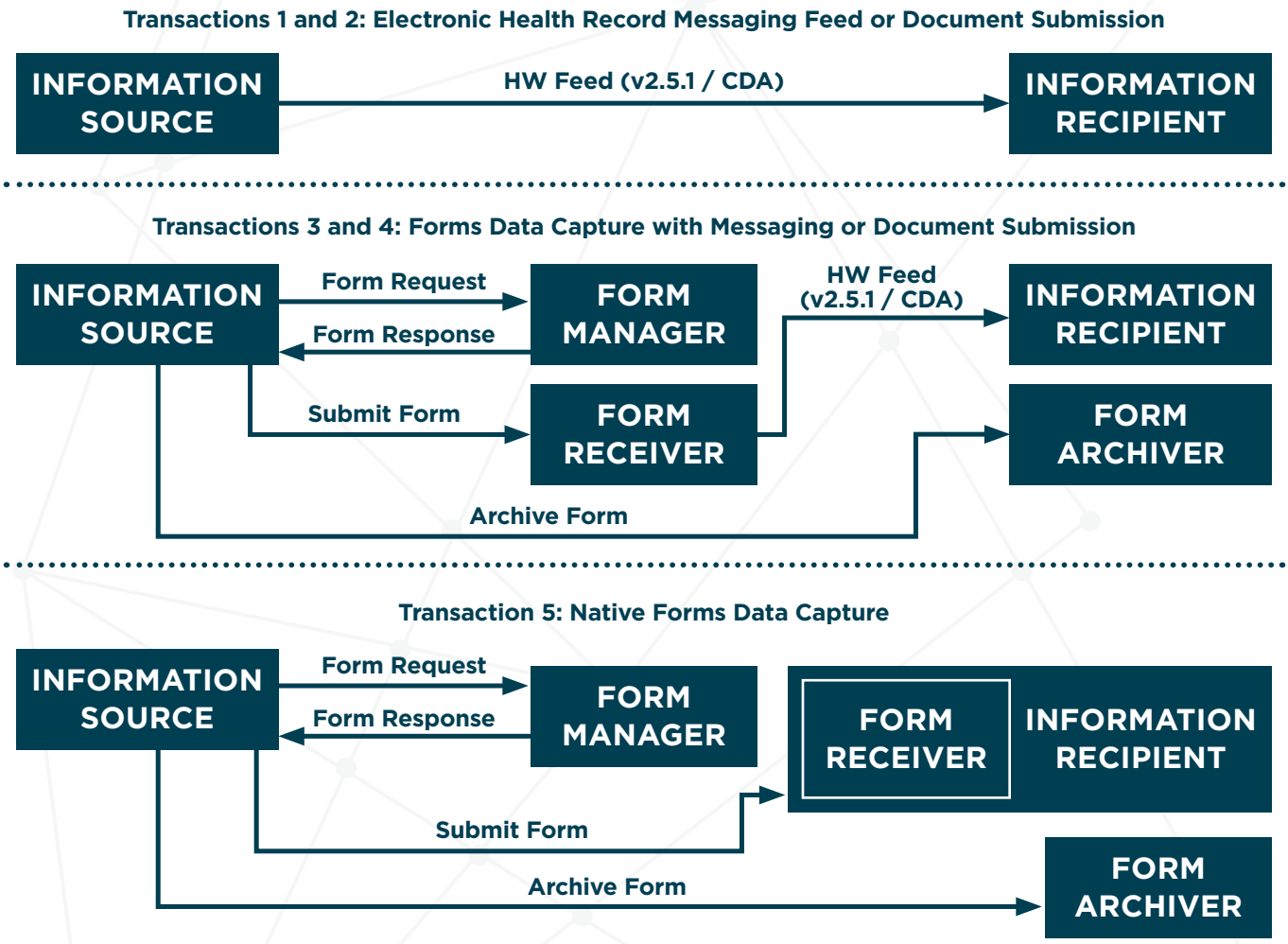
1. The direct transmission of an HL7 v2.5.1 message from an Information Source (e.g. EHR record from a clinician) to an Information Recipient (e.g. public health jurisdiction).
2. The direct transmission of a CDA document from an Information Source to an Information Recipient.
3. An Information Source requests a structured form from a separate Form Manager system using the IHE Retrieve Form for Data Capture (RFD) functionality. The form is rendered on the user's (the Form Filler) screen, filled out, and sent to separate Form Archiver and Form Receiver systems. The Form Receiver parses the form and generates an HL7 v2.5.1 message that is sent to the Information Recipient. The Form Archiver saves original copies of submitted forms to support data traceability.
4. Similar to transaction 3, an Information Source requests a structured form from a separate Form Manager. After the form is rendered, filled out, and sent, the Form Receiver parses the form to create a CDA document that is sent to the Information Recipient.
5. Similar to transaction 3, an Information Source requests a structured form from a Form Manager. After the form is rendered and filled out, it is sent directly to the Information Recipient whose system has an internal Form Receiver module that parses the form.

