STATE MEDICAID POLICY LEVERS RELATED TO SUCCESSFUL HEALTH INFORMATION EXCHANGE AMONG PROVIDERS

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ABSTRACT

Sepheen Chung Byron: State Medicaid Policy Levers Related to Successful Health Information Exchange Among Providers
(Under the direction of Christopher Shea)

Background: In the U.S., patients seek health care across a variety of settings. Many providers must manage care without needed information about the patient's history, past services or experiences. Health information exchange (HIE), the process of securely and appropriately sharing a patient's medical data electronically, can enable coordinated, effective and efficient care by providing a fuller picture of the patient's health. Despite legislative and regulatory efforts, meaningful sharing of clinical information for patient care remains elusive. States as payers of Medicaid may be poised to effect successful HIE.

Purpose: To assess whether state Medicaid policy actions implemented in the context of the 2009 Health Information Technology for Economic and Clinical Health Act promoted HIE among health care providers.

Methods: A coincidence analysis, a mathematical, cross-case approach, was conducted to assess which levers implemented by Medicaid agencies in 20 states could be considered difference makers for HIE among health care providers. States were categorized as having HIE based on the proportion of providers that reported exchanging data outside their systems. Results were reviewed with a Medicaid stakeholder panel to inform a plan for change.

Results: State Medicaid agencies assessed in this study used a variety of policy levers in the areas of technical assistance, infrastructure investment and financial incentives and mandates. The coincidence analysis revealed two strategies that were consistently present among states that demonstrated data sharing. States that had HIE were those that assisted with electronic clinical quality measure submissions and used financial incentive programs to incentivize HIE, or invested in a statewide HIE organization and laboratory infrastructure but lacked financial incentive programs.

Conclusion: Combining Medicaid policy levers in at least one of two ways made a difference for HIE. The success of specific forms of infrastructure investment was conditional on the use or absence of financial incentive programs, which suggests the burden of increased requirements on clinicians engaged in multiple quality improvement efforts may distract from HIE. State Medicaid stakeholders supported these conclusions and recommended actions such as aligning HIE efforts across programs and capitalizing on strategic priorities for Medicaid in order to address the complex issue of HIE.

To Leila, my tiniest yet most effective study buddy.

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LIST OF ABBREVIATIONS AND SYMBOLS

CCM	Configurational comparative method
CMS	Centers for Medicare & Medicaid Services
CNA	Coincidence analysis
COVID-19	Coronavirus disease 2019
encamp	Electronic clinical quality measure
EHR	Electronic health record
HIE	Health information exchange
HIO	Health information exchange organization
HIT	Health information technology
HITECH	Health Information Technology for Economic and Clinical Health Act
INUS	Insufficient but necessary parts of a configuration of conditions which is itself unnecessary but sufficient for the outcome
IIS	Immunization information system
msc	Minimally sufficient condition
NCQA	National Committee for Quality Assurance
NEHRS	National Electronic Health Records Survey
ONC	Office of the National Coordinator for Health Information Technology
SDoH	Social Determinants of Health
SMHP	State Medicaid Health Information Technology Plan
*	Within a configuration, this symbol indicates the Boolean operator AND
+	Within a configuration, this symbol indicates the Boolean operator OR
<->	Within a configuration, this symbol indicates *if, and only if*

CHAPTER 1: INTRODUCTION

Statement of the Issue

Health information exchange and its benefits

Nearly two decades ago, the Institute of Medicine stated that collecting health information about a patient in a purposeful and standardized way is one of the most important ways to promote provision of effective care.[1] The Institute's prominent health care quality report reprehended the existing system's disorganized, uncoordinated and siloed approach, in which providers across the patient's care continuum operate without the benefit of key data.[1] Such sentiments were early appreciation for *Health information exchange* (HIE). HIE is the process of securely and appropriately sharing a patient's medical data electronically.[2]

HIE can enable coordinated, effective and efficient care by providing care teams with a fuller picture of the patient's health.[3] Given the variety of settings in which patients seek care, having the data readily available to health care providers has been shown to improve clinical decision-making, reduce redundancies and decrease medical errors.[4] A systematic review of studies published between 2005 and 2016 showed HIE can improve health care quality and produce cost savings.[5]

While HIE can benefit the patient in the form of better care, payers may also benefit.[6,7] In the U.S., at a basic level, payers include private health insurance plans as well as public payers --- primarily the federal government and states through funding of Medicare and Medicaid.[8] Cross et al.[7] identified six HIE use cases that ranged from improved care management of enrollees, such as identification of needed screenings, to more informed care coordination, such as monitoring of hand-offs between providers. In addition, an important HIE use case was quality reporting to identify performance gaps, fulfill pay-for-performance reporting requirements, and create metrics for use in value-based purchasing.[7]

Legislative and policy efforts

Recognizing the benefits of HIE, several large-scale initiatives were enacted to accelerate the adoption and meaningful use of health information technology (HIT). Most notable was the Health Information Technology for Economic and Clinical Health (HITECH) Act, passed in 2009 as part of the American Recovery and Reinvestment Act.[9] Through HITECH, legislators used a staged and building-block approach to address the foundational needs of HIE. At the provider level, HITECH's programs focused first on electronic health record (EHR) uptake and subsequently nudged providers towards the more advanced goal of HIE through use of payment reform, incentives and, eventually, penalties.[9] At the technical level, HITECH focused on interoperability, the access and exchange of electronic health information for authorized use without special effort by the user, by setting national standards for data capture and sharing.[10,11] At the policy level, HITECH's programs addressed drivers of HIE by establishing privacy and security protections for electronic data; access to technology; and organizational interfaces that enable data exchange.[12]

