Analyzing the Public Benefit Attributable to Interoperable Health Information Exchange

DRAFT FINAL REPORT

Fredric Blavin, Christal Ramos, Nicole Cafarella Lallemand, and Jacob Fass
URBAN INSTITUTE

Gary Ozanich
HEALTHTECH SOLUTIONS

Julia Adler-Milstein
UCSF

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Executive Summary

With robust interconnected electronic systems, important pieces of a patient's health record can be electronically accessed and reconciled during planned and unplanned care transitions, potentially reducing duplicative care and costs and supporting improved outcomes. This project aims to develop a set of measures and methods that can be used to *quantify the public benefits*—a broad set of clinical, economic, and population health outcomes—resulting from interoperable exchange of health information (IEHI) and to inform policy efforts aimed at improving care delivery in an evidence-based manner. The first phase of this study addressed an interrelated set of research questions, including the following:

1. Are providers engaging in IEHI to improve patient care?
2. In what ways does the structure of the current market for IEHI facilitate or impede IEHI?
3. What is the state of current knowledge about the costs of building and maintaining an interoperable health care system?
4. What are potential data sources and methods for quantifying the benefits of IEHI? Can methods and measures be developed that will further the empirical evidence on whether IEHI improves public benefits?
5. What are the major areas where there is empirical evidence that IEHI results in public benefits?

To answer these questions, we conducted a review of peer-reviewed and gray literature published from 2009 to 2016, held two rounds of phone conversations with IEHI subject matter experts (SMEs), developed a concept paper based on the literature review and first round of SME discussions, and facilitated two technical expert panel (TEP) meetings.

Major findings from the first phase of the study include the following:

- Actual use of IEHI is often not measured in existing literature, and where it is measured, use appears to be low.

- Inadequate business case, misaligned incentives in payment models, and technical challenges may be contributing to low use of IEHI.

- The start-up costs and short-term efficiency losses related to the implementation of new technology (such as EHRs) suggest IEHI may need to be in place for a long time before benefits may be realized.

- The literature about IEHI is still largely descriptive, focused on quantifying the extent to which IEHI infrastructure is in place.

- A small subset of studies focus on the relationship between IEHI and public benefit outcomes. Such studies often have limited ability to make causal inferences because they lack a baseline, comparison group, or information on whether IEHI is actually being used.

- Although existing studies provide suggestive evidence that IEHI is associated with some reductions in unnecessary utilization and associated costs, expert interviews suggest that the literature has yet to document the broader range of IEHI benefits.

Consistent with the literature review and first round of expert discussions, participants in the project's first TEP meeting emphasized significant data and methodological barriers that make it challenging to assess the causal link between IEHI and outcomes. Many confounding factors can complicate the assessment of a causal relationship between the presence of exchange and public benefit outcomes. Additional barriers include the lack of baseline data and the lack of valid comparison groups. Data sources also lack sufficient detail for understanding IEHI use. Without information on whether IEHI is being used, the opportunities for public benefit outcomes are unclear. Thus, measures of interoperability and public benefit ought to be developed in parallel.

In the second phase of this study, we propose to advance the evidence base by focusing on specific IEHI use cases. A use case approach offers the ability to describe and assess a plausible causal pathway that begins with IEHI infrastructure availability, advances to IEHI use, and ultimately leads to an impact on public benefit outcomes. That is, advancing measurement that assesses public benefit from IEHI will be most usefully pursued in the context of use cases and specific measures, rather than general ones. We therefore employ a use case approach to identify measures that may be used to study targeted linkages between the process of IEHI use and intermediate outcomes expected as a direct result of those processes, such as improved clinical workflow for providers. From a broad list of use cases, we selected three use case examples to identify measures in areas where IEHI may result in public benefits, based upon the literature review and interviews with SMEs. The three use cases selected were (1) alert, discharge, and transfer (ADT) event notifications to reduce unnecessary health care utilization through improved communication between providers and patients; (2) medication reconciliation to reduce adverse drug events during care transitions through reduced medication discrepancies; and (3) closing the referral loop to improve safety and efficiency through better care coordination between primary care and specialist providers.

The use case approach to identifying measures can help fill gaps in assessing progress related to interoperability. In addition, researchers can use these measures to expand the literature and demonstrate public benefit while avoiding our identified methodological challenges. Primarily, we aim to address the lack of data to support the IEHI use measures that enable robust evaluation of the impacts of IEHI, and to gather such data from study settings where valid results can be obtained (e.g., where IEHI technology is sufficiently mature and where the technology is actually being used). The use case approach also considers the evolving nature of the technology and how to better quantify the process and intermediate outcomes that are part of the causal link between IEHI and public benefits.

The use case approach is also a useful vehicle to collect and present information that can help address market barriers to IEHI. Use cases have historically been developed by health information exchanges (HIEs) to describe the value proposition of their services in attempts to justify fees. By focusing on specific uses of IEHI and the potential benefits, this approach may help build evidence to support the business case for IEHI.

However, we do not mean to suggest that there is no value in other approaches to IEHI benefits assessment, as each has its own pros and cons. The use case approach opts for more granular, logically related measures and robust study designs on a smaller scale over less accurate and less related measures at a higher level. A variety of approaches may contribute to the complete story of how IEHI is influencing public benefits.

Potential next steps would use the template in this report to develop a broader library of use cases that can be prioritized for further development of measures. Ultimately, such measures could be deployed in real-world settings to report on progress related to interoperability at the local, regional, state and/or national level. In parallel, another next step would test the application of use cases and associated measures in real-world settings that have implemented the specific IEHI functionalities in the examples described in this report. This would allow the measures to be tested and refined, as well as generate new evidence on IEHI benefits. ASPE and the Office of the National Coordinator for Health Information Technology (ONC) may also consider applying the use case approach to study the results of future IEHI efforts.

Analyzing the Public Benefit Attributable to Interoperable Health Information Exchange

Introduction

A core purpose of IEHI, defined as the exchange of information between electronic systems without special effort on the part of the user, is to make all relevant patient data available to the clinical care team at the point of care, regardless of where that information was generated. With robust interconnected electronic systems, important pieces of a patient's health record can be electronically accessed and reconciled during planned and unplanned care transitions, potentially reducing duplicative care and costs and supporting improved outcomes.[1] This project aims to develop a set of measures and methods that can be used to *quantify the public benefits*—a broad set of clinical, economic, and population health outcomes—resulting from IEHI and to inform policy efforts aimed at improving care delivery in an evidence-based manner.

This study complements an ongoing effort led by the National Quality Forum (NQF) to develop a measurement framework for addressing the current gaps in the measurement of interoperability.[2] The first phase of this study addressed an interrelated set of research questions, including the following:

1. Are providers engaging in IEHI to improve patient care?
2. In what ways does the structure of the current market for IEHI facilitate or impede IEHI?
3. What is the state of current knowledge about the costs of building and maintaining an interoperable health care system?
4. What are potential data sources and methods for quantifying the benefits of IEHI? Can methods and measures be developed that will further the empirical evidence on whether IEHI improves public benefits?
5. What are the major areas where there is empirical evidence that IEHI results in public benefits?

Based on our findings, the second phase of this study identified measures and methods that may be developed to further the empirical evidence on whether IEHI improves the public benefit.
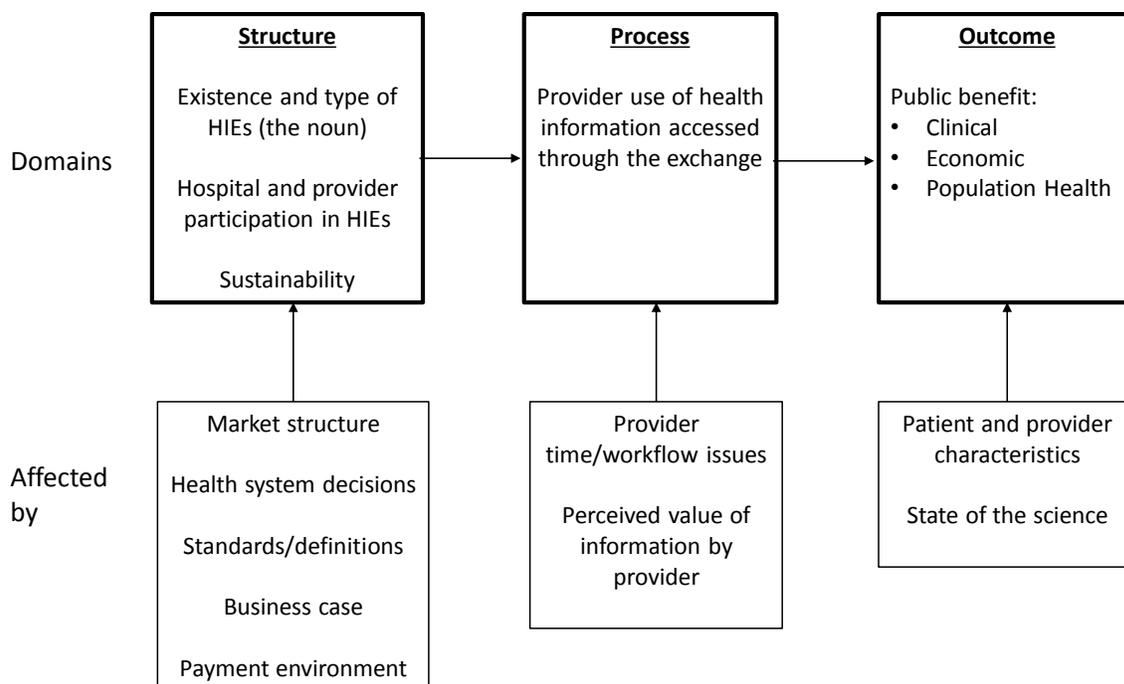
Methods

To answer these questions, we conducted a review of peer-reviewed and gray literature published from 2009 to 2016, held two rounds of phone conversations with IEHI subject matter experts (9 interviews in round 1 and 19 interviews in round 2), developed a concept paper based on the literature review and first round of SME discussions, and facilitated technical expert panel meetings in February and July 2017. We used the concept paper to solicit feedback during the first TEP meeting on which areas to prioritize for the development of measures and methods and to provide a foundation for the recommendations included in this final report. We conducted a second round of SME discussions to further develop recommendations on how to quantify the public benefits of IEHI in the areas prioritized by the TEP. The appendix includes the list of TEP members and SMEs that participated in this study.

Based on recommendations from the first TEP meeting, we developed a use case approach to link the public benefits that result from specific IEHI functionalities. To facilitate this approach, we developed a template that includes a series of measures linking an IEHI use case to public benefits, and we populated the template with three examples of IEHI functionalities. Findings from the literature review and the second round of SME discussions informed the development of each use case topic. We also used the second round of SME discussions and second TEP meeting to improve the case study template and examples. Based on recommendations from the second TEP meeting, we expanded our list of potential use cases and sub–use cases. The template can be applied to the broader list of use cases to further develop measures. These measures can be implemented by researchers and practitioners to evaluate the impact of various IEHI functionalities, and used by policymakers to assess progress related to interoperability.

Framework

In this report, we conceptualize the mechanism through which public benefits associated with IEHI may occur using Donabedian's framework for measuring quality, with structure, process, and outcomes as the domains (Exhibit 1).[3] In the IEHI context, this framework assumes that certain IEHI and market infrastructures (structure) can lead to the actual exchange and increased use of electronic health information (process), which affects desired outcomes. This framework may be useful in identifying areas where the development of measures may help quantify the public benefit of IEHI, as well as specific barriers to IEHI infrastructure development and use that may demand a stronger evidence base. We used this framework to analyze the literature and frame our phone conversations with experts.