These transactions are depicted in Figure 1. The technical specifications include the use of both terminology and data exchange standards and are updated based on suggestions proposed by interested stakeholders and area experts.

Creating Demonstration Systems

In 2013 the CDC convened a public-private partnership including government, industry, and academic partners to create test systems that demonstrate the use of the HW profile to communicate between multiple stakeholders in the health care and public health fields. This partnership included 12 software solution venders and academic development teams who provide various types of software systems such as personal health records (PHR), EHR systems, RFD form managers, health information exchange (HIE) systems, and public health focused surveillance systems. This partnership collaborated in the creation of test systems and products that would communicate with each other. The goal was to demonstrate how the HL7 standards and IHE HW profile facilitate various end-to-end workflows that encompass data exchanges important both for clinical and public health tasks. The partnership defined workflows profiling health care-public health linkages, beginning when a patient initiates contact with the health care system, continuing through to when clinical HW data are received in a public health HW surveillance system, and concluding when information is aggregated for both public health and clinical purposes. These workflows encompass

Figure 1. IHE Healthy Weight Profile Data Transactions



tasks such as patient self-management, care plan creation, referral to community services, and the creation of population-based visualizations of HW data to support epidemiological analysis and service planning. The data exchange interactions defined in the IHE HW profile were tested at the 2014 and 2015 IHE Connectathon events, where software vendors and technology partners test the creation and consumption of data and connections with complementary systems to validate interoperability and adherence to IHE profiles. Specific data exchanges are tested with one or more integration partners and are judged for completeness based on pre-defined criteria by impartial monitors.

Findings

Transaction Testing

During the 2014 and 2015 IHE Connectathon events, members of the private-public partnership collectively completed and validated 86 separate tests related to the IHE profile and completed 38 data exchanges involving multiple partners. Testing also included the successful validation of HL7

v2.5.1 HW messages using the "Height and Weight Report" integration profile in the National Institute of Standards and Technology's message validation tool.[36] Table 1 lists the public-private partners who participated in demonstrating the HW profile and the number of successful tests they participated in based on the roles they played in the transactions defined in the profile. The following roles were tested:

1. Content Creator: Creates content that is sent in the HW profile
2. Content Consumer: Consumes content received through the HW profile
3. Form Filler: Retrieves and submits HW profile forms
4. Form Manager: Supplies HW profile forms on request with a unique identifier
5. Form Receiver: Receives HW profile forms and converts to HL7 messages or documents
6. Information Source (HL7): Sends standard HW HL7 messages and documents
7. Information Recipient (HL7): Receives standard HW HL7 messages and documents

Typically an IHE partner will fill a limited subset of roles in a profile and will test against a small number of partners, which is reflected in the sparse population of Table 1. All attempts at transacting HL7 V2.5.1 messages and generating appropriate CDA documents were successful. Further information on Connectathon participants and results across profiles and events can be found on IHE's Connectathon Results Browser.[37]