Appreciating the critical role of states in building capacity for exchanging data, HITECH provided over $540 million in the form of state cooperative agreements to support state- and regional-level HIE.[9] In 2010, 56 eligible territories, states and qualified State Designated Entities received HITECH funding. States were charged with monitoring provider HIE capabilities, implementing privacy and security requirements; ensuring consistency with national standards; and integrating the approach for Medicaid and public health programs.[13] By engaging states, HITECH allowed for a tailored approach to meet local needs to enable HIE.[14] States could pursue models of HIE that were least disruptive to existing regulations, relationships and infrastructure.[15]

Barriers to health information exchange

Despite the benefit of improved data flow and focused efforts of federal and state governments, meaningful exchange of clinical information for patient care remains uneven and fragmentary.[3,16–18] In its tracking of the HIT landscape across health care providers, the Office of the National Coordinator for Health Information Technology (ONC) found that HITECH was successful in producing a dramatic increase in the use of EHRs over the past ten years. For example, in 2009, 16 percent of non-federal acute care hospitals had adopted an EHR system; by 2015, the number was 88 percent. However, ONC tracking shows that less than half of these systems were considered “comprehensive” (defined as implementation of EHR functions across all hospital units).[19] Still fewer were able to engage in activities to support HIE. In 2017, less than half of hospital providers could find, send, receive and integrate patient information electronically from external sources.[20] The most frequently cited barriers were difficulty integrating information into EHRs, lack of timeliness of information, user-unfriendly formats, and challenges locating patient information that is specific and relevant.[20]

While interoperability of various HIT systems is a concern, the barriers to successful health information exchange are not solely technological. A federally-commissioned systematic review examining HIE in the U.S. found lack of a critical mass of participants to be a key barrier.[21] Studies have found that poor participation among both providers and patients arises from several factors. For providers, data ownership questions, liability concerns, inadequate EHR functionality, and poor data quality disincentivize HIE.[17,22] For patients, privacy concerns, security worries, and unfamiliarity with HIE and its benefits hamper participation.[23] At a state policy level, more restrictive HIE policies, such as *opt-in* consent models that require patients to explicitly enroll (as opposed to *opt-out* policies that automatically enroll patients), can lower participation.[24]

Moreover, the intensity of efforts to improve data exchange may, ironically, hinder it. The multitude of federal-, state-, community-, enterprise- and vendor-level initiatives that have burgeoned across the country have produced data exchange that is highly heterogenous.[25] This heterogeneity has resulted in barriers that span myriad areas, including technical, financial and regulatory spheres, and that involve diverse stakeholders.[12,25] The role of the private health care market in the U.S. further complicates matters. As health systems compete to increase their market share, patient data are seen as an asset that confers a competitive business advantage to the owner.[25] As a result, health systems have at best weak incentives to overcome obstacles to sharing a patient’s clinical data with competing health systems. At worst, health systems experience perverse incentives, which result in information blocking.[26,27]

Background

Models for exchanging data

Health information exchange can be classified along several different dimensions. Two key features of HIE are the method of data exchange and the structure governing the exchange. ONC describes three methods of data exchange:[2]

- *Directed Exchange* ("push" exchange) describes methods providers use to send secure patient information to another provider or entity;
- *Query-Based Exchange* ("pull" exchange) describes methods providers use to obtain patient care information by searching for or requesting it from other providers or entities;
- *Consumer-Mediated Exchange* describes methods patients use to collect or direct the use of their health information among providers.

HIE governance structures fall into three main types:[25]

- *EHR vendor HIE networks* describe health information exchange within a community of provider organizations that use the same EHR system;
- *Enterprise HIE networks* exist when provider organizations engage in health information exchange with some restriction, beyond geography, that dictates which organizations participate;
- *Community HIE networks* describe health information exchange among provider organizations in a community, usually defined by geography.

The ways in which HIE is structured and governed produce a range of behaviors that can contribute to its success or failure. Regarding how data are exchanged, different mechanisms are needed for different scenarios, as described by Holmgren and Adler-Milstein.[25] Push exchange is ideal for scenarios in which there is a known information gap and known information source. Examples are post-discharge transitions from hospitals to skilled nursing care settings. Pull exchange, on the other hand, is needed for scenarios in which there is a known information gap, but the information source is unknown. Examples are instances when a patient outside a hospital's data system presents for emergency care. Each mechanism requires varying degrees of human effort, with many opportunities along the way for data flow collapse.

Regarding how HIEs are governed, different configurations can produce different motivations for engaging in --- or blocking --- data sharing. Studies have found that enterprise and vendor HIE networks typically restrict HIE based on strategic proprietary interests.[28,29] Community and state HIE networks, by contrast, regard HIE as a public good and therefore are less restrictive.[25] The latter are often referred to as health information exchange organizations (HIOs), and these organizations figured prominently in state strategies for promoting HIE.

State levers for HIE

Given the local and regional nature of HIE, HITECH provided substantial funding and support to states to begin building the foundation needed for successful data exchange.[9] HITECH made available incentive payments for Medicare- and Medicaid-paid eligible providers and hospitals to achieve *Meaningful Use*, defined as 1) use of certified EHR technology in a "demonstrably meaningful manner," 2) the electronic exchange of health information to improve health care quality, and 3) reporting of clinical quality and other measures to the Secretary of Health and Human Services.[30] For certain providers ineligible for the Medicare component of the program, the state Medicaid EHR Incentive program provided a means for participating in HIT capacity-building activities. Such providers included those practicing predominantly within federally-qualified health centers and rural health clinics, which are paid using a prospective payment system rather than Medicare's resource-based relative value scale.[31]

Importantly, HITECH provided funding for state Medicaid agencies to implement and administer the Medicaid EHR Incentive Program. While most administrative functions for Medicaid are reimbursed at a 50 percent federal matching rate, states were eligible for a 100 percent matching rate for incentive payments made to Medicaid hospitals and eligible providers, and a 90 percent matching rate to cover costs of administering the program.[9] Examples include onboarding of eligible providers to the program and the design, development and implementation of public health infrastructure.[32,33] To ensure fidelity to the process, Medicaid agencies were required to seek approval from the Centers for Medicare & Medicaid Services (CMS) for several planning documents that outlined their activities. Key among these documents was the *State Medicaid Health Information Technology Plan* (SMHP). The SMHP delineates how the agency will integrate and promote current and planned Medicaid HIT activities within the larger state HIT roadmap.[32]