Exhibit 1: Proposed Framework

Domains	**Structure** Existence and type of HIEs (the noun) Hospital and provider participation in HIEs Sustainability	**Process** Provider use of health information accessed through the exchange	**Outcome** Public benefit: • Clinical • Economic • Population Health
Affected by	Market structure Health system decisions Standards/definitions Business case Payment environment	Provider time/workflow issues Perceived value of information by provider	Patient and provider characteristics State of the science

Outcomes used to quantify benefits may include a broad set of clinical, economic, and population health outcomes, expanding upon measures analyzed in earlier literature reviews (Exhibit 2).

Exhibit 2: Outcomes That May Be Influenced by IEHI

Category	Specific Examples
Clinical	
Utilization	Hospital admissions, hospital readmissions, number of imaging tests, repeat imaging tests, number of lab/diagnostic tests, repeat lab/diagnostic tests, number of ED visits, repeat ED visits, length of stay, outpatient visits
Quality of Care	Drug reconciliation and adherence, hemoglobin A1c levels, patient satisfaction
Care Coordination	Communication between different providers, consultation, referral ordering
Economic	
Costs	Visit costs, annual financial savings, costs of lab tests, costs of radiology tests
Population	
Public Health	Completeness of public health reporting, follow-up care for HIV patients
Disease Surveillance.	Automatic reporting of diseases requiring public health notification

Source: Information derived from Rahurkar et al. (2015) and Hersh et al. (2015).[4]

Findings

In this section, we first summarize findings from the literature review, the initial round of SME interviews, and the February TEP meeting on the existing measures and methods that can be used to measure IEHI (and its barriers) and quantify the public benefits resulting from IEHI. Overall, this phase of the project highlighted the challenges of proving the causal link between IEHI and public benefits. This is because in many places where IEHI infrastructure was present, actual use was low. Thus, studies focused on examples where IEHI infrastructure exists may find it has not resulted in the expected benefits, if actual IEHI use is low or the exchanged information lacks value and is not effectively used.

Next, given the state of the evidence, we identify a use case path to more robust IEHI benefits assessment. In the context of use cases, future studies can focus on examples where IEHI infrastructure is actually being used to better understand its benefits. We therefore employed a use case approach to study targeted linkages between process measures that capture IEHI use and intermediate outcomes expected as a direct result of those processes. We developed a broad list of use cases and selected three examples to identify measures in areas where IEHI may result in public benefits, based on the literature review and interviews with SMEs: (1) using alert, discharge, and transfer (ADT) event notifications to reduce unnecessary health care utilization through improved communication between providers and patients; (2) using medication reconciliation to reduce adverse drug events during care transitions through reduced medication discrepancies; and (3) closing the referral loop to improve safety and efficiency through better care coordination between primary care and specialist providers.

Are Providers Engaging in IEHI to Improve Patient Care?

Most studies in the literature review measured whether providers engaged in any electronic exchange of health information or had the ability to engage in exchange through HIE participation. Measures from these studies include any HIE use, type of HIE use or patterns of use, successful retrieval of HIE data, and attitudes toward HIE use and workflow. For example, an estimated 76 percent of hospitals[5] and 14 percent of office-based physicians[6] exchanged any information with providers outside their organization in 2014. But fewer studies measured the actual volume of information exchanged, including clinical exchange volume, rates of HIE use, proportion of encounters with HIE use, proportion of physician time spent using the HIE. Overall, these studies suggested IEHI use was relatively low, a finding confirmed by multiple expert interviewees and the TEP. This result was found both in HIE log data showing the percentage of clinical encounters that involved the exchange of information and in

survey data of hospitals and clinicians. One study showed that HIE data was accessed in only 6.8 percent of emergency department visits across 12 different emergency rooms.[7] Other studies suggest similarly low rates of use.[8]

Given these relatively low rates of HIE use, researchers tried to examine factors associated with increased HIE use both for individual patients and for organizations. One study found that radiology exchange was more likely in the outpatient setting and for patients who were male, had increasing disease severity, were covered by Medicaid, and had an imaging procedure in the last 30 days or a recent ED encounter.[9] However, the extent to which measurement challenges or barriers keep IEHI use low remains unknown. Below, we summarize challenges to measuring provider use as IEHI data and barriers that may be preventing use.

MEASURING INTEROPERABILITY

Current efforts to measure interoperability focus on the use of certified technology and whether information was sent, received, queried, and integrated by providers. Some efforts have quantified the information exchanged between specific trading partners. But many challenges hinder the collection of information required for measures, particularly when trading partners include providers who do not qualify for the meaningful use (MU) program. Existing measures are broad, simple, and not patient-centered (e.g., information may not follow a patient across settings). Two major sources of data on interoperability include meaningful use attestation data and national survey data, which are both self-reported—another limitation.[10] Finally, past measurement efforts have focused on providers involved in MU, but effective patient care means interoperability with providers who are not eligible for the program. To achieve and measure interoperability across a wide range of providers, improvements must be made to standards and clinical workflows across the healthcare system.[11]

HIE volume data can come directly from community and state HIEs. HIE audit logs may provide information to measure interoperability. Many HIEs, particularly those in markets with a single dominant HIE node (e.g., Maryland, Vermont, Tulsa, and San Diego), measure transaction volume and volume growth by provider type. But many community and state HIEs are federated and do not have ways to track transaction volume. For example, Minnesota uses a network-of-networks approach, with most exchange point-to-point. This makes measuring or assessing exchange processes across states or regions a challenge.

Data on the level of exchange could also come from HIEs developed within integrated delivery networks (IDNs) and accountable care organizations (ACOs), electronic health record (EHR) vendor networks, and payer networks. For example, Epic Health Services (Epic) vendor clients exchanged

roughly 250 million records in 2015 and 2016, 80 percent of which were Epic-to-Epic transactions.[12] However, the total number of private HIEs and levels of exchange are unknown because of inconsistent definitions, limited data, and inconsistent means of exchanging information. Another drawback identified through the literature review is that the organizations connected through private exchanges are sometimes restricted by strategic and proprietary interests.

MEASURING PROVIDER ACCESS

We know very little about the quality and value of the data transmitted. Experts cited provider concerns about exchanged clinical data that were not valuable or reliable. In addition, even when providers can engage in IEHI, they may not electronically send or receive information. Even if providers are exchanging large volumes of information, we do not know how much of it is useful and what produces benefits to the receiving side. In 2015, over one-third (36 percent) of hospitals reported that they did not use information they electronically received from outside sources. Among these nonusers, half indicated that the information was not easily accessible or not integrated within their EHR or clinical workflow; three in ten nonusers indicated the information was not useful. The size of continuity of care documents can deter provider use. One expert said in an interview that we will see the most benefit when "we actually filter the firehose down to something that is actually meaningful and useful and usable to the end user. That is where the benefit will come, not in simply turning on the firehose. We have successfully turned on the firehose but we have not successfully made the information coming out at the other end useful in many cases." In other words, knowing the quality and value of the data transmitted, not just the volume, is critical to assessing the use and impacts of IEHI.

TEP participants emphasized the need to focus on both clinicians and nonclinicians when measuring provider access to and use of IEHI. TEP participants noted that models focusing on clinicians accessing data in real time in an ambulatory setting may miss the vast majority of IEHI use. Nonclinicians such as care managers, office support staff, and administrative staff are among the most frequent users of IEHI; this would not be reflected in a study focused on clinician activities.

In What Ways Does the Structure of the Current Market for IEHI Facilitate or Impede IEHI?

The Health Information Technology for Economic and Clinical Health (HITECH) Act promoted health information exchange across the United States. A significant portion of providers, particularly hospitals, participated in the effort. The State HIE Cooperative Agreement Program, which received federal

funding from 2010 through 2014, fostered a variety of state- or region-specific approaches to developing and supporting IEHI through public organizations or public-private partnerships. Private HIEs have also developed within IDNs and ACOs, EHR vendor networks, and payer networks.

However, the expert discussions, TEP participants, and literature review identified several organizational, market-related, and technological barriers to widespread IEHI. The most commonly cited—and most difficult to overcome—were organizational and market-related (e.g., competition).

BUSINESS CASE

In the expert discussions, the most commonly cited barrier to robust IEHI was the inadequate business case for providers and vendors. At the most basic level, IEHI's altruistic goal of improving public health is not necessarily consistent with the bottom line of industry stakeholders. Although robust IEHI may exist within IDNs and affiliated providers, these providers may avoid sharing data with competitors. Organizations with a contractual agreement can more easily—and more cheaply—share the cost and benefits of exchange. This finding is consistent with the literature review, which found that exchange was not common among competing organizations;[13][14] exchange between organizations within the same health care system is more likely, suggesting that provider consolidation may be associated with more exchange.[15] In addition to competition among health care organizations, vendor competition in a market has also been found to affect exchange, with more exchange occurring among hospitals where a dominant vendor controls a larger market share.[16]

There is also some evidence of information blocking—when "persons or entities knowingly and unreasonably interfere with the exchange or use of electronic health information."[17] Although the prevalence of information blocking is unclear, ONC received 60 unsolicited complaints about it in 2014.[18] An analysis of 2005–12 claims data found that information blocking may be producing local network effects, where each hospital is influenced by the decision made by a subset of other hospitals in the region. This study also found that lower-quality hospitals were more likely to forgo HIE because they feared losing market share. Health information blocking had an even greater impact on the number of patients in the community who could be counted in the HIE network. Small collusions among one or two hospitals reduced the expected number of patients in HIE by at least 29 percent.[19]

PAYMENT MODELS

The literature review and expert discussions indicated that different payment models influence provider motivation to share data with other providers. Many providers paid under the fee-for-service system do not want to share data because they think it will reduce the number of tests and procedures,

thereby reducing revenue. Yet other providers paid under the fee-for-service model may selectively share data to increase referrals and revenue. In contrast, providers paid under alternative payment models (e.g., Medicare Shared Savings, Complete Joint Replacement Model) through the Medicare Access and CHIP Reauthorization Act of 2015 (MACRA) require the use of certified EHRs and could drive interoperability between different types of providers. Participating providers could realize a return on investment if they can achieve delivery process efficiencies such as improved care coordination through team-based care and reductions of duplicative procedures and tests.

One study found that US hospitals engaged in important domains of interoperability were more likely to have certain information technology infrastructures and to participate in delivery reform.[20] The 2014 eHealth Initiative survey of 125 identified HIEs (out of 267)—including 74 community-based public health information organizations (HIOs), 25 statewide efforts, and 26 health care delivery organizations—found that advanced HIE initiatives are supporting new payment and advanced care delivery models. Of those surveyed, 51 percent supported an ACO, 41 percent supported a patient-centered medical home, 17 percent supported a State Innovation Model, and 9 percent supported a bundled payment initiative.[21]

DEFINITIONS AND STANDARDS

The literature and expert discussions described several technical challenges to connecting multiple disparate EHR systems. Providers have adopted and integrated EHRs specifically to suit their organizations' needs, resulting in a wide variety of EHR systems with unique interoperability requirements and different implementation of standards; this makes exchange difficult. To address the inconsistent use of standards, ONC developed a framework for measures to evaluate the adoption and implementation of standards. The ONC framework focused on two key measurement areas: implementation of standards in a health IT product and use of standards, including customization of the standards, by end users to meet specific interoperability needs.[22] ONC's Interoperability Standards Advisory process also encourages a common set of standards and a common approach to implementation.[23]

A 2011–13 eHealth initiative survey of 199 HIE initiatives found that 68 initiatives had to connect to more than 10 different health systems; those surveyed wanted to see standardized pricing and integrated solutions from vendors. Another study highlighted the challenges of application program interfaces, calling for federal stimulation of competition through vendor mandates. In addition, one SME noted that maintaining accurate data through exchange with heterogeneous EHR systems is challenging

because "when information is filtered through the exchange artifact and reformatted, it can get lost, transformed in odd ways, lose its fidelity and context, and so forth."