Workflow Demonstrations

Members of the private-public partnership that underwent the Connectathon transaction testing also created demonstration health care-public health linkage workflows that are supported by the HW profile at international conferences to demonstrate the use of the HW profile and spur development and uptake.[31] One linkage workflow scenario follows a pregnant woman who is tracking her weight and health through a PHR. The PHR communicates HW information to the EHR system used by the woman's primary care provider (PCP) using a direct HL7 message feed. Using RFD transactions, the EHR renders a HW form provided by a Form Manager at the PCP's request during a well visit. The woman's PCP fills out the form with their own height and weight measurements as well as information about the woman's goals and treatments, and a flag denoting that the patient is pregnant. This form is then sent to a Form Receiver managed by a third party technology vendor contracting with the PCP's office, which then parses the form and creates either HL7 v2.5.1 messages or CDA documents that are sent to a surveillance public health information system (PHIS) managed by the local health department. In another scenario, a child visits her pediatrician for an immunization. The provider records information related to the child's height and weight in their EHR, and a HW summary that includes weight-based as well as demographic information is sent to the HIE that serves the provider using direct HL7 v2.5.1 messages or CDA documents. The HIE then sends this weight-related information to a PHIS through direct messaging. A third scenario additionally provides information to a community-based obesity program to aid in the management of the patient's weight. This scenario starts at a well-child visit where the patient's pediatrician determines that the patient has an overweight BMI based on their height, weight, and age. The provider documents this weight-related information in the EHR and refers the patient to a community-based obesity program. Using direct HL7 v2.5.1 messaging or CDA documents, the patient's weight-related information is sent to the provider's HIE where a community health worker can look up the patient's information using an HIE-based patient portal system. The HIE then sends the

Table 1. Number of Successful HW Transaction Tests by Participant and Transaction Role During the 2014 and 2015 IHE Connectathon Events

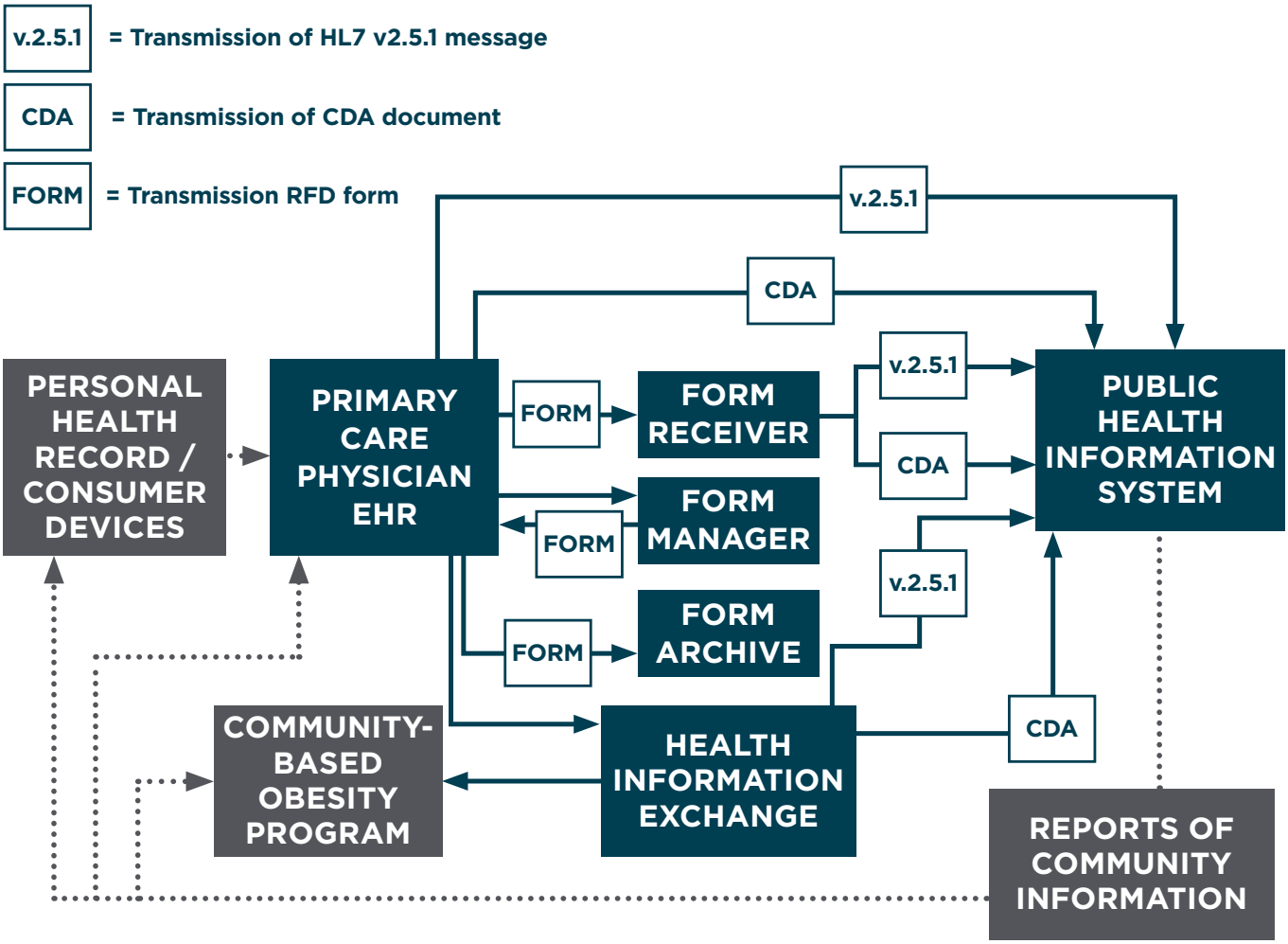
PARTICIPANTS	CONTENT CREATOR	CONTENT CONSUMER	FORM FILLER	FORM MANAGER	FORM RECEIVER	INFORMATION SOURCE (HL7)	INFORMATION RECIPIENT (HL7)
AEGIS.net				3	3		
CareEvolution Inc.		7				3	2
Epic	8		4				
Forcare B.V.		3					
GE Healthcare	3	1	2				
ITH icoserve			1				
Medical Informatics Engineering	1	1					
NoMore Clipboard	2	2					
OZ Systems				4	12		
Qvera			1				
Software Partners LLC	4	2				3	2
University of Washington		8					3