In addition to federal financial participation for states to administer the Medicaid EHR Incentive Program, HITECH implemented the State Health Information Exchange Cooperative Agreement Program. As noted, all states received funding under this program. The program allowed grantees to develop new HIE infrastructure or leverage existing work, recognizing that different approaches would be needed in different states.[34] The program emphasized the immediate priority of ensuring all eligible providers had at least one option available to meet the HIE requirements of the Medicare and Medicaid EHR Incentive Programs.[34]

States implemented a wide range of activities with HITECH funds. An evaluation of state grantee actions under this program documented the following approaches:[35]

> *Technical Levers*. State technical approaches focused on establishing HIOs to facilitate the exchange of data. Most grantees (70%) chose to support a single, statewide HIO.[35] In addition, the majority of grantees (79%) implemented approaches to make exchange of data more available by providing or contracting for direct secure messaging services. States also, in many cases, offered HIE services such as quality reporting, electronic reporting of immunizations, submission of reportable lab results, and public health agency reporting.
>
> *Legal and Policy Approaches*. Legal approaches frequently took the form of legislation that required or incentivized provider participation in EHR use, HIE or both. Many states required that Medicaid-reimbursed providers connect with the state or community HIO. Legislation also addressed privacy and security concerns associated with patient data sharing. Policy approaches included financial incentives, accreditation and certification requirements, and restructuring of consent policies to ease patient participation.

HITECH provided an immense boost to state HIT development, with each state receiving significant dollars to invest in HIE activities. However, the majority of funding has since been disbursed, and meaningful HIE has remained elusive. An understanding of policy levers that have contributed to data sharing is needed.

Study Scope and Significance

Study purpose

This study aimed to understand what actions at a state Medicaid policy level promote health information exchange. HITECH recognized the importance of complementing federal policy with state-level efforts in order to achieve HIE.[18] State Medicaid Agencies, in their role as payers of health care for over 72.1 million individuals,[36] can play an integral role. States can influence the HIE landscape by capitalizing on its role as a payer for Medicaid and the Children's Health Insurance Program, and as a licensing authority.[37] Therefore, this study examined state efforts, with a focus on Medicaid agency activities, to understand whether policy levers implemented in the context of HITECH improved HIE.

The study examined this issue in several ways. First, a literature review was conducted to assess whether use of a health information exchange organization improved data quality. These organizations figured prominently in many state Medicaid agency efforts to improve data exchange. Second, state Medicaid policy levers were collected by reviewing HIT-related documents, and a coincidence analysis was conducted to assess which policy levers, either individually or in combination, contributed to health information exchange. Last, results were presented to a panel of Medicaid agency staff engaged in HIE efforts in order to inform a plan for change.

Significance and rationale

Understanding the levers that bring about HIE can contribute to effective care. HIE can improve the coordination of health care both horizontally and vertically. Horizontally, HIE can facilitate communication across the commonly broad range of providers participating in a patient's care. Providers can access data that inform procedures and care plans for patients who flow across numerous and diverse settings, including primary care, specialty care, hospitals, pharmacies, and laboratories. Vertically, HIE can expedite the transfer of critical information between clinicians on the ground and policymakers and other entities charged with safeguarding public health. Public health agencies can access data that help them to monitor the incidence and prevalence of disease, manage outbreaks and respond to other critical situations.[38] Moreover, HIE is the foundation of a learning health system.[39] Perhaps most importantly, HIE is an enabler of sound population health management. Consolidated, usable and accessible data can trigger completion of needed screenings and interventions, improve monitoring of chronic conditions and maximize the efficiency of overall health care services.[3,40,41] To the extent that HIE improves care coordination, HIE can minimize errors and enhance patient safety.[42]

An uncoordinated data system, by contrast, can result in an overburdened health care system that does not provide optimal care for patients, or that cannot respond effectively to crises. The ongoing public health emergency due to coronavirus disease 2019 (COVID-19) provides perhaps the starkest illustration of this problem in the U.S.[43–45] Attempts by the federal government to collect COVID-19 testing information exposed a patchwork system of completely nonstandard data that was highly dependent on manual processes such as faxing.[46] The inability to share race and ethnicity data during the pandemic compromised the ability to allocate much-needed resources and attention to marginalized communities that were disproportionately suffering the effects of the pandemic.[39,46] The consequences of these HIE shortcomings have been profoundly damaging. Incomplete and poor-quality data became the basis for operational decisions, travel bans and resource allocation, and hampered crisis response and management efforts.[46,47] Conflicting information resulted in a lack of clear guidance, which eroded public trust.[46]

HITECH was an important step towards advancing HIE. However, HITECH only partially addressed the impact of the variation of state policy environments on data exchange.[18] The state HIE strategy enabled states to build on their existing HIE environments and develop plans that respond to regional and local concerns. While a tailored approach is sensible given the diversity of HIE needs across the U.S., an understanding of what combination of levers contributed to successful HIE would be useful to state and federal policymakers. The evaluation of the State HIE Cooperative Agreement Program yielded early information about what actions states initiated under HITECH, but a comprehensive study evaluating the longer-term success of these strategies has not been conducted.

As the barriers preventing meaningful exchange of electronic health information are diverse and wide-ranging, a combination of tools likely will be needed to move HIE forward. The results of this study can be used to inform strategies for improving HIE. State Medicaid agencies may serve as useful models for how to address the procedural, social, political, and proprietary-driven issues that currently inhibit HIE. As the health care system moves more resolutely towards value-based payment, states may be the entities to align incentives across the diversity of providers whose cooperation is needed to achieve successful data exchange.