But there is reason to be optimistic that this technological barrier can be solved over time. The eHealth Exchange, a national network of exchange partners including four federal agencies, has developed a common set of standards and specifications as well as legal and governance agreements to support a single network architecture to enable interoperability. eHealth Exchange is managed by the Sequoia Project, which also manages a parallel but independent initiative, Carequality. Carequality facilitates exchange through the development of a network-to-network trust framework between stakeholders. A second vendor-led organization, CommonWell Health Alliance, provides patient matching, consent management, and record locator and query services across networks and across the platforms of participating vendors. In December 2016, Carequality and CommonWell announced a partnership to support the joint use of their respective trust frameworks and patient matching/query services. Providers would opt in and be obligated to share data with other providers who have opted in. Full deployment is expected in early 2018.[24] Beyond these industry-led efforts, the 21st Century Cures Act calls for developing a national exchange trusted network.[25]

OTHER TECHNICAL BARRIERS

Studies and experts named several other technical barriers associated with the development and sustainability of HIE infrastructure. Providers and patients cited privacy and security issues (including the need for consent) as major barriers. In addition, the absence of a national provider directory and master patient index were considered missing pieces of the IEHI infrastructure. One expert emphasized that few EHR systems are focused on exchanging the original source records (data provenance), creating a major barrier to true interoperability. Instead, systems are focused on getting data into the exchange artifact, typically an HL7 message, C-CDA document, or Fast Healthcare Interoperability Resources (FHIR); the authenticity of the source record is not part of the design. The challenge is that much of the source information is not encoded within free text, which represents much of the important content within the source record; this includes progress notes, clinical impressions, and discharge summaries. Thus, exchanged information must be encoded somewhere downstream by software, potentially creating differences in the source record and in the final communications.

What Is the State of Current Knowledge about the Costs of Building and Maintaining an Interoperable Health Care System?

The literature review and expert discussions identified limited information on the costs of starting and maintaining an HIE. Private HIEs, such as those developing within IDNs or EHR vendor networks, typically do not publicly share information on costs. An online search of the non-peer-reviewed literature yielded few findings on the start-up costs for state and community HIEs.

The literature review found several examples of grants or private funding covering HIE startup costs. For instance, the Delaware Health Information Network (DHIN) received $5,000,000 from the state of Delaware, $2,000,000 in matching funds from the private sector, and $4,700,000 from an Agency for Healthcare Research and Quality (AHRQ) grant, for a total of $11,700,000. HealthBridge, a local HIE connecting health care providers in parts of Ohio, Indiana, and Kentucky, needed $1,750,000 of start-up financing to implement its HIE. But despite receiving three large federal awards in 2010, HealthBridge uses several pricing models to charge hospitals and physicians for its services to maintain a cash-positive sustainable business model.[26] Similarly, the Indiana Health Information Exchange received $1,800,000 from Biocrossroads, $2,000,000 from Fairbanks Foundation, and additional start-up funding from federal and state governments, the Regenstrief Institute, eHealth Initiative, and Anthem BCBS.[27]

The expert discussions and literature review provided consistent information on the marginal costs associated with operating state and community HIEs. Two state officials representing different HIE efforts indicated that the marginal costs associated with their state HIE programs were approximately $1 to $3 per person (in the state) per year. San Diego Health Connect estimated its ongoing operational costs at approximately $1,800,000 per year, or $1.33 per resident per year, and the MyHealth Access Network (Oklahoma's regional health information organization) estimated average yearly costs at around $5,000,000, or $1.25 per resident per year. Operating costs for state and community HIEs likely vary depending on various factors, such as HIE type, legal framework, and number of participants.

According to TEP participants, rapidly shifting business models make it more difficult to measure the cost of implementation and exchange. Capturing costs in traditional, centrally based HIE models relies on calculating total costs and dividing by the number of covered lives. As technology improves, EHR vendors will include IEHI in their products, and IEHI will not require locally based infrastructure over the long term.

The boundaries of what constitutes the infrastructure of exchange technology are becoming less clear. For example, vendors encroach on them by bundling proprietary exchange solutions with EHR systems such as those provided by Epic or Cerner to their customers. Industry initiatives such as the Sequoia project and CommonWell have expanded the reach of these solutions beyond proprietary networks and effectively allow for the bypassing of more expensive and complex centralized models.

Traditional HIEs provide patient and provider indexes, which are beginning to be offered by companies with population health products. With the advent of value-based payment models, these index products are expected to be used more widely and could usurp stand-alone HIE services. Both approaches make it very difficult to measure costs, because IEHI is part of larger services supporting multiple value propositions. Moreover, measuring costs associated with technological and product evolution requires the use of application programming interfaces (APIs). Two trading partners may find it cost effective to establish FHIR-based exchange of important data elements or templates. For example, a long-term care provider may bidirectionally exchange data directly with an acute care provider in what is more of a peer-to-peer solution.

Given the different IEHI business models, measurement of IEHI and its value must transcend basic counts and an analytical framework based upon end-to-end transactions and clinical outcomes. HIE is fundamental to broad-range analytics and value-added services; measurement methods will require multiple sources of data which are difficult to unpack in an aggregated form.

SUSTAINABILITY

The sustainability of state and community HIE organizations has been a challenge, particularly with public funding from the State HIE Cooperative Agreement Program coming to an end. Revenue sources for state and community HIEs include transaction fees, hospital and health system monthly subscription fees, per-member-per-month fees for health plans and insurance companies, charges on volume of premium services, and subscription fees for value-added services to be implemented. However, a survey of HIE organizations found that only 17 of the 35 organizations (49 percent) considered themselves to be sustainable, defined as having revenues that exceed operational costs. Although 60 percent of CEOs interviewed felt confident that their organization would survive over the next five years, nearly 9 percent of participating organizations were in some phase of divestiture or exit from the market.[28] More information is needed to determine which types of HIE organizations are more susceptible to sustainability problems than others (e.g., EHR vendor HIE networks may have fewer issues).

Measuring costs is a challenge not only for HIEs, but also for lab and imaging systems and providers that want to exchange but pay additional costs or must hire another vendor to do so. For example, six out of ten hospitals nationwide participated in a state, regional, or local HIO and used a HIE vendor to enable exchange.[29] However, these hospitals likely had a parallel network within their hospital system and may also use a vendor network for exchange with their trading partners.

Interface costs were a commonly cited IEHI expense for providers in the expert discussions and literature review. There are four potential interface costs: software license fees, software maintenance fees, implementation fees, and transaction fees (if applied). In the 2014 eHealth Initiative survey of 125 HIEs, 74 respondents cited the financial costs of building interfaces between an exchange and EHR systems as a main interoperability challenge. Moreover, getting consistent and timely responses from EHR vendor interface developers and the technical difficulty of building interfaces were cited as issues by 68 respondents and 48 respondents, respectively.[30] Although interface costs continue to be part of the IEHI business model, these barriers were more apparent during the rollout of the State HIE Cooperative Agreement Program.

What Are Potential Data Sources and Methods for Quantifying IEHI and Its Potential Benefits?

DATA SOURCES

Most studies of IEHI and resulting health outcomes rely on survey data because it is the most easily obtained source of nationally representative samples (see Exhibit 3). Common surveys that collect information on EHR adoption and IEHI use include the IT supplement of the American Hospital Association Annual Survey and supplements to the National Ambulatory Medical Care Survey of office-based physicians, including the National Electronic Health Records Survey and the Medical Record supplement, which abstracts clinical care data from EHRs through summary of care records. However, survey data are limited in precision because they rely on self-reported information based on the respondent's perceptions. Other potential data sources and measures include the following:

- **Audit logs from source record systems.** Log audit data, potentially combined with clinical data, can be used for local or regional studies that do not tell national stories. These data could also include direct secure messaging and ADT logs and could come from several sources, including EHR vendors, state and local HIEs, and providers. The audit log would need to be captured to

ensure that it remains unaltered in its retention. A life-cycle origination model for health information can show the set of information captured, the set of information retained, and the set of information exchanged later. Software can keep an audit log of those kinds of transitions; that level of detail is needed to ultimately demonstrate interoperability. One IEHI expert proposed an algorithmic measure to monitor this process and produce audit logs that can show what happened to that information throughout the entire end-to-end process. However, TEP participants noted audit logs have important limitations: although audit logs can show whether a provider looked at a patient chart, they do not show whether providers have looked at specific measures or data fields important to patient care.

- **Data from HIEs or EHRs.** Some state and community HIEs can provide data on volume transactions as process measures. Depending on the HIE, these data can also be used for analytic purposes such as identifying frequent ED users across multiple providers. Data could be obtained from large national networks such as the CommonWell or Sequoia initiatives, national EHR vendors (e.g., Epic's Care Everywhere), or cloud-based EHR vendors (e.g., Athena Health). However, the CommonWell and Sequoia initiatives are still in early stages and will need some time to produce useful output. It may also be possible to obtain data from members of the Strategic Health Information Exchange Collaborative, a nonprofit national consortium of about 50 state and community HIEs that has launched a multistate master patient index.

- **Time and motion studies of providers using IEHI tools and measures.** These studies may be used to observe providers, either directly or through recordings of their computer screens. They can be used to compare the efficiency and timeliness of electronic exchange with that of other methods of communication, as well as the steps taken and the actions required by the provider once they have received the data to use it.

- **Data from payment incentive programs.** Providers report quality measures for various payment incentive programs, such as the meaningful use EHR Incentive Program. One challenge of using this data is that eligible professionals may be relatively new to entering and reporting information in their EHRs used to calculate these measures. In addition, multiple Medicare quality reporting programs, including the EHR Incentive Program, will be streamlined through the Merit-Based Incentive Payment System (MIPS) under MACRA. MIPS measures could be very useful because they cover aspects of exchange beyond those in the EHR Incentive Program.

- **Claims data.** Claims can be used as an external data source to develop measures of patient outcomes and provider and patient networks. Because most care is billed to insurers, claims can show all the places where a patient has received care. Readmissions rate is the classic outcome measure to analyze, but it is challenging to isolate the IEHI effect from other confounding factors. For process measures, transition of care and care coordination billing codes can be used to measure the connectivity between the inpatient and outpatient settings. Although claims data may not be the best sole source for clinical quality measurement, they can be very useful in combination with survey and/or clinical data.

Exhibit 3 summarizes these data sources and their potential applications.

Exhibit 3: Data Sources and Potential Measures

Data source	Measures
Survey data	Process Measures; perceptions of usefulness of IEHI and usability of systems
Audit logs	Process measures: volume and use of exchange
HIE or EHR data	Process measures: volume and use of exchange
Time and motion studies	Process and outcome measures (e.g., efficiency and timeliness of electronic exchange)
Payment incentive program data (e.g., MIPS)	Process and outcome measures
Claims data, in combination with survey or clinical data	Process and outcome measures (e.g., patient outcomes, source of care, provider patient networks)

METHODS

Most recent studies had limited capacity to make causal inferences because of the lack of pre-IEHI baseline information, lack of a comparison group, and lack of information on whether and how IEHI data was actually being used. Insights from the first TEP meeting were consistent with these findings. Out of 100 studies included in the review, only 5 included both pre- and post-IEHI information, and only 12 used a comparison group (Exhibit 3). Thus, several confounding factors likely played a role in the outcomes studied, including concurrent implementation of payment and delivery system reforms and other quality improvement initiatives.