information to a HW surveillance system used by the local health department where it can be aggregated, de-identified, grouped by different factors such as demographics or location, analyzed, and sent back to stakeholders across the community to foster a learning health system that supports program planning and patient care. For example, community level data on weight trends over time and the use of weight loss interventions could help stakeholders chooses between different community-based programs based on relative efficacy. A composite chart of the actors involved in these demonstrations and the data flows is presented in Figure 2.

Healthy Weight Data for Data Visualization and Community Monitoring

In addition to demonstrating the use of the HW profile to exchange information for individual patient care, two HW partners demonstrated potential usages of community-level aggregates of HW data defined in the profile. Researchers and software developers at the University of Washington Clinical

Figure 2. Composite Workflow Encompassing Demonstration Scenarios



Note: Blue connections indicate tested IHE HW profile transactions. The gray connections indicate potential data informational exchanges to support a learning health system of care.

Informatics Research Group (CIRG) created and iteratively updated a test HW surveillance system.[38] The test system (which can be accessed at http://ihe2014.cirg.washington.edu/isds/index.html) aggregates all of the synthetic HW messages that were sent through the demonstration linkage workflows and combines them with synthetic data based on population distributions for Washington State. The synthetic data are modeled from height, weight, and other related data from the National Health Interview Survey (NHIS), and also distributions of weight by age, gender, exercise, and fruit and vegetable consumption taken from the Behavioral Risk Factor Surveillance System (BRFSS) overlaid on census tracts for King County, Washington. Synthetic data was generated based on a weighted resampling of the NHIS dataset based on synthetic trends within obesity categories. BMI data was simulated based on geographical population estimates for WA states regardless of the

actual distributions of reported risk factors. Physical activity levels were simulated to match marginal associations between BMI levels, and, and gender observed in the BRFSS data. These data are used for illustrative purposes only to show potential HW data distributions.