CHAPTER 2: LITERATURE REVIEW

One model for facilitating data exchange is the use of a health information exchange organization. As noted, state engagement was seen as a critical building block for moving the nation towards improved data sharing.[18] To that end, HITECH provided extensive funding for states to develop an HIE strategy, and many states focused resources on developing or bolstering statewide or regional HIE organizations.[35] Given the potential strategic importance of HIE organizations to state efforts, a literature review was conducted to understand the contribution of these organizations to data quality. The specific question explored was *whether HIE organizations improve electronic clinical data quality for participating entities.*

This review was designed to build on a federally commissioned systematic evidence review on HIE, which assessed studies published from 1990 to 2015.[16] Studies conducted during that period occurred either prior to HITECH's 2009 passage or at most six years post passage. This timing may be considered early given the immense HIT infrastructure build-up needs; HITECH's long-term, staged approach; and the complexity of its programs.[18] Therefore, this review assessed studies published from January 1, 2015 through March 10, 2019.

Note that the term *health information exchange* can comprise two concepts: the *verb* refers to the appropriate sharing of clinical information; the *noun* refers to an organization with specific operating rules to enable this electronic exchange.[2] To help distinguish between the two concepts, this study uses the term *health information exchange organization* (HIO) to refer to the latter concept. HIOs have the potential to assist with data sharing through aggregation of data and improvement of data quality. Data quality in the context of health information exchange can refer to the correctness of the data being entered into --- and flowing between --- health care systems. It also can refer to the completeness of the data when being accessed by care teams.[48]

Methods

This review used systematic methods to identify studies assessing HIOs and data quality. HIOs were defined as any type of organization with business operating rules to collect and share electronic health-related data. These could include state, regional, community or commercial HIOs. Immunization information systems (IIS) also were included; these entities focus on immunization data yet serve HIE functions.

The inclusion criteria were designed to cast a wide net yet capture those studies that examined the use of an HIE organization to improve data quality for care provision or surveillance purposes. Studies that measured any outcomes that address data quality, whether directly (e.g., data completeness) or more distally (e.g., improved patient care as a result of better data quality) were included. Studies of any design were included, but commentaries, opinion pieces and systematic or literature reviews were excluded. Because many aspects of the HIT ecosystem are influenced by country-specific factors (e.g., health care payment system, existing infrastructure), the review was limited to U.S.-based studies. However, any health care setting (e.g., hospital, emergency department, outpatient), as well as studies that are not setting-specific yet relate to using data for health care purposes (e.g., use of HIE organizations to supplement public health reporting) were included. Studies of any quality were included, though studies were limited to those in the peer-reviewed literature. The search was limited to English-language reports published after January 1, 2015.

Study results were categorized as “positive” if HIO use was found to improve data quality. Results were categorized as “negative” if HIO use did not improve data quality. Study results were considered “mixed” if HIO use resulted in improvement in some aspects examined, but not in others. As studies of all types were considered relevant, including non-experimental and qualitative studies, rather than focusing on traditional evidence ratings that rely on protocols such as randomization, studies were assessed for risk of bias. Risk of bias was determined by examining how study characteristics might affect one’s confidence in the results. Study attributes and limitations were qualitatively assessed for factors such as generalizability, presence of potential confounders, or issues that could predispose results, e.g., recruitment bias. Qualitative studies were judged using questions recommended by the Critical Appraisal Skills Programme.[49]

An electronic search was conducted in PubMed, PsycInfo and CINAHL. Together, these databases encompass a significant number of publications addressing health care interventions across a variety of settings. The search string combined health information exchange and data quality terms, with limits applied. The expectation was that studies assessing both usages of the term *health information exchange* (i.e., the *process* of sharing electronic clinical data and *organizations* operating to conduct the exchange) would be captured. However, because each sense of the word is used interchangeably in the literature, the broader term was included for the initial electronic search.

The titles and abstracts of studies identified through the initial search were screened for relevance using the eligibility criteria. If relevance could not be conclusively determined using the title or abstract, the study was included for further review. The full articles of studies that met the eligibility criteria were reviewed, and data were recorded using a data extraction form.

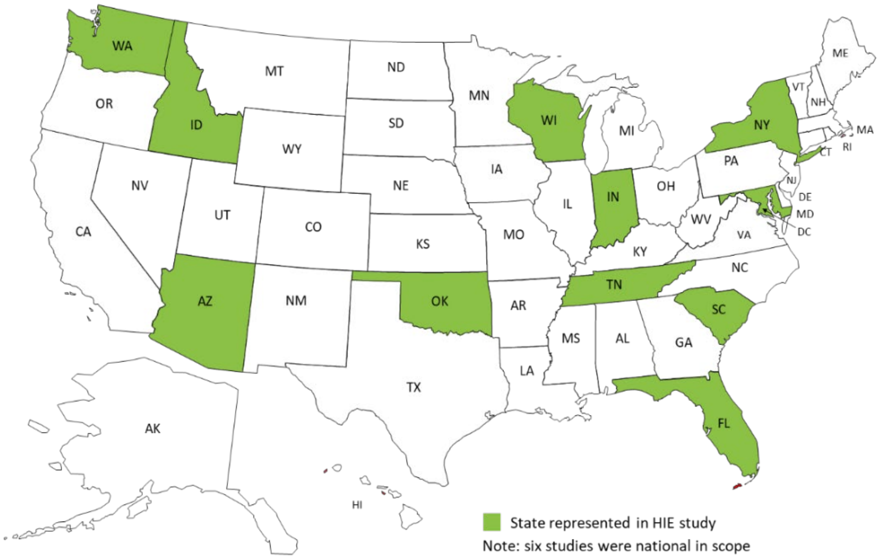
Results

The search of PubMed, PsycInfo and CINAHL databases produced 608 total references. After removal of duplicates, 524 references were screened for relevance using titles and abstracts. Of these, 445 clearly did not meet inclusion criteria and were removed. The full-text articles of 79 studies were retrieved for a more detailed review. Of these, most studies were removed because the study did not focus on data quality; the intervention did not involve an HIO; or the HIO was not being assessed for clinical or public health purposes (e.g., HIO used as a secondary data source for research purposes). A total of 22 studies were included in the final review.