In addition, most studies had small samples, focused on emergency department settings only, and/or looked at one community-based HIE network, region, or organization (Exhibit 3). Overall, it appears national studies were used to document existing HIE infrastructure and trends, but more targeted studies have been used to document HIE use and the effect of HIE on outcomes. The use of a wide variety of outcome measures and data sources (each with their own limitations) also makes synthesis of study results difficult.

Exhibit 4: Study Designs for Literature Included in Review and Studies Focused on Outcomes

Classification	Number of articles total (n=100)	Number of articles with statistically significant outcomes (n=18)	Number of articles without statistically significant outcomes (n=12)
Data Used			
HIE data	24% (24)	67% (12)	25% (3)
Encounter data	6% (6)	22% (4)	0% (0)
Claims	8% (8)	28% (5)	0% (0)
Survey	41% (41)	28% (5)	42% (5)
Other	27% (27)	0% (0)	42% (5)
Study Design			
Post-test only	85% (85)	83% (15)	50% (6)
Pre- and post-test	5% (5)	17% (3)	8% (1)
Used comparison group	12% (12)	44% (8)	17% (2)
Used HIE process measure	33% (33)	56% (10)	33% (4)
Type of HIE Network			
Statewide	17% (17)	17% (3)	25% (3)
Community	49% (49)	67% (12)	50% (6)
Enterprise	15% (15)	22% (4)	17% (2)
Organizational Setting			
Hospital (general)	12% (12)	11% (2)	25% (3)
Hospital—emergency department	30% (30)	50% (9)	50% (6)
Hospital—inpatient	21% (21)	22% (4)	33% (4)
Ambulatory setting (hospital outpatient or physician practice)	24% (24)	28% (5)	17% (2)
HIE organization	21% (21)	17% (3)	25% (3)
Integrated Delivery System	14% (14)	17% (3)	8% (1)
Sample			
National	17% (17)	6% (1)	17% (2)
State or region	51% (51)	72% (13)	67% (8)
Organization	50% (50)	72% (13)	75% (9)

Note: Studies examining outcomes n=30. Numbers may not sum to total n because individual articles often fell into multiple categories.

Of the 100 studies included in our review, 30 studies examined the effect of IEHI on clinical and economic outcome measures, and the remainder focused on IEHI structure and processes. Of the studies focused on outcomes, 18 had statistically significant outcomes. The studies without statistically significant differences in outcomes associated with IEHI provide important information, but because our task is to identify areas of potential public benefit, we focus here on studies that found statistically significant outcomes. Many of these studies used HIE data, had a post-test only design, included an HIE process measure, focused on a community HIE network, took place in a hospital setting (particularly in

the emergency department), and were not national in scope. Only 30 studies from the review looked at the relationship between IEHI and a given outcome; the remaining studies were more descriptive, seeking to measure the presence of IEHI infrastructure or the extent to which IEHI was used. The results of studies that found statistically significant effects of IEHI on a given outcome are further described in the next section.

What Are the Major Areas where There Is Empirical Evidence That IEHI Results in Public Benefits?

The literature review and conversations with IEHI experts highlighted a broad range of public benefits that may result from IEHI. These include improvements in efficiency, safety, public health reporting, patient satisfaction, and quality through mechanisms such as improved care coordination and greater receipt of recommended care. However, recent studies have limited ability to attribute changes in these outcomes to IEHI, in part because of challenges with measurement and methods, as described in the previous section. We summarize public benefit outcomes supported by the evidence below.

UTILIZATION

Most studies have focused on the volume of clinical service use, with a subset looking at appropriate use factors, such as repeat imaging, readmissions, and recommended colonoscopies. Although the studies varied widely in their methods and in the magnitude of changes they found, they consistently found that HIE was associated with a decrease in repeat or unnecessary use of diagnostic and imaging services, with decreases ranging from 0.4 to 13.0 percent.[31] However, the estimated effects of IEHI on hospitalizations varied and was difficult to interpret because of the unclear distinction between appropriate and inappropriate hospital use. Most studies yielded ambiguous findings for overall admissions, readmissions, and ED use.[32][33]

QUALITY

Studies looking at quality of care often used vague measures, such as provider-perceived improvements in quality reported through a survey.[34] Two studies found survey-reported patient satisfaction improvements associated with IEHI.[35] Only one study found a potential health outcome improvement: among 138 primary care physicians, 86 percent of HIE users met or exceeded performance metrics on lipid control and glycemic control for patients with diabetes, compared with 66 percent of nonusers.[36]

COST REDUCTION

Few studies estimated cost reductions resulting from IEHI, and those that did based their findings on the decreased number of services in the hospital setting. But the real magnitude of this utilization reduction is less clear and is a function of the unit of analysis. For example, one study estimated that the savings associated with HIE use in 105 ED patient encounters was $283,477 over four months because of avoided hospital admissions and radiology services (e.g., CT scans).[37] However, this study had a weak methodological design without baseline information and a control group. Another study calculated that if all hospitals in Memphis accessed the HIE, net savings would be $1.1 million a year, mostly from reduced hospital admissions (baseline costs not provided). Most studies do not adequately control for confounding factors beyond interoperability (e.g., concurrent shifts toward new payment and delivery system models) that can influence health care costs. For example, in a fee-for-service payment environment, cost reductions accrue to the payer; providers paid through value-based arrangements (e.g., shared savings) may also benefit from those cost reductions. SMEs agreed that estimating the financial impact of IEHI is a major gap in the literature. There is also no evidence on the effect of IEHI on costs for the patient, either in direct health care costs or other indirect social costs such as missed work.

EFFICIENCY

Our literature review and conversations with experts suggest that IEHI has an ambiguous effect on provider efficiency and related costs, when balancing the initial workflow disruption with improved documentation and cash flow efficiency (e.g., getting paid sooner). The disruptions during the implementation period and the time needed for clinicians to master a new technology may decrease workflow efficiency in the short term before providers can capture the productivity gains of improved communication. Surveys of physicians show that loss of productivity during the start-up phase of an HIE is considered a major barrier to implementation,[38] and related EHR studies show that physician time to chart increased 50 percent in the 18 months after implementation before returning to original levels.[39] Productivity losses associated with the implementation phase of IEHI may limit researchers' ability to measure the benefits of exchange, especially if studies are conducted over a short period of time.

Experts suggest there may be additional literature outside the scope of our review that points to the potential for IEHI to reduce gaps in missing information. For example, deficits in communication and information transfer between providers and the negative impact on patient safety have been well documented.[40] This literature review did not examine studies of medical errors generally, such as malpractice literature or data on the percentage of medical errors attributable to information gaps. However, these bodies of research may highlight potential problems that IEHI could help solve and are worth exploring in future work to further develop measures of the benefits of IEHI.

Limitations of Existing Approaches to Quantifying the Public Benefits Resulting from IEHI

To summarize the information above aimed at addressing the five research questions, major findings from the first phase of the study include the following:

- Actual use of IEHI is often not measured in existing literature, and where it is measured, use appears to be low.

- Inadequate business case, misaligned incentives in payment models, and technical challenges may be contributing to low use of IEHI.

- The start-up costs and short-term efficiency losses related to the implementation of new technology (such as EHRs) suggest IEHI may need to be in place for a long time before benefits may be realized.

- The literature about IEHI is still largely descriptive, focused on quantifying the extent to which IEHI infrastructure is in place.

- A small subset studies focus on the relationship between IEHI and public benefit outcomes. Such studies often have limited ability to make causal inferences because they lack a baseline, comparison group, or information on whether IEHI is actually being used.

  Although existing studies provide suggestive evidence that IEHI is associated with some reductions in unnecessary utilization and associated costs, expert interviews suggest that the literature has yet to document the broader range of IEHI benefits. Exhibit 5 summarizes these range of benefits.

Exhibit 5: IEHI Benefits Demonstrated Empirically in Literature Review and Potential Benefits Suggested by Subject Matter Experts

Benefits Shown by Empirical Research	Potential Benefits Based on Expert Input That the Literature Has Yet to Document

Benefits Shown by Empirical Research	Potential Benefits Based on Expert Input That the Literature Has Yet to Document
▪ Decrease in repeat or unnecessary use of diagnostic and imaging service ▪ Hospital admissions, readmissions, and ED use (evidence is ambiguous) ▪ Provider-perceived quality improvements ▪ Patient satisfaction ▪ Cost reductions associated with decreased use of hospital services	▪ Improved care coordination and transitions of care, along with their associated benefits ▪ Improved coordination of public services and associated benefits (e.g., decrease in unnecessary use) ▪ Increased child immunization rates ▪ Improved diabetes care (checking and controlling A1C) ▪ Improved patient satisfaction ▪ Improved mental health and substance use disorder outcomes ▪ Improved patient safety (reductions in delayed or missed diagnoses)

Consistent with the literature review and the first round of expert discussions, participants in the project's first TEP meeting emphasized that proving the causal link between IEHI and outcomes is a significant and ongoing challenge. Often the presence or absence of IEHI capabilities is insufficient to prove a direct effect on outcomes. Many confounding factors can complicate the presumed causal relationship between the presence of exchange and public benefit outcomes. Thus, measures of interoperability and public benefit ought to be developed in parallel.

Another significant barrier identified by the TEP is the rapidly changing environment of IEHI technology. Organizations use a variety of alternative approaches to IEHI, including ADT and secure messaging systems, which make it difficult to assess whether these organizations should be in the treatment or control group.

In addition, defining the pre- and post-period is a challenge in studies that include multiple organizations or providers because the implementation and adoption of IEHI likely occurred at different periods and rates for each one. Disentangling the baseline period (pre-IEHI) from the post-IEHI implementation period is often not straightforward, and baseline data are often unavailable.

Finally, larger national data sources do not provide sufficient detail for understanding IEHI use. Many measures and data sources are incomplete, difficult to access, or do not fully capture the effects of IEHI because of the effects of confounding variables. Obtaining sufficiently detailed data on IEHI inevitably pushes researchers to more targeted, smaller-scale studies of the relationship between IEHI and outcomes. Our literature review findings were consistent with the TEP's observation. It appears that researchers have used national studies to document existing HIE infrastructure and trends and more targeted studies to document the effect of IEHI on outcomes.

A Way Forward: Use Case Studies

One way to advance the field is to focus on applications of IEHI that offer the best opportunities to observe benefits, rather than simply studying where IEHI infrastructure or volume is present, as many existing studies do. Focusing on use cases allows us to develop measures of the extent to which IEHI applications have occurred and to examine the specific outcomes expected from implementation. Although this approach does not address all the limitations listed in the previous section, it does allow for a study design that explores the causal link between a specific use of IEHI and associated intermediate and final outcomes.

A related takeaway from the TEP meeting is that understanding the relationship between the process of IEHI use and intermediate outcomes (such as workflow improvements) are not well understood, but serve as important links in the causal chain between IEHI infrastructure and expected public benefit outcomes. Stated another way, the current primary focus on IEHI infrastructure and public benefit outcomes may miss improvements to workflow and care processes that occur in the intermediate term and ultimately improve public benefit outcomes. In addition, use cases can be timed after the start-up period of initial IEHI infrastructure implementation (when efficiency losses are likely to occur) and instead focus on a period when the organization is ready to apply the technology for a specific use case.