In order to support stakeholders engaged in addressing weight issues, the aggregated information is organized into simple visualizations to give stakeholders different views of their population of interest and environment. These visualizations are aimed at three different domains encompassing those who address weight-related issues in the community: public health, clinical, and individual.[39] For public health stakeholders, the visualizations include summary charts of BMI and health related behaviors stratified by demographic information, geographic maps of summary values by zip code, and community 'growth charts' of adolescent information. These maps are continually updated as new messages are received from various sources such as EHRs and PHRs. Such visualizations could help state and local health departments define populations that could benefit the most from weight-related community interventions. Provider-focused visualizations compare the provider's cohort of patients to patients throughout their county and state for comparison. Visualizations could potentially be used for educational purposes for both patients and providers, showing plots of an individual's BMI compared to health behaviors such as diet and exercise that are tracked over time, to better understand how their health behaviors affect their own weight. Example visualizations can be seen in Figure 3. The real-time analysis and dissemination of community-wide HW data could facilitate a better understanding of how weight-based interventions are related to health outcomes than data collected through existing survey methods.

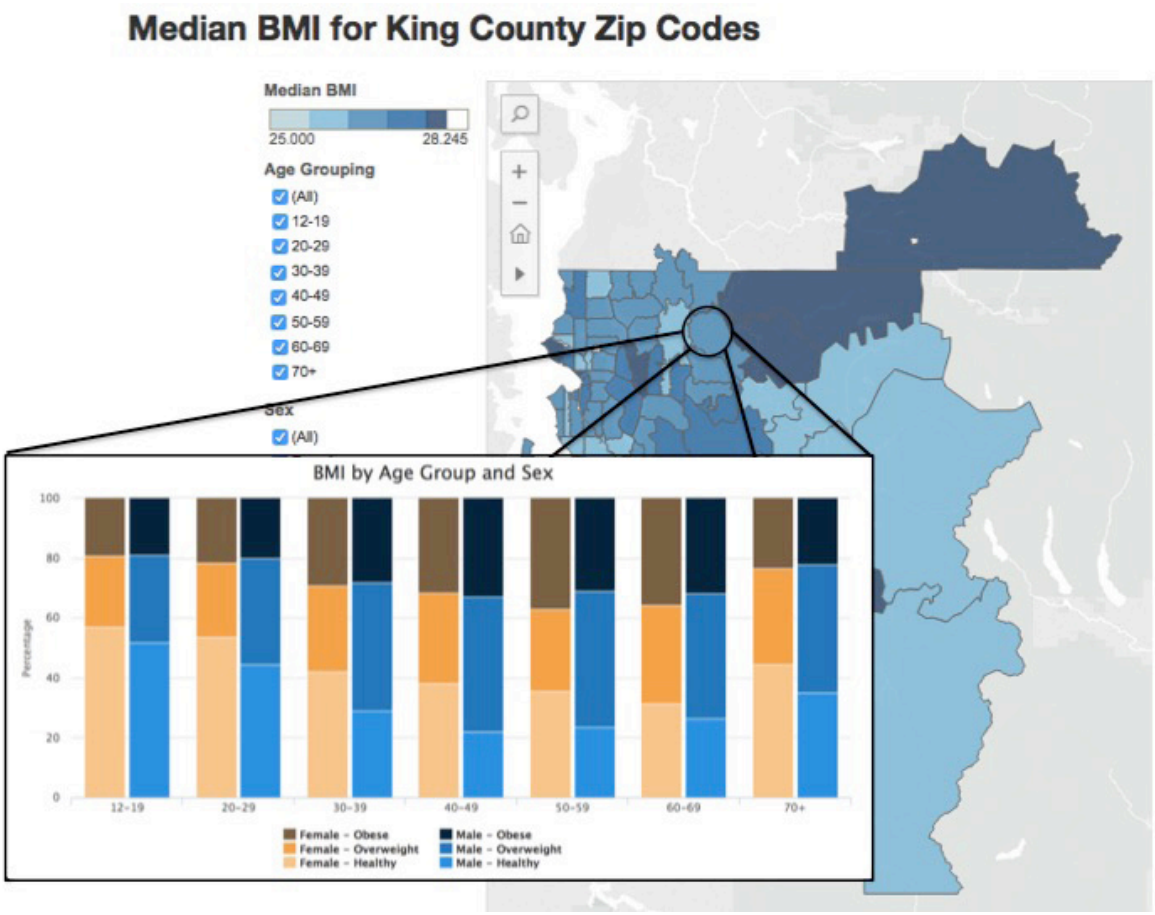
This test HW surveillance system consists of open source components, utilizing the Mirth Connect interface engine (www.mirth.com) and Java code to receive HW messages using both the HL7 v2.5.1 and CDA standards and store the data in a defined database schema. Perl scripts create JavaScript Object Notation (JSON) objects that are the basis for visualizations created in Tableau and Highcharts, which are displayed on a HW dashboard website. All of the test code is freely available in CIRG's GitHub repository (https://github.com/uwcirg/ihe-healthy-weight/).