Characteristics of HIOs studied

The HIOs studied were distributed across three types: statewide HIOs, regional/ community HIOs, and IIS. In terms of geographic representation, studies included HIOs from 11 different states, spread across most regions in the U.S. (Figure 2.1). Six studies were national in scope, and one study did not specify the geographic area.

Figure 2.1. States Represented Across Included Studies



Note: six studies were national in scope

The intervention addressed in each of the 22 studies was use of or participation with an HIO, with a wide range of users and settings targeted. For example, users included physicians, medical assistants, pharmacists and public health department staff. Settings included accountable care organizations, hospitals, emergency departments and primary care clinics. Interventions were frequently compared to no HIO use or "usual processes," such as data derived from a single, contained EHR system. Study outcomes all pertained to data quality, though this was measured in a variety of ways. About half of the studies specified the outcome as "data completeness." Another half measured an HIO's ability to provide information in order to improve clinical care. Other data quality assessments included data accuracy, technological efficiency and use of HIO data for secondary purposes (e.g., quality measures). Note the categories are not mutually exclusive, as some studies specified multiple outcomes.

Risk of bias

Risk of bias varied across the studies and is reported for each study in Table A1 in Appendix 1. The majority of studies were rated as either *Low* or *Medium Risk* (seven and nine, respectively). Six were rated *High Risk.* Among the six studies found to have high risk of bias, reasons included small sample size, lack of comparison or other verification data, possible response bias, and an inability to adjust for potentially serious confounders. Risk of bias is further described across study findings below.

Results of individual studies

In general, all but one of the 22 studies assessed showed HIO use was associated with either positive or mixed results. Half of the studies had a positive result.[50–60] Of studies reporting a positive result, two[52,59] were found to have a high risk of bias. Ten studies had mixed results,[61–70] with three[65–67] rated as high risk of bias. Only one study[71] produced a negative result, though this study had a high risk of bias. The major findings of each individual study are reported in Table A1 and summarized below.

Data completeness. Nine studies measured data completeness, showing mostly positive or mixed results.[55,58–62,65,68,71] Among four studies showing positive results, one[59] was rated high risk of bias because findings were based on case studies, and therefore the generalizability of results was limited. The remaining three verified the completeness of HIO data and found that HIOs filled gaps in information regarding patient health care needs.[55,58,60] For example, one study found that HIOs improved documentation of mammography, providing information missing from the EHR.[58] Of the four studies showing mixed results, one was rated high risk of bias.[65] The remaining three generally found HIO data to be an improvement over current methods but lagging behind other sources of information.[61,62,68] For example, a study of the Arizona IIS found that IIS data completeness was comparable to EHR data but inferior to personal records.[62] Similarly, a review of IIS across the country found that while the percentage of children with immunizations recorded in the IIS has increased, variability in data quality persisted, with 30 of 55 IIS producing vaccine rates at least ten percentage points below national estimates.[68] The study showing a negative result found varying availability of HIO data elements for use in a predictive model; however, this study was determined to have a high risk of bias because accuracy and timeliness of the data were not verified.[65]

Effect on clinical care. Ten studies more directly examined how HIO use might improve clinical care.[51–56,58,59,63,68] Eight demonstrated positive results, and two[63,68] had mixed results. Two of the studies with positive results had a high risk of bias due to small sample size, no comparisons or other concerns.[52,59] Among the remaining studies, HIO use was shown to assist providers with identifying patients for needed services or tracking events suggestive of suboptimal care. For instance, one study found a 35 percent increase in preventive services received after implementation of a community-based patient outreach program using an HIO to target eligible patients.[56] Another study found that hospitals participating in the HIO showed a decline in 30-day readmission rates, a common metric used to highlight potentially poor care coordination post-discharge.[51]

Other data quality outcomes. Six studies assessed data quality in other ways.[50,55,57,61,66,70] Two studies examined data timeliness, both finding HIO data were more timely than usual processes.[57,61] Two studies found that HIOs had varying ability to help providers with activities related to quality measurement[66] and HITECH incentives,[50] though the former had a high risk of bias due to probable selection bias of participants. One study found mixed results regarding whether HIO participation was associated with improved technological productivity and efficiency.[70] The sixth study found that IIS data were highly accurate as measured by matched vaccinations.[55]

Provider perception of data quality. Six studies sought to understand health care providers' perceptions of HIO data quality through surveys or semi-structured interviews, producing mostly mixed results.[50,63,64,66,67,69] Two of the studies were rated high risk of bias due to probable selection bias and other concerns.[66,67] The remaining studies found widely varied opinions of HIO data quality across providers. While respondents across the studies generally believed that HIO data are useful for improving clinical care, it was often the case that fewer respondents reported actually using HIO data for specified activities. For instance, one survey found that two-thirds of respondents believed HIO data improved quality of care. However, only one-fourth of respondents reported using the HIO data to calculate and report quality measures.[64]

Limitations

Across the majority of the individual studies, generalizability was limited due to several factors. In some cases, small sample sizes and other study limitations resulted in a high risk of bias. Surveys and interviews of clinicians often were subject to potential selection bias and did not account for factors such as baseline knowledge of the participant or length of time with an operational HIO.

In addition, overall results should be interpreted with caution. The review identified 22 studies, and six were considered high-risk for bias. Many studies did not detail the functions and capabilities of the HIO. This lack of detail is a particular hindrance given the wide range of configurations, governance rules, and stakeholder participation arrangements possible. Further, an important limitation is that rapidly changing technology may render results less useful to other time periods.