The expert discussions and literature review identified several use case examples where IEHI functionalities were used to further a specific goal. For example, Hennepin County has extensive interoperability specifically focused on radiology and the exchange of diagnostic images. Michigan's HIE has developed a series of use cases that includes electronic referrals, information exchange outside of Michigan, and Tobacco Free electronic referral.[41] In Portland, Oregon, Intel's advanced payment model saw between 30,000 and 40,000 ADT messages exchanged in the first few months of operation. This employer-led initiative is a subset of a larger, sustainable, and highly successful ADT exchange service offered across the state of Oregon. Finally, Surescripts could be one of the most robust examples of interoperability in the country because it handles roughly 90 percent of all e-prescribing transactions in the US.

We propose applying the Donabedian framework (Exhibit 1) to identify measures that trace the connection between a specific IEHI use case and public benefit outcomes. This framework can be used to lay out the steps involved in using the specific IEHI functionality for a given goal, including the process of using IEHI and intermediate outcomes. Studies of IEHI use cases can then follow the steps that connect IEHI use to a specific outcome, and they can be used to study the benefits resulting from

IEHI and the barriers in cases where the expected benefits are not occurring. Process and intermediate outcome measures that may reduce preventable hospitalization are a possible area of priority (e.g., availability of a complete medication list; timeliness, completeness, and usability of data) and warrant further exploration through use cases.

Measuring the Process of IEHI Use

To identify where IEHI has occurred, we ideally would identify the types of information used by providers during a given care episode in ways expected to affect a given outcome. For example, an emergency room physician querying for past lab results and viewing those results was associated with lower lab use during the ED encounter. Two potential points of data collection related to use are network servers for public health information organizations and servers supporting private HIEs, such as those of IDNs, ACOs, and vendor networks.

However, most public HIO participation agreements do not allow the HIO to capture specific information about the nature and type of most clinical data transmitted. Network logs would only provide metadata, including the volume of information exchanged and the source and receiver of the information. Such metadata nevertheless could be useful in providing descriptive statistics indicating the geographic range and volume of data exchanged, as well as information about important network nodes and areas where exchange happens less than may be optimal. For private HIEs, more robust data could be available if these organizations are willing to share information. Data from private networks open to sharing could provide richer information, particularly if examined in conjunction with EHR logs.

Potential data sources for measuring the impact of IEHI on public benefits include the following:

1. claims data (to measure utilization, cost, and quality, such as through HEDIS measures)
2. EHR data (to measure utilization and quality, such as through HEDIS or meaningful use measures)
3. patient experience (e.g., Consumer Assessment of Healthcare Providers and Systems survey)
4. providers' financial data (e.g., Medicare Cost Reports)

In the sections that follow, we apply the use case approach to identify measures that trace a specific IEHI functionality to outcomes that benefit a broad range of stakeholders. First, we describe a use case template developed by our research team using feedback from the TEP and a second round of discussions with IEHI experts. This template is flexible enough to be applied to several use cases, settings, intermediate processes and outcome measures, technologies, and data sources. It may also

serve as the basis for measures to include in various study designs that focus on a specific use case, depending on whether a comparison group and/or baseline data are available.

Second, we demonstrate how the use case template could be used to identify measures to study a specific IEHI functionality: ADT notifications, medication reconciliation, and referral loop closure. These examples identify specific measures that could be used in quantifying the intermediate and public benefit outcomes that result from an instance where that specific IEHI functionality was implemented.

Finally, we describe a range of methods that may be used to analyze the measures identified to study a specific use case. Different methods may be chosen depending on factors such as data availability and ability to identify a comparison group.

The Use Case Template

The following template was developed to help identify measures that trace a causal chain between specific IEHI functionalities and the expected intermediate and public benefit outcomes that should result from IEHI implementation. The purposes of the template are as follows:

- Describe the theoretical case for implementing a specific IEHI functionality, given its expected effect on certain outcomes

- Present an actual case where a specific IEHI functionality was implemented, documenting the outcomes that resulted (including quantifying the public benefit)

- Develop a comprehensive logic model for a use case study where a specific IEHI functionality has been implemented

- Present a consistent approach for multiple use case studies where the same IEHI functionality has been implemented in multiple locations

- Assess the availability of measures and data to conduct a use case study of a specific IEHI functionality, and identify areas for future measure development

- Identify where in the causal chain barriers may prevent an implemented IEHI functionality from achieving its intended goal to inform quality improvement, research efforts, or policy decisions

- Identify points in the causal chain that may be ripe for research, quality improvement, or policy interventions

The scope of the use case study may be a single provider, practice or hospital, health care system, accountable care organization, health plan, or geographic area where a certain IEHI functionality has been implemented. As displayed below, the template includes instructions for the user to describe the use case, to develop a logic model (framework) of how that functionality is expected to affect outcomes, followed by the identification of measures that can be used at each step of the logic model.

Interoperable Exchange of Health Information (IEHI) Use Case Template

Suggested Title: Using [Functionality] to improve [Outcome] through [Intermediate Outcome]

This template is intended to link IEHI functionalities to outcomes for specific use cases. Use cases allow us to build conceptual links between IEHI functionalities, the resulting processes they enable, the intermediate outcomes those processes achieve, and, ultimately, the public benefit outcomes that result. This template may be used to describe a general use case for an identified functionality or to capture specific information and data from an organization using this functionality.

Use Case Description
- *Describe IEHI functionality, relevant stakeholders, and intended audience of the use case*

Use Case Framework

⟶

1. Structure	2. Key Processes	3a. Intermediate Outcome (provider workflow)	3b. Intermediate Outcome (patient care)	4. Public Benefit Outcomes
Payment environment, IEHI functionality, provider incentives	*Transactions/network traffic and access/use of data or functionality*	*Improved workflow*	*Improved care process*	*Improved public benefit outcome*

Steps
- *Populate the framework above with the expected chain of causality between the IEHI functionality and selected outcomes covered in this use case.*
- *Give overview of the structure, key processes, intermediate outcomes, and public benefit outcomes covered in this use case and data sources used for each. The sequence of intermediate and public benefit outcomes can be thought of as tracing upstream and downstream benefits, starting with workflow and operations benefits to providers, progressing to improved care and health for patients, and ending in benefits to payers and the public. There may be tradeoffs between the benefits experienced by different stakeholders; for example, providers may need to incorporate a new step into their workflow to ensure shared information improves patient care. For this reason, it is important to trace the entire chain of potential upstream and downstream effects of using IEHI functionalities to measure the benefits that occur. In addition, the payment environment is important to understand the extent to which incentives are aligned across stakeholders—for example, whether providers still ultimately benefit when tradeoffs occur where additional time or resources are required to use a specific IEHI functionality.*
- *Summarize key existing literature supporting linkages between parts of the framework.*
- *Note: Although we present a linear framework for simplicity, structure, processes, and outcomes are often more interdependent and cyclical in practice (e.g., key processes must also be in place for the intermediate outcomes to result in public benefits).*
- *Ideally, the information used to populate the sections below for each framework domain should reflect some of the chronology of the order in the framework. This may be through the documentation of when structural elements were implemented to show that implementation preceded data collected for the other domains, as well as through the collection of process, intermediate outcome, and public benefit outcomes at multiple points in time.*

1. *Structure*

- *Briefly describe IEHI functionality and related technology*
- *Describe any existing incentives for use of this functionality in the setting of focus (e.g., payment incentives, quality measurement, requirements or mandates, alignment with other existing quality and performance improvement initiatives)*

2. *Key Processes*

- *Within this framework, key processes refer to the process of accessing and using the IEHI functionality instead of more commonly considered health care process measures in a quality framework. The latter types of measures (such as improved workflow and care processes) are considered intermediate outcomes that result from the process of accessing/using IEHI.*
- *Identify key process steps in the access and use of this IEHI function*
- *Populate table below with measures that can be used to track these key processes*
- *Note: Although some aspects of the tables below have been filled in to convey the concept, additional details for specific measures from the literature and endorsed or other validated measures will be added once this template is finalized*

Process	Measures	Description	Data Sources

3. *Intermediate Outcomes*

- *Identify intermediate outcomes that should result from use of the IEHI functionality and lead to improvements in public benefit outcomes*
- *Populate table below with measures that can be used to track these intermediate outcomes*

Intermediate Outcome	Measures	Description	Data Sources

4. *Public Benefit Outcomes*

- *Identify public benefit outcomes (e.g., quality, cost, or public health) resulting from or expected to result from the key processes and intermediate outcomes identified above*
- *Populate table below with measures that can be used to track these outcomes*

Outcome	Measures	Description	Data Sources

Summary
- *Summarize how this use case demonstrates the value this IEHI functionality brings, specifying which outcomes may be of value to which stakeholders*
- *Describe key barriers or limitations associated with this use case*
- *Describe policy levers to improve value*

Use Case Examples

To test and refine the use case template, we populated it with three use case examples identified through the literature review, TEP discussions, and interviewee discussions: ADT notifications, medication reconciliation, and referral loop closure. These examples were selected based on evidence and expert opinions suggesting that these IEHI functionalities are increasingly being implemented and have the potential to result in a wide range of benefits to multiple stakeholders through improved provider workflow, care coordination and care processes, and, ultimately, clinical and economic outcomes.

Although we have selected these specific use cases for the reasons described above, researchers and practitioners could use many other types of cases to test IEHI functionalities. Some additional use cases suggested by our TEP panelists and SME interviews are listed in Exhibit 6.

Exhibit 6: Additional Potential Use Cases

Potential Use Cases
■ Public health reporting such as syndromic surveillance and immunization registries
■ Tracking of opiate prescribing and use by integrating Prescription Drug Monitoring Program (PDMP) systems with IEHI
■ Death notice integration with alert systems
■ Advanced directive registry integration with IEHI
■ ACO case management
■ Data portability through structured clinical data exchange
■ Query-based exchange to locate a patient's medical record
■ Consent management
■ Facilitation of coordination across diverse care teams
■ Social determinants of health and unstructured data integration into a care plan available in an EHR
■ Reporting of clinical quality measures
■ Patient and/or provider attribution
■ Provider directories

These use case examples describe broad IEHI functionalities to illustrate the use case concept. However, the process of implementation and the measures used to capture value from that functionality may vary significantly depending on the setting, patient population, or other contextual factors. Those implementing IEHI use cases may find it helpful to develop more granular use cases or sub–use cases with a narrow care setting or patient population and more clearly defined process, structure, and outcome measures. To illustrate the variety of use cases that could be developed within these broader functionalities, each example use case contains a list of several potential sub-uses that can be developed further using the use case template.

Example 1. Using Admission, Discharge, and Transfer (ADT) Event Notifications to Reduce Unnecessary Health Care Utilization through Improved Communication between Providers and Patients

Use Case Description

This use case focuses on alerts triggered by an admission, discharge, or transfer (ADT) event to facilitate care transitions and follow-up care after an acute-care hospitalization. These alerts take the form of an electronic message automatically sent (using "push" exchange) to relevant stakeholders such as the patient's care team, primary care provider, payer, or skilled nursing facility when the patient has been admitted to, discharged from, or transferred from the hospital. ADT alerts are perhaps the most basic function of interoperable exchange of health information (IEHI) between multiple health care providers, and vary in the number of stakeholders involved and the sophistication of the rules used to trigger the alerts. Key stakeholders in this process include physicians, care teams, patients, hospitals, and payers.

The value of ADT alerts may vary across stakeholders. For example, these alerts may be valuable to primary care providers who can follow up with patients to ensure they understand discharge instructions and reconcile new prescriptions with pre-existing medications. A payer may see a benefit if the hospital sends an alert to a doctor and the doctor acts to reduce unnecessary care. Although ACOs and other risk-bearing stakeholders can benefit from ADT, other hospitals could be financially worse off under strict fee-for-service reimbursement and therefore lack the incentive to send or receive/use these alerts.