Profile Updates

Throughout the demonstrations, stakeholders identified 42 issues and open questions, currently listed in the IHE HW profile specification[35] that, once addressed, could support better alignment between systems. These issues range from harmonizing the HW profile with other IHE profiles, the inclusion of new data such as social history, and the creation of standardized value set items to document health behaviors. As of August 2015, the IHE HW profile has undergone updates to address 19 of these issues to improve interoperability between systems. New Logical Observation Identifiers Names and Codes (LOINC) terminology has been documented for concepts important to the HW profile such as whether the patient has access to nutritious food, their readiness for behavior changes, and frequency terms for different types of TV and video game 'screen time.' Concepts such as these could provide additional insights to public health and clinical professionals on the factors that affect changes in weight for individual patients and communities of people.

Remaining identified issues are documented for future efforts to address. These remaining issues range from aligning this profile with other health

Figure 3. Demonstration Visualizations of Synthetic HW Data for King County, Washington



initiatives such as monitoring the intake of calcium-rich foods and the potential adding of school-related behaviors for children to better understand the nutrition and exercise factors that affect peoples' weight. The current profile also only addresses overweight conditions, so further work is needed to update these data standards so that they can adequately track and address underweight conditions as well. Future versions of the data exchange profile should aim to address the full range of weight-related health issues. The August 2015 IHE HW profile document lists both the addressed and the currently outstanding issues with the profile.[35]

Discussion

Through multiple demonstrations and testing sessions enacted by a public-private partnership, we have shown the feasibility of integrating the new HW profile into HIT products and systems to exchange information related to a patient's height, weight, and weight-related behaviors. We have also demonstrated how the standards can support workflows that link clinicians, patients, public health practitioners, and other community stakeholders to help monitor and manage weight-related issues on a personal and a community level. The HW profile provides unified terminologies and data exchange

formats that address a significant barrier to clinical data exchange and the subsequent use of clinical data for analysis and surveillance purposes. These standards could help to support multicomponent interventions to address obesity, and also help to support healthy weight in a learning health system. A recent survey found that less than half of health care providers had EHRs with the ability to create obesity care plans and few had capabilities to create electronic referrals for obesity-related issues.[40] The HW profile can aid health care organizations and HIT software companies to build these essential functions into their systems.

Workflow scenarios for future HW profile use present new options for gathering information, supporting clinic visits, and sharing that information to improve patient health, health care quality, and community health monitoring programs. These could include:

- An adolescent patient visits their primary care provider for a yearly checkup. The medical assistant takes measurements for height and weight, and documents weight-related conditions and behaviors in the EHR. The EHR automatically calculates BMI, plots the patient's BMI on a growth chart, and also manages the relevant height, weight, and age data needed for BMI percentile calculations and relevant patient demographics to support surveillance grouping by factors such as age and location. Information is sent to the surveillance program at the jurisdiction's public health department using the HW profile, and the department proactively monitors the community's weight status across age and location. Comparative analysis reports are provided back to the clinician to inform ongoing care quality improvement programs within their clinic.
- A clinic sets up an EHR interface to allow patients to track their physical activity using a kiosk or their own personal device. This patient-provided information is also securely sent to the local health department's surveillance system where population-level analyses are performed and results disseminated to many community stakeholders to help them determine where to target weight-related interventions. To help support the transmission of data, the local public health department establishes a healthy weight surveillance system to illuminate areas of need, which includes a Form Manager system that optimizes interoperability by sending up to date HW documents to EHRs across the community upon request. This can alleviate the burden of maintaining data collection tools within providers' EHRs, which in turn may encourage more providers to capture weight-based data. Analyzing anthropometric, demographic, and behavioral, and occupation data, the program identifies that some regions have significantly higher obesity rates, and particularly low physical activity rates. Research has suggested that workplace-based weight management programs could have a positive effect on weight for working adults.[41,42] In order to improve the health of the communities, the health education outreach coordinator contacts the largest employers in the region that employ the occupations with the highest obesity prevalence with a proposal to initiate a workplace-base program to support physical activity during the workday. Additionally, the coordinator contacts the schools with high rates of obesity, and they work together to increase physical activity throughout the day and support programs for open playground access during off-school hours.
- A clinician requests that a patient fills out a chronic disease risk behavior survey in advance of their regular visit through a PHR, which also collects information from personal devices such as step counts. During the visit, the provider captures the height and weight data and decides to refer the patient for nutrition counseling as a result of the high BMI. A guideline- based obesity care plan is

generated and transmitted along with their referral for nutrition counseling using the HW summary, which includes a record of the patient's HW goals. During these routine transactions, HL7 messages and documents are also sent to the local public health department's surveillance system. As part of the nutrition visit, the provider is able to recommend community resources relevant to the patient's home, school, workplace (e.g., locations of parks, farmers markets, wellness coaching), and update the plan with more specific nutrition goals. The patient uses their PHR to track their ongoing diet behaviors to inform the next clinician visit. The updated care plan and patient diet tracking is available to inform the next provider visit.

While the standards alleviate one barrier to addressing the rise of obesity in the United States, future projects are needed to assess how this clinical data exchange affects both clinical and public health practice in a real world setting. There are still significant barriers to effectively using clinical EHR data for purposes such as public health surveillance. It can be difficult to determine accurate denominators for calculating the prevalence of chronic diseases when using clinical data from primary care provider EHRs.[43] Some clinician-recorded information related to BMI, such as a patient's height, may not be accurately recorded in the EHR,[31] and the collection of social and behavioral health factors may impose added time and resource burdens on clinicians,[18] One survey of primary care physicians around the management of obesity found that few even documented changes in physical activity and dietary behaviors for their overweight and obese patients.[44] Collecting information from many sources in the community, such as patients, clinicians, and community programs also could lead to potential conflicts in entered data that would need to be reconciled. Further work is also needed to explore the resources that are needed by many different stakeholders, including clinicians, public health departments, and community groups, to establish and maintain HW data transactions and associated surveillance systems. The current work was supported by seed grants and leveraged existing resources and expertise. While the resultant methods are available for free to the public, the cost to implement them will vary depending on different organizations' existing infrastructures and resources. While there are potential issues that will have to be addressed to improve the accuracy of exchanged data and determine the best methods for using weight-based information to track weight-related issues in a community, the HW profile can be used to support pilot projects that address the problem of obesity and more easily measure program effectiveness on a population level. The test systems and demonstrations detailed above provide templates and structures that communities can utilize to implement their own comprehensive systems to address weight-related issues.

Conclusion

In this paper we have described a public-private partnership to demonstrate international HW interoperability standards to support weight-based interventions within the community. These demonstrations facilitate working weight-based data exchange into the national HIT infrastructure. As work is still ongoing to improve data transactions, an important next step is the use of these standards in larger scale real world projects. Further implementations will help the clinical and technical experts involved with HW profile creation assess the importance of different data elements and formats, thus strengthening the standards for use in future projects.

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