In terms of the review methods, while care was taken to cast a wide net during the search for relevant studies, studies nevertheless may have been missed. The term “Health Information Exchange” is commonly used and included as a National Library of Medicine Medical Subject Heading. However, studies that referred only to specific HIO names or that used non-standard terms may not have appeared in search results. Similarly, “data quality” is a somewhat broad term, and studies that used more specific terms when describing data quality may have been missed.

These issues aside, the studies assessed in this review were reasonably distributed across geographic regions of the U.S., with six national studies (Figure 2.1). Included studies assessed the data quality of HIOs of varying types (regional, state, IIS), and across a range of settings (clinician practice, pharmacy, emergency department, community). Of the studies not considered high-risk for bias, HIO use was examined against comparison processes, such as faxed reports or EHR-derived data.

Discussion and Implications

A key component of many states’ strategies to improve data exchange was the bolstering of HIOs, and significant resources were dedicated to establishing these organizations across the U.S.[18] In addition, data quality has important implications for establishing a business case for participation in HIOs, which was found to be a chief barrier to effective HIE.[21] As such, this review focused on HIOs and their effect on data quality. The review sought to build on earlier work, examining studies further out from HITECH’s passage to account for time needed to establish the necessary infrastructure.

Based on studies from 2015 to 2019, HIOs show promise as a means for encouraging data exchange across diverse entities. Despite imperfect data completeness and uptake, the review identified several examples of HIOs' ability to successfully augment conventional data sources. In the critical area of patient safety, HIOs bolstered efforts to track phenomena suggestive of unsafe or fragmented care.[51,54,60,63] In the area of notifiable disease reporting, HIOs reduced reporting lag and improved treatment rates.[53,57] In the area of clinical care, HIOs enhanced the provision of services.[56,58] IIS were particularly promising: the vaccine rates of IIS included in this review approached national estimates.[55,59,62,68]

However, HIOs must overcome barriers related to poor uptake. Results of surveys and interviews of clinicians revealed that they recognized the promise of HIO, but that actual use was mixed.[50,64] The slower-than-anticipated progress towards adoption may be explained by several factors. Barriers identified in a review of the landscape of HIOs included struggles securing participation among diverse stakeholders and a lack of incentives to share information.[25] These findings align with those of the 2015 federally commissioned systematic review, which found that reasons for insufficient data included poor participation by patients, incomplete information when patients sought care outside the catchment area, and providers abandoning use when queries were not fruitful.[17]

Studies examining facilitators to high-quality HIE are needed. Specifically, an understanding of policy levers that improve HIE participation may be useful. For example, IIS showed particular promise, and state mandates requiring reporting to IIS may be a factor. In 2015, 31 of 53 jurisdictions mandated at least one type of provider entity to report immunizations to an IIS.[72] Given these findings, this dissertation aimed to understand what state Medicaid policy features can help to overcome barriers to HIE and improve participation among health care providers.

CHAPTER 3. RESEARCH DESIGN AND METHODOLOGY

Overview

The purpose of this study was to better understand how state Medicaid agencies could promote HIE within the context of the HITECH Act and the Medicaid EHR Incentive Program. The study explored the following research question: *Which policy levers implemented by state Medicaid agencies have contributed to HIE participation?* A document review (Aim 1) was conducted to gather policy levers that were implemented by a sample of state Medicaid agencies to promote HIE. Data were extracted from HIT-related documents and used to conduct a coincidence analysis (Aim 2), which uses configurational comparative methods to identify "difference makers" in producing an outcome of interest – in this case, higher levels of data exchange. At the end of the study, results were reviewed with a Medicaid stakeholder panel in order to inform a Plan for Change.

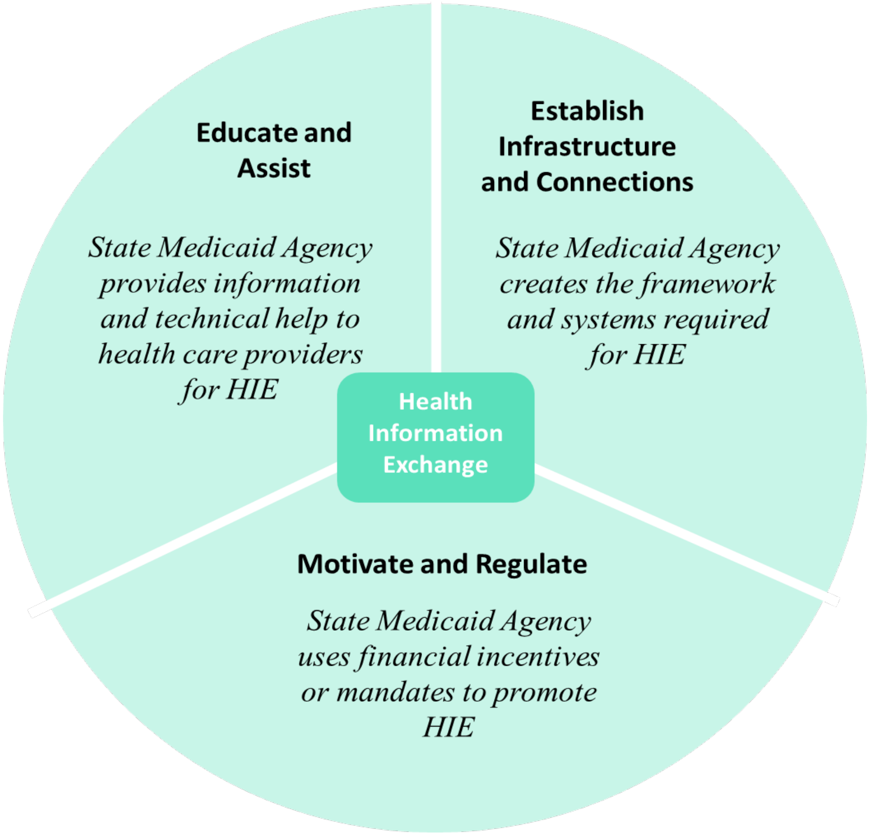
Conceptual Model

A conceptual model (Figure 3.1) guided the selection of state Medicaid agency policy levers on which to focus. Three domains comprise the model; specific levers that align to each domain are detailed in the Aim 1 Methods description.