This ADT use case is not specific to a particular setting. However, experts agree that ADT alerts have the most value in emergency and inpatient departments; ACOs (where ADT filters into a case management process); and settings with frequent and costly transitions, such as transitions within a long-term care setting (e.g., those from long-term acute care hospitals to intermediate home care situations) and outpatient or rehab notification after discharge (e.g., from acute care to outpatient or rehab services for joint arthroplasty patients in need of rehabilitative services). Other potential examples (sub–use cases) or settings for ADT that can be explored in future research include the following:

- Use of predictive analytics to put risk score on ADT
- Outpatient ADT alerting
- ADT identification of high-risk patients in real time
- ADT to identify ED super users and create a community-wide database to help define frequent ED use across hospitals

- Payer use of ADT data for care management
- Alerts to identify patients who may benefit from social/behavioral intervention during a care transition
- Alerts to identify patients with infectious disease requiring special care such as an isolation room

Use Case Framework

1. Structure	2. Key Processes	3a. Intermediate Outcome (provider workflow)	3b. Intermediate Outcome (patient care)	4. Public Benefit Outcomes
Exchange infrastructure and ADT event notification; provider incentives to prevent unnecessary utilization	Capture of triggering event; receipt and use of alerts	Improved communication among providers; triggering communication to patients	More timely and appropriate follow-up care	Reduced unnecessary utilization; lower health care costs for patients and payers

An ADT event notification system may be most valuable where payment incentives prevent unnecessary utilization (e.g., avoidable hospital readmissions and ED visits). Once the system is in place, capture of the ADT event triggers an alert to the appropriate recipients. Through this system, improved communication between the hospital and recipients of the alerts who care for the patient allows for more timely and appropriate follow-up care, and prevents unnecessary worsening of the condition that would have led to avoidable hospital or ED use.

1. *Structure*

When an ADT event occurs, agents (e.g., providers, HIEs, insurers) send an alert to patient-specific stakeholders through a secure message. This can occur through a health information exchange, integration with an EHR system, or direct secure messaging. However, several other components, such as patient matching, must also be in place for the ADT functionality to serve its intended purpose. The absence of these components may create the following barriers to providers' receipt of alerts or their use of alerts received:

- the ability to identify which patients to send alerts to and the ability to connect providers to patients (e.g., matching patients to a primary care provider to send them ADT alerts). Either the hospital or the HIE must be able to match up the firehose of events to a roster of relevant patients and providers. Information from patient panels, state health directories, provider

surveys, and other organizations (e.g., HIEs, CommonWell) can help determine which providers are actively connected to patients.

▪ the ability of the provider to identify the patient once ADT is received, based on the information in the alert.

Ultimately, the value of interoperability and ADT alerts depends on the payment systems and on the alignment of financial incentives in which they are embedded. In a pure fee-for-service world, the financial value of interoperability to providers could be zero or negative because adverse events (e.g., readmissions, bad outcomes, and complications) could generate revenue. Ideally, stakeholders are held accountable for the well-being of the patient through quality measurement, payment incentives, and/or some bearing of financial risk. The hospital would have an incentive to alert the patient's primary care provider so that this provider could provide transitional and follow-up care as appropriate after such an event; this would prevent a hospital readmission, which incurs financial penalties for hospitals under Medicare.

2. *Key Processes*

Key processes that must occur are the capture of the triggering event, the transmittal and receipt of the alert by the appropriate stakeholder(s)/provider(s), and the use of the information to prompt appropriate action. Each of these processes may be measured as described in the table below.

Process	Measures	Description	Data Sources
Capture triggering event	Capture rate (theoretical)	[events captured] / [events occurred] (e.g., discharges covered by an ADT arrangement/all discharges)	EHR log or HIE transaction log for events captured, claims for events occurred.
Capture triggering event	Capture rate (actual)	[ADT alerts received/all observed events] (e.g., of all discharges observed in claims, how many ADT alerts were received?)	Claims, EHR/HIE/ADT log data.
Message recipients (network traffic analysis)	Scope of stakeholders	[providers who received ADT alert] / [providers who are part of patient's care team]	ADT notification system log for message recipients; claims data to establish patient-centric provider networks. May not be feasible/practical.
Information use	How message recipients used information	Did the alert prompt the recipient to take any action? If so, what?	Survey or semistructured interviews of message recipients, task log data. May not be feasible/practical, although some HIEs have used similar metrics to calculate how often physicians use HIE data when they have the opportunity to do so.

3. *Intermediate Outcomes*

As a result of the key processes that triggered, sent, and used the ADT alert, provider communication and the provision of more timely and appropriate care for the patient improve. Use of the ADT alerts may also increase as adoption increases and/or providers recognize their value. These intermediate outcomes are described in the table below:

Intermediate Outcome	Measures	Description	Data Sources
Improved communication among providers and improved communication between providers and patients	ADT received and parsed into EHR. Did PCP know when their patient had been in the hospital?	[ADT alerts received and parsed into EHR] / [ADT events occurred]. [provider or care team member knowledge of ADT event] / [ADT events occurred among their patients]	Qualitative interviews or survey of provider/care team member/patients; EHR logs. May not be feasible/practical.
Increased efficiency through elimination of unnecessary paperwork			Workflow, qualitative survey, and time and motion analyses.
More appropriate care	Compare events where alerts did and did not occur, and before and after alert system was in place	[patients w/ADT events where recommended care was provided] / [all patients w/ADT events]	EHR, claims. May not be feasible/practical.
More timely care and/or improved transitions of care	Follow-up calls and visits scheduled/kept	Among patients eligible for transitional care management visit, how many had a phone call within 48 hours and a follow-up visit within 7–14 days?	Claims—transitional care management billing code.
Improved data quality and automation		Update patient demographic information; append information to multiple parties (e.g., high- utilizer flag)	

4. *Public Benefit Outcomes*

Many of the intermediate outcomes resulting from ADT alerts can reduce unnecessary utilization such as 30-day readmissions[42] and related costs. By automatically alerting the patient's provider network of the ADT event and prompting them to take timely and appropriate action, the ADT alerts are an important piece in the chain of events that can help prevent such unnecessary use.

Outcome	Measures	Description	Data Sources
Reduced unnecessary utilization	Reduced avoidable readmissions, admissions, ED visits; reduced	[patients w/ADT events where unnecessary utilization followed] /	Claims, AHRQ's PQ1 measures.

Outcome	Measures	Description	Data Sources
	ambulatory-sensitivity care admissions	[all patients w/ADT events] Compare events where alerts did and did not occur, and before and after alert system was in place	
Improved care coordination			NQF, medical home, or other existing measures
Increased patient safety	Adverse events	Reduced medication and medical errors through communication with other providers about what was prescribed at hospital	EHR, claims. May not be feasible/practical.
Reduced healthcare costs	Costs associated with reduced avoidable readmissions, admissions, ED visits	Estimated number of avoided events, cost per typical avoided event	Claims and cost/charge data.

Summary

In most cases, public payers stand to benefit greatly from investing in and promoting the use of ADT event notification alerts, given their potential to reduce unnecessary health care use and costs. These alerts are increasingly valuable to health systems and providers because increasingly both are paid to provide value over volume. Ultimately, patients will benefit from having their whole health team alerted when they have an ADT event. This process will prompt the action they need to ensure the best possible health outcome and prevent any avoidable loss of time, money, and productivity associated with unnecessary health care use.

Example 2. Using Medication Reconciliation to Reduce Adverse Drug Events during Care Transitions through Reduced Medication Discrepancies

Use Case Description
This use case focuses on the use of health information exchange for medication reconciliation (MedRec) to reduce discrepancies among documented medication regimens across different sites of care during care transitions. These discrepancies can lead to adverse drug events that result in longer hospital stays, readmissions, ED visits, or even death.[43] MedRec is the process of obtaining and verifying a complete and accurate list of a patient's current medications for consistent transmittal across care transitions. For example, MedRec may occur when a patient is discharged from the hospital back to their home if any changes were made to their medication regimen. The current and accurate list of the patient's medications should be shared with the hospital, pharmacies, doctors' offices, other facilities such as outpatient and skilled nursing facilities, and health plans.
Potential sub–use cases for medication reconciliation include

- Use of predictive analytics to put risk score on MedRec

- MedRec during care transition to hospital

- MedRec during care transition from hospital

- Use of community HIE or central cloud as central list, with clear rules for MedRec

- Promotion of communication between outpatient and pharmacy settings (e.g., canceled medications)

- Polypharmacy flags and alerts

- Support for medication therapy management for therapeutic and cost optimization

- Support for integrated care through shared medication lists across provider types

Use Case Framework

1. Structure	2. Key Processes	3a. Intermediate Outcome (provider workflow)	3b. Intermediate Outcome (patient care)	4. Public Benefit Outcomes
Exchange infrastructure to facilitate MedRec; provider incentives to prevent avoidable utilization	Notification of hospital admission; Med list sent from provider(s) and hospital; MedRec info sent from hospital to provider(s) at discharge	Reduced medication discrepancies between care settings	Fewer adverse drug events	Reduced lengths of hospital stay, readmissions, and ED visits; lower risk of death; lower health care costs for patients and payers

The use of a health information exchange to facilitate more consistent MedRec may be most valuable where payment incentives prevent unnecessary use such as avoidable hospital readmissions or ED visits. Once the system is in place, the MedRec process is initiated upon the provider's receipt of an ADT notification that their patient has been admitted to the hospital. Ideally, this notification would include a single medication list for each patient that all providers could work from to reference and

update, but in practice, there is no list that can serve as the single source of truth. More typically, the patient's provider will generate a list of active medications from the EHR and transmit it back to the hospital when notified that the patient has been admitted; the hospital updates with any changes made during the patient's hospitalization and transmits the list back to the provider upon discharge. Although this process can help prevent medication discrepancies across care settings that may result in patient harm during treatment at the hospital or after discharge, many experts agree that the capability to share and work from a single medication list would eliminate medication discrepancies. In the meantime, decreasing medication discrepancies is an important step toward reducing adverse drug events and in reducing lengths of hospital stays, readmissions, ED visits, and related deaths.

This framework is displayed in a linear manner, but in reality the steps are often more cyclical. In addition, this chain of events assumes that the hospital can identify providers actively caring for the admitted patient, and that enough information is sent to providers upon admission that they can identify the patient in their EHR to share the active medication list. Also, the framework assumes that patients and their families provided a comprehensive list of over-the-counter medications (including supplements) to providers and that this has been captured in the record.

1. *Structure*

Several electronic tools facilitate the exchange of information for more consistent and standardized MedRec by reconciling electronic data from different sources, such as pharmacy claims data, EHRs, and computerized physician order entry. A public or private health information exchange may also be leveraged to submit and receive information for MedRec.[44]

An electronic MedRec process typically relies on an ADT notification system in place, because these notifications trigger the MedRec process. The medication list sent by the patient's provider to the hospital may be included in a larger summary of care generated from the hospital's EHR. The ability to generate a summary that includes the current medication list and medication allergy list in a format that facilitates exchange (including Clinical Document Architecture (C-CDA), developed by HL7) was a Meaningful Use Stage 1 requirement, and the actual transmittal of this summary using the C-CDA format is a Stage 2 Meaningful Use requirement.[45]

Ideally, stakeholders are held accountable for the well-being of the patient through quality measurement, payment incentives, and/or some bearing of financial risk. The hospital would then have incentive to alert these providers of an ADT event, the providers would have incentive to transmit medication information, and the hospital would have incentive to send the reconciled list back to the provider upon discharge.