1. *Educate and Assist.* This domain describes state Medicaid agency actions intended to increase providers' proficiency with HIT and to support their achievement of meaningful use. It includes the provision of technical assistance and efforts to improve participation in the Medicaid EHR Incentive Program.
2. *Establish Infrastructure and Connections*. This domain describes state Medicaid agency actions intended to build the underlying framework, systems and pathways required to exchange health data. It includes actions such as investing in a statewide HIO, providing electronic Medicaid claims and clinical data for patient management, and creating data connections between state agencies and other health care entities.

3. *Motivate and Regulate*. This domain describes state Medicaid agency actions that mandate HIE or highly incentivize it through financial rewards or penalties. It includes requiring data connections in Medicaid contracts with health insurance plans, using payment programs that reward HIE, and bolstering HIE participation policies.

Figure 3.1. State Medicaid Agency HIE Lever Conceptual Model



The model was informed by findings from a case study of five demographically diverse states of differing HIE maturity[14] and a statewide HIE environmental scan that included broad conclusions about states' roles in HIE.[37] These studies found that common challenges to be addressed by states included limited demand for HIE, lack of sustainability models, and clinician adoption and workflow issues.[14] Enablers of HIE included states' effective use of policy and directives to promote HIE and the strategic leveraging of existing HIE investments.[14] Specific actions states could adopt included provision of technical assistance to providers seeking to adopt HIT; acting as a service provider, such as electronically sharing claims or clinical information; and using their regulatory power to mandate HIE.[37]

State Sample

A sample of 20 states was purposefully chosen in order to ensure a diversity of states based on performance of the outcome of interest as well as four descriptive characteristics: geographic region, Medicaid expansion and two variables describing capacity for data innovation.

Outcome

A state-level summary measure describing health information exchange served as the outcome. The outcome was obtained from the National Electronic Health Records Survey (NEHRS). Sponsored by ONC and stewarded by the National Center for Health Statistics, NEHRS is an annual, nationally representative survey of office-based providers and collects information on HIT capabilities, systems and other characteristics.[73] In 2010, NEHRS was expanded to produce state-based estimates. The measure used in this analysis was a composite calculated by ONC at the state level and describes the proportion of providers who electronically exchange patient health information with external sources. The measure is based on responses to questions that assess the percentage of physicians who electronically send or receive patient health information, including at least one of the following: problem lists, medication and allergy lists, imaging reports, laboratory results, registry data (e.g., immunizations, cancer), and referrals with other providers and public health agencies outside the physicians' organization.[74] "Electronically" does not include paper-based methods or e-fax.[74] Data for the 2017 measurement year were used to allow for state actions completed between 2009-2016 to potentially take effect.

Descriptive Characteristics

- *Geographic Region.* U.S. Census regions were used to describe states as falling within the northeast, southern, midwestern or western areas of the country.
- *Medicaid Expansion.* Medicaid expansion was determined based on whether the state had expanded Medicaid by January 1, 2016. This date is one year prior to measurement of the outcome of interest.
- *Data Innovation: Broadband Rank.* Broadband is a necessary component of data-driven interactions, as it provides users with access to data-driven services and enables communication between devices.[75] Castro et al. developed a state-level composite measure of internet users,

households with broadband coverage and average connections speeds, which was used to rank states from best (1) to worst (50).[75]

- *Data Innovation: Open-Data Policies.* The extent to which states make available government data sets was used to understand a state's openness to data innovation. Generous open-data portals and policies allow users to access government data sets across a range of topics and can serve as an indication of a state's dedication to data innovation by permitting access in an open and machine-readable format.[76] Drees and Castro scored states on the presence and quality of their open-data portals and policies on a scale of 1-8, with a higher score indicating better performance on this metric.[76]

To determine the sample, states were handpicked to ensure diversity based on the selected characteristics. First, states missing the outcome measure were removed (13 of 50). For publicly-available National Center for Health Statistics reports (which stewards the National Electronic Health Records Survey), data are not disclosed if too few observations are reported for a particular variable.[77] Remaining states were rank-ordered highest to lowest for the outcome. Descriptive characteristics were added. States were then selected moving down from the highest- and up from the lowest-performing on the outcome, and inclusion was determined by ensuring a range based on region, Medicaid expansion, broadband capabilities, and open-data policy scores. Table 3.1 lists the states included in the sample, the proportion of providers who shared data electronically within the state (the outcome), and the state's descriptive characteristics.

Table 3.1. States Assessed for Medicaid Health Information Exchange Policy Levers

State	Proportion of Providers who Report Sharing Data Electronically[†] (%)	U.S. Census Region	Medicaid Expansion[‡]	Broadband Rank	Open Data Score
Minnesota	71.3	Midwest	Yes	9	3
Oregon	64.6	West	Yes	12	4
Louisiana	63.6	South	No	45	1
North Dakota	60.9	Midwest	Yes	27	2
Washington	58.6	West	Yes	5	3
North Carolina	56.9	South	No	29	3
Oklahoma	55.0	South	No	42	8
Idaho	54.7	West	No	25	2
Connecticut	54.4	Northeast	Yes	13	7
Vermont	51.9	Northeast	Yes	10	4
Delaware	42.4	South	Yes	8	3
Arizona	40.5	West	Yes	37	2
Florida	40.3	South	No	33	2
New Jersey	40.2	Northeast	Yes	7	4
Maryland	40.2	South	Yes	3	8
Alaska	39.8	West	Yes	22	1
California	38.5	West	Yes	17	4
New York	37.3	Northeast	Yes	19	8
Alabama	32.3	South	No	47	1
Missouri	31.7	Midwest	No	31	4

[†] Source: National Electronic Health Records Survey, 2017

[‡] Expanded Medicaid as of January 1, 2016

Study Aim 1. Document Review

The purpose of the document review was to collect levers implemented by state Medicaid agencies aimed at promoting HIE. The time frame of focus was 2009-2016, given the timing of the HITECH Act and the provision of resources to states to implement the Medicaid EHR Incentive Program and other initiatives.