2. *Key Processes*

Key processes that must occur are the notification of hospital admission to the provider(s), provider transmittal of the patient's medication list to the hospital, and hospital return of MedRec information (a reconciled list) to the provider(s) and other relevant stakeholders (such as the pharmacy and health plan) upon patient discharge. Each of these processes may be measured as described in the table below.

Process	Measures	Description	Data Sources
Notification of hospital admission	ADT alerts sent to appropriate provider(s)	[admissions where ADT alert was sent] / [admissions occurred]	HIE transaction log for alerts sent, claims for admissions occurred.
Medication list sent from provider to the hospital	Transmittal of medication list (e.g., MU Stage 2 Summary of Care measure)	[providers who received ADT alert for admission] / [providers who transmitted medication list back to the hospital] MU measure: provider who transitions or refers patient to another setting of care or provider creates and electronically transmits a summary of care (including current medication list)	EHR log for transmittal of medication list (summary of care), claims data to establish patient-centric provider networks, MU attestation data.
MedRec completed by the hospital	Did hospital complete MedRec? Manually or automatically?		EHR log, semistructured interview or survey.
MedRec info sent from hospital to provider upon discharge	Transmittal and receipt of MedRec info	[discharges where MedRec information was sent from the hospital] / [discharges occurred]	HIE transaction log for MedRec info sent, claims for discharges occurred.
Provider performs MedRec	Did the provider compare the medical record to the external list received? (e.g., MU Stage 2 Medication Reconciliation measure)	MU measure: provider who receives a patient from another setting of care or provider or believes an encounter is relevant performs medication reconciliation	EHR log, MU attestation data.

3. *Intermediate Outcomes*

As a result of these processes, intermediate outcomes such as medication discrepancies and adverse drug events are reduced. These intermediate outcomes are described in the table below. MedRec may help individuals at risk of opioid abuse by identifying duplicate pain prescriptions.

Intermediate Outcome	Measures	Description	Data Sources
Medication	Addition, omission or	[number of medication	EHR data for readmission and

Intermediate Outcome	Measures	Description	Data Sources
discrepancies	duplication of medications; change in dosage, frequency, or formulation of medication	discrepancies] / [number of patients discharged]	discharge, medication lists from hospital, current medication list from provider, claims for discharges occurred.
Adverse drug events	Percent of admissions with adverse drug events	[number of admissions with adverse drug event] / [admissions occurred]	EHR data for adverse drug events, claims for admissions occurred.

4. *Public Benefit Outcomes*

By automatically initiating the MedRec process upon each hospital admission, HIE-facilitated MedRec is an important piece in the chain of events that must occur to prevent adverse drug events that can lead to unnecessary utilization (and associated costs) and even death.

Outcome	Measures	Description	Data Sources
Reduced unnecessary utilization due to adverse drug events	Reduced hospital length of stay, readmissions, admissions, and ED visits due to adverse drug events	[patients w/hospital admission where unnecessary use followed] / [all patients w/hospital admission]	EHR data for adverse drug events, claims for hospital admission and unnecessary use.
Reduced health care costs	Costs associated with hospital length of stay, readmissions, admissions, and ED visits due to adverse drug events	Estimated number of avoided events*, cost per typical avoided event	Claims and cost/charge data.
Death	Death resulting from adverse drug events	[patient deaths due to adverse drug event] / [all patients w/hospital admission]	EHR data for adverse drug events and death, claims for hospital admission.

Summary
Adverse drug events are estimated to result in 1 million ED visits and 280,000 hospitalizations a year and are associated with $3.5 billion in annual excess medical costs.[46,47] The use of IEHI to ensure more consistent MedRec to reduce drug discrepancies may contribute to the reduction of avoidable health care utilization and associated costs. Ultimately, the reduction of patient harm is the greatest benefit. In addition, as providers are increasingly paid for value over volume, the incentive to avoid unnecessary health care costs increases. Payers also benefit from the reduction in cost.

AHRQ and others have noted that medication reconciliation between the hospital and providers is important but not sufficient to prevent adverse drug events that may lead to unnecessary utilization.[48] Some studies have found that patient engagement and pharmacy involvement may help prevent adverse drug events as well.

Example 3. Closure of the referral loop to improve safety and efficiency through better care coordination between primary care and specialist providers

This use case focuses on closing the loop between primary care and specialist providers during referrals, a foundation of care coordination. Closing the loop describes a process whereby consultation requests, relevant information, and findings from an episode of care flow bidirectionally between the EHRs of referring providers and other health care professionals; this typically occurs between a primary care provider and specialist health care providers.[49] Closing the loop can reduce duplicate and unnecessary testing, reduce delays in diagnosis, optimize medication prescribing, and increase safety through improved and timely care coordination.[50] These alerts are especially valuable to primary care providers, payers, and consumers.

Potential sub–use cases for closing the referral loop include

- Referral decisions resulting in entry into specialty care or causes for decline of specialized care
- Types of referral consultations (e.g., consulting or procedural) and their relationship to closed referral loops and provider communication
- Comanagement (e.g., shared care or principal care) strategies as a predictor of efficiencies from closing the loop
- The relationship of referral loop communication to resource use (services, costs) and the relationship of referral loop communication to the quality of care (e.g., appropriateness, timeliness, efficacy, safety)
- The relationship of referral loop communication to patient satisfaction
- The effect of MIPS Quality Measure 374 (Closing the Referral Loop: Receipt of Specialist Report on care coordination).

Use Case Framework

A closed-loop referral occurs when a provider electronically sends a referral or consultation request and relevant patient information (including administrative and clinical data) to a provider either within or outside a network, potentially using EHRs from different vendors. This is accomplished from within the workflow using the provider's EHR. The consulting provider receives that request and information directly within an EHR and then either accepts or rejects the consultation. If the consulting provider sees the patient, there are three possible outcomes: short-term consultation (e.g., one visit), comanaged care, and transferred care. Regardless of the outcomes of patient encounters, a consultation summary and other relevant information are exchanged directly back to the referring provider's EHR. The referring provider then takes action based upon the summary and information, thereby closing the loop.

The process of a closed-loop referral using IEHI is most useful in a value-based care environment where payment incentives help prevent unnecessary use and optimize care. The referral process is complicated because of interoperability technical standards and workflow challenges, and because providers can have different methods for referrals and wide parameters for referral networks. In addition, a variety of intermediate processes and outcomes are necessary to support closed-loop referrals.

One comprehensive systematic review of the literature of the performance measures of the specialty referral process identified limited measures available for assessing the process and outcomes of referrals.[51] Drawing from 214 studies published between 1973 and 2009, the authors found 244 unique referral metrics. Based upon a non–mutually exclusive categorization, 60 percent assessed structural features, 34 percent processes, and 19 percent outcomes. Methodologically, 62 percent of the studies used surveys, 31 percent manual chart reviews, and 20 percent administrative claims data. These studies were conducted before HITECH with no focus on interoperability. The authors found few to no measures of quality, effectiveness, efficiency, or patient-centeredness within the context of coordination and identified no measures of safety.

1. Structure	2. Key Processes	3a. Intermediate Outcome (provider workflow)	3b. Intermediate Outcome (patient care)	4. Outcomes
Certified EHRs, exchange solution, MPI, incentives to encourage coordination	Request for consultation, exchange, physician address ID, patient matching, consultation acceptance, patient entry into care, exchange of consultation summary, use of summary data	Incorporation of consultation request and relevant information into workflow, returned communication of consultation summary and relevant data into workflow	Improved care coordination with appropriate actions taken based upon consultation	Reduced unnecessary use, timely patient care, medication optimization

1. *Structure*

Closed-loop referral management is most easily supported and automated within a single vendor system. The use case where the referring and consulting providers have different EHR vendors creates the greatest challenge for intermediate processes and outcomes. A closed-loop process requires IEHI through a transport technology, likely an IDN, vendor network, public HIO/HIE, or a direct peer connection. It also

requires successful patient matching between the systems used by the two providers and the exchange (if used). Upon receiving the request, the consulting provider must either accept or reject the referral. If the referral is rejected, that must be communicated back to the referring provider's EHR system.

If the patient is seen, the EHR system at the consulting provider facility must be able to accept the documents and information and parse them into the EHR such that they may be integrated into the provider workflow. One challenge is ensuring that the information is targeted and tailored to the needs of the consultation. After a patient encounter, the consultation note and other pertinent data must be transmitted back to the referring provider and parsed into the EHR and integrated into the workflow such that the provider can act upon the information.

2. *Key Processes*

Key processes that must occur are the initiation of a consultation request, identification of the consulting provider address based upon the exchange technology used, patient matching, exchange with an EHR and workflow integration, an encounter between the patient and provider, exchange back to the requesting provider's EHR and workflow integration, and action taken based upon the information. This is summarized below:

Process	Measures	Specification	Data Sources
Electronic Consultation Request	Number of eRequests compared with total number of consultation requests	[number of consultation requests transmitted electronically] / [number of consultation requests]	EHR log, HIE transaction log
Consulting Physician Address ID	Consulting physician's address successfully identified (e.g., HISP has DSM address)	[number eRequest bounce backs due to address/total number of eRequests]	EHR log, HIE transaction log
Patient Match	Successful patient ID match between the two systems	[number eRequests rejected due to patient ID failure/total number of eRequests]	EHR log, HIE transaction log
Electronic referral declined	Indication to referring provider that referral is declined	[eMessage to referring provider of rejection/ total number of eRequests]	EHR log, HIE transaction log, count of other communication modes for decline (fax, phone)
Patient entry into specialty care	Patient is seen by the specialty provider	number of patients who attend first specialty visit/number of patients accepted by specialist	EHR log, claims data
Exchange of Consultation Summary (Electronic portion of the loop is closed)	Referring provider receives consultation note and other relevant data within EHR	[number of consultation notes received] / [number consultations requested] Meaningful Use eCQM identifier CMS50v3	EHR log, HIE transaction log, MU attestation data

Process	Measures	Specification	Data Sources
		"Closing the Referral Loop: Receipt of Specialist Report"	
Use of Information	Referring provider uses information	Indication that action taken	EHR, qualitative measures, claims data

3. *Intermediate Outcomes*

The intermediate outcomes are primarily clinical and are associated with improved care coordination. They include improved provider communication, timely diagnosis, more timely care, increased patient safety. These intermediate outcomes must be accomplished within the context of integrating the consultation request and information with the consulting physician's workflow and consultation notes, including workups and tests within the workflow of the referring provider. A summary is below:

Intermediate Outcome	Measures	Specification	Data Sources
Improved communication among providers	Consultation requests received and parsed into EHR. Consultation summary received and parsed into EHR.	[number of consultation requests transmitted electronically] / [number of consultation requests] [number of consultation notes received] / [number of consultations requested] provider and care team member view of completeness and efficiency of process	Qualitative interviews or survey with provider/care team member, EHR log, HIE network analysis.
Improved care coordination	NQF, medical home, or other existing measures	Assessed needs and goals (PCP develops care plan including specialist consultation/referred patients)	Qualitative interviews, surveys, chart review, claims
More timely diagnosis	Time to diagnose and treat	Length of time from initial referring provider appointment to treatment by that provider	Longitudinal study with control group using EHR, claims.
More appropriate care	Appropriate tests and treatment	Compare treatment protocols for IEHI closed-loop referrals and non-IEHI referral processes	Longitudinal study with control group using EHR, claims
Increased patient safety	Reduced medication and medical errors, appropriate patient self-management	MedRec (assessment of medication regime at all points of care or referred patients seen), patient self-management through adherence, behavior change	EHR medication data, claims data, summary care notes, prescription data

4. *Outcomes*

The literature provides substantial evidence of the benefits of care coordination. In this use case of closing the referral loop, coordination may result in the following outcomes: reduced unnecessary utilization, timely patient care, reduced healthcare costs, and increased revenue.

Outcome	Measures	Specification	Data Sources
Reduced unnecessary utilization	Reduced duplicative tests, optimization of medication, appropriate workup	Compare treatment for IEHI closed-loop referrals and non-IEHI referral processes	Claims.
Reduced healthcare costs	Costs associated with reduced avoidable admissions, tests, and treatments	Compare treatment for IEHI closed-loop referrals and non-IEHI referral processes	Claims and cost/charge data.
Increased revenue	Revenue related to greater efficiency, quality and performance improvement targets, qualifying for payment incentives	Provider eligibility for performance payments through quality measurement criteria	Public reporting on provider's quality, information on qualifying for incentives, revenue.

Summary

For patients, providers, and payers, the seamless integration of a closed-loop referral process provides benefits including timely diagnosis and treatment, appropriate and optimal medications, avoidance of unnecessary tests and studies, and improved communication between all stakeholders. Central to achieving these process efficiencies and outcomes is the integration of the referral and consultation processes into providers' workflow, which requires the exchange of appropriate information through interoperable systems.

Methods for Analysis in Use Case Studies

A range of methodologies and analytic approaches may be used in conjunction with a use case study. The use case template is designed to identify a specific IEHI use case, lay out the theoretical causal chain between structure/processes and desired outcomes, and identify measures that may be used in each step of the causal chain. Once this exercise is complete, the researcher must determine which measures can be calculated; which study design to use, based on the data available during the relevant time periods; and what a suitable comparison group would be. The following factors should be considered:

- **Measures.** At minimum, a process measure of IEHI use and an intermediate outcome measure should be used because these steps indicate whether there was an opportunity for public benefit outcomes to occur.

- **Time period considerations.** The study should include data covering more than one time period. Ideally this would include baseline observations before the use case was implemented, but it is often difficult to define the pre-period because EHR implementation and IEHI use are often gradual. Although baseline data are needed to estimate the impact of the IEHI use case, multiple observations without a pre-period would still allow for estimates of the association between the measures of focus. For example, multiple observations over time will allow the researcher to examine the correlation between IEHI use and intermediate outcomes (i.e., as use increased, did the expected intermediate outcome also increase?).

- **Comparison group.** Identifying a suitable comparison group can be difficult because an IEHI use case is typically implemented across an entire organization. A study could compare similar organizations or similar units within an organization that differ in their use of IEHI, but other differences between these units could drive differences in outcomes observed. One advantage of focusing on a specific use case rather than the presence or absence of IEHI infrastructure is that the providers within a given organization likely vary in the consistency with which they use the specific IEHI functionality as intended. This may provide opportunities to compare providers based on how frequently they use the IEHI functionality, or to compare patient visits where the IEHI functionality was or was not used.

Depending on the availability and timing of data and the comparison group, the researcher may pursue an experimental, quasi-experimental, or descriptive design (see Exhibit 7).

Exhibit 7. Potential Designs for Use Case Studies Based on Data Availability

	Random assignment	Pre-test (or multiple observations over time)	Comparison group	Post-test
Experimental	X	X	X	X
Quasi-experimental		X	X	X
Descriptive				X

Because the gold standard of an experimental design (such as a randomized controlled trial) is often not possible (e.g., because the researcher cannot randomly assign who does and does not adopt IEHI), a quasi-experimental study design is the second-best approach. A common quasi-experimental design could examine outcomes before and after an identifiable IEHI use case is implemented (pre-post analysis) or as use of the IEHI functionality increases (time series or trend analysis) for a group of affected participants (or providers) relative to a comparison group not affected by the change (difference-in-difference analysis). For this design type, researchers could estimate multivariate regression models that compare intermediate outcomes (e.g., workflow, patient outcomes, and costs) where IEHI is occurring with the same outcomes in areas or for providers where IEHI is not occurring. Researchers could also use a propensity score reweighting method (or other method if appropriate) to match the treatment group (i.e., patients in provider settings for whom IEHI is used during their care episode) with a comparison group based on observable provider, area, and patient characteristics (e.g., demographics and health status) available in the given data source. Impacts would be assessed based on adjusted comparisons between the experiences of the treatment group and comparison group during the period of IEHI use.

The feasibility of conducting a strong quasi-experimental design evaluation depends on the following:

- The ability to examine outcomes before and after an identifiable policy or system change (pre-post analysis)

- The ability to separately identify the effects associated with IEHI from other interventions that aim to improve public benefits (such as by focusing on care episodes where IEHI was used and expected outcomes from that use, or by including fixed effects to account for differences among individual patients or providers)

- The ability to identify a comparison group not affected by the change (such as care episodes where IEHI was not used) and to analyze outcomes over the same period

- Access to administrative or clinical data (e.g., claims and/or EHR data) to assess outcomes (e.g., 30-day post-hospital discharge readmission rates and hospital admission rates from the emergency room)

- Information about provider characteristics and the types of IEHI occurring, which could be obtained from network servers for public or private HIEs.

If data are not consistently available over multiple points in time or for a comparison group, a descriptive case study may also contribute useful evidence on the particular IEHI use case. A case study is an "empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between the phenomenon and context are not clearly evident."[52] Although experimental and quasi-experimental study designs are well suited to answer explanatory research questions on the relationship between a well-defined treatment and outcome, a case study approach is often preferred when the variables may be more difficult to define. A logic model can analyze case study evidence by laying out a complex chain of events over time, similar to the framework used in the use case template.[53] In this way, the case study allows consideration of a variety of evidence to describe the actual chain of events compared with the expected model. Case studies often use a variety of data sources to examine these interrelated issues, including quantitative and qualitative data based on the best information available, and the types of information best suited to answer the research question. For example, interview data may help describe the patterns of and barriers to use of a specific IEHI functionality if process measures are not available. Measures of intermediate outcomes or public benefit outcomes over the period described may be included in the narrative. These types of studies may complement quasi-experimental studies and inform interpretation of findings.

Conclusion

The overall aim of this project was to develop methods and measures that can be used to quantify the public benefits that result from IEHI. In this report, we conceptualize the mechanism through which these public benefits may occur using Donabedian's framework for measuring quality, using structure, process, and outcomes as the domains. Key findings from the initial phase of this project—literature review, concept paper, and first round of SME discussions—include the following:

- The current empirical evidence on the public benefits associated with IEHI is limited. Based on the available evidence on public benefits, the most promising starting point appears to be the ability of HIE to reduce use of repeat and unnecessary imaging and perhaps hospital admissions.

- There is limited information on the impact of IEHI on health care costs and outcomes.

- Measuring interoperability itself is extremely challenging, and there is no single "silver bullet" measure that will tell us whether interoperability has occurred.

- There is limited information on whether providers can access the information they need to improve patient care through IEHI.

- The competitive environment and inadequate business case for providers impedes widespread use of IEHI.

- The lack of uniform definitions and standards has resulted in a patchwork of varied, siloed approaches to health information exchange.

- Little information is available about the cost of building and operating an HIE, and many state and community HIEs are considered unsustainable.

- Interoperability technology remains prohibitively costly for many providers.

- Most available data rely on surveys of providers, provider networks, or HIEs.

Most recent studies had limited ability to make causal inferences because of the lack of pre-IEHI baseline information, lack of a comparison group showing results where there was no IEHI, and lack of information on whether IEHI data was actually being used. Thus, several confounding factors likely played a role in the outcomes studied, which included concurrent implementation of payment and delivery system reforms and other quality improvement initiatives.

Using the information collected from a variety of sources in the beginning of this project, we identified a use case approach to identifying measures that can be used to help fill gaps in existing literature and demonstrate public benefit while avoiding some methodological challenges. Primarily, we aim to address the lack of data to support the IEHI use measures that enable robust evaluation of the impacts associated with IEHI and to gather such data from study settings where valid results can be obtained (e.g., where IEHI technology is sufficiently mature and where the technology is actually being used). The use case approach also considers the evolving nature of the technology and how to better quantify the process and intermediate outcomes that are part of the causal link between IEHI and public benefits.

The use case approach may be a useful vehicle to collect and present information that can help address market barriers to IEHI. For example, use cases have historically been developed by HIEs to

describe the value proposition of their services in attempts to justify fees. By focusing on specific uses of IEHI and their potential benefits, this approach may help build the business case for IEHI.

However, we do not mean to suggest that there is no value in other approaches to IEHI benefits assessment, as each has its own pros and cons. The use case approach opts for more granular, logically related measures and robust study designs on a smaller scale over less accurate and less related measures at a higher level. A variety of approaches may contribute to the complete story of how IEHI is influencing public benefits.

The NQF Interoperability Framework calls for applying a use case approach to advancing the measurement of interoperability. NQF recommends developing a "library" of use cases and measures based upon those use cases, similar to what this project has begun. This work illustrates the implementation of those next steps recommended by NQF. Potential next steps would use the template in this report to develop a broader library of use cases that can be prioritized for further development of measures. These use cases can be prioritized based upon the outcome areas identified by this project and the NQF framework. Ultimately, such measures could be deployed in real-world settings to report on progress related to interoperability at the local, regional, state and/or national level. In parallel, another next step would test the application of use cases and associated measures in real-world settings that have implemented the specific IEHI functionalities in the examples described in this report. This would allow the measures to be tested and refined, as well as generate new evidence on IEHI benefits. ASPE and the Office of the National Coordinator for Health Information Technology (ONC) may also consider applying the use case approach to study the results of future IEHI efforts.

Appendix

Technical Expert Panel

Melinda Buntin, *Vanderbilt University*

Robert Rudin, *Rand Corporation*

Jeff McCullough, *University of Michigan*

Gordon Schiff, *Brigham and Women's Hospital*

Jason Shapiro, *Mount Sinai*

Michael Furukawa, *ARQH*

Kevin Larsen, *CMS*

Joshua Vest, *Indiana University*

Jonathan Kolstad, *University of California Berkley*

Mark Frisse, *Vanderbilt University*

John Halamka, *Harvard Medical School*

Subject Matter Experts

Kevin Larsen, *CMS*

Rim Cothren, *CAHIE*

Gary Dickinson, *CentriHealth*

Tim Pletcher, *MHIN*

David Kendrick, MyHealth Access Network

Patricia Fontaine, *HealthPartners*

Hardeep Singh, *Baylor College of Medicine*

Jesse James, *Evolent Health*

William Hersh, *Oregon Health and Sciences University*

Mariann Yeager, *Sequoia Project*

Paul Uhrig, *Surescripts*

Steven Lane, *Sutter Health*

Susan Otter, *Oregon Health Authority*

Gordon Schiff, *Brigham and Women's Hospital*

Micky Tripathi, *Massachusetts eHealth Collaborative*

Thomas Simmer, *Blue Cross Blue Shield of Michigan*

Angela Mitchel, *Intel*

Ellen Ward and Lynda McMillin, *Blue Cross Blue Shield of Michigan*

Chris Longhurst, *UC San Diego Health*

Dean Sittig, *UTHealth School of Biomedical Informatics*

Marni Greenberger, *HIMMS*

Farzard Mostashari and Travis Broome, *Aledade*

Joshua Vest, *Indiana University*

David Hunt, *ONC*

Brian Ahier, *Medicity*

Lynda Rowe, *InterSystems*

Kristen Lynch, *athenahealth*

David McCallie and Meg Marshall, *Cerner*

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