Data sources

State Medicaid Health Information Technology Plans (SMHPs) were the primary data sources reviewed. CMS' approval of these documents was required for states to receive Medicaid federal matching funds to support the Medicaid EHR Incentive Program. CMS provided state Medicaid Agencies with a standard template that delineated specific content to be addressed. Required content included a description of the state's current environment, the state's vision of its HIT future, specific actions necessary to implement the EHR Incentive Program for Medicaid, and the Medicaid agency's planned HIT roadmap. SMHPs were first submitted and approved in early 2011 and typically updated on an annual basis. The documents are publicly available and reside on Medicaid agency websites.

In most cases, additional HIT-related documents were reviewed. Further review occurred if the SMHP referenced additional documents regarding HIE efforts, or if there was a need to assess more information, for example when it was unclear whether a policy lever had been implemented. In some cases, documents were reviewed if they were presented on state Medicaid agency websites as pertaining to HIT efforts. In addition, *State HIE Strategic and Operational Plan Profiles* were consulted for most states. These were brief overviews compiled by ONC using state reports that were required as a condition of participation in the State HIE Cooperative Agreement Program. The documents described the state's general HIE strategy and included an inventory of the state's HIE-related policies. In some cases, *State HIT Implementation Advanced Planning Documents* were consulted. These documents were submitted to CMS in order to receive funding to administer the Medicaid EHR Incentive Program and so provided components of information that were similar to the SMHP. In addition, across all states, two reports[78,79] describing state opt-in/opt-out policies for HIE participation were used and cross-checked with SMHPs. Last, additional HIT-related documents included programmatic or operational documents and presentations or meeting minutes of HIT advisory councils and similar bodies.

SMHPs and related documents ranged in their date of publication. However, all documents contained information regarding the study period of 2009-2016. When documents reviewed were published after the study period, state actions listed were verified to have been completed rather than only planned. In all cases in which different versions of SMHPs were reviewed across multiple years, it was clear that SMHPs were built from the originally submitted versions, with new information added, and no information removed. Therefore, while some SMHPs reviewed were published after the study period, these documents still contained information dating back to the initial implementation years of 2009-2011 and beyond. Documents across all states were determined to contain sufficient detail for state policy lever identification and abstraction. All documents reviewed are listed by state in Appendix 2.

Data abstraction and policy levers

Sixteen state actions that aligned to the three domains of the conceptual model were established. These actions were the "levers" and were collected from data sources using decision rules to determine their presence or absence. Table 3.2 describes the levers and decision rules used. Levers were dichotomous (either present or absent). Results were recorded in a Microsoft Excel spreadsheet, and detailed notes documenting the findings, along with page references, were taken.

Table 3.2. Decision Rules for Determining Presence or Absence of a Lever

Domain	Lever	Description and Decision Rule
Educate and Assist	Technical assistance	State Medicaid agency provides a high level of technical assistance for HIE activities by partnering with or funding regional extension centers, or through other partnerships such as contractual relationships with technical assistance providers.
	EHR Incentive Program assistance	State Medicaid agency has explicit efforts to increase enrollment and participation in the Medicaid EHR Incentive Program, such as through administrative simplification, electronic verification of eligibility, or dedicated employees. Passive forms of assistance, such as advertising on the agency website, would not be sufficient to be counted as present.
Establish Infra-structure and Con-nections	Statewide HIO	A key element of the state Medicaid agency's HIE strategy is to establish a statewide HIO and to connect hospitals, clinicians and other providers (e.g., laboratories) to the HIO. The agency must commit resources in some way towards this effort, such as through dedicated employees, or by contracting with or funding the HIO.
	Regional HIO	A key element of the state Medicaid agency's HIE strategy is to connect providers to local/ regional health information exchange organizations (RHIOs). While the state may be seeking to connect these RHIOs together in a statewide fashion, this model will be coded as RHIO rather than a "statewide HIO". The agency must commit resources in some way to the RHIO, such as through dedicated employees, or by contracting with or funding the RHIO. Simple existence of RHIOs within the state does not qualify.
	Public health connections	State Medicaid agency requires, sponsors or enables electronic reporting for at least one type of public health reporting, such as syndromic surveillance or communicable disease reporting.
	e-Prescribing connections	State Medicaid agency requires, sponsors or enables electronic reporting by pharmacies or through prescription drug monitoring programs.
	Laboratory connections	State Medicaid agency requires, sponsors or enables electronic reporting by laboratories.
	Electronic claims	State Medicaid agency facilitates electronic Medicaid claims transactions in order to support claims review and/or to support patient care.
	Electronic quality measures submission	State Medicaid agency facilitates submission of electronic clinical quality measures for the EHR Incentive Program or other programs by serving as or supporting the electronic submission mechanism.
	Quality measure data provision	State Medicaid agency provides quality measure numerator data (i.e., information on health care services accessed by Medicaid enrollees) to health care providers. Sole provision of alerts of admissions or discharges would not be sufficient to be counted as present for this lever.
Motivate and Regulate	HIE mandate for clinicians	State Medicaid agency explicitly requires clinicians to make HIE connections as a condition of participation in a program or to receive resources/incentive payments. This mandate may require connection to an HIO, or it may be a requirement to share data outside one's system without the use of an HIO.
	HIE mandate for hospitals	State Medicaid agency explicitly requires hospitals to make HIE connections as a condition of participation in a program or to receive resources/incentive payments. This mandate may require connection to an HIO, or it may be a requirement to share data outside one's system without the use of an HIO.
	HIE mandate for health plans	State Medicaid agency explicitly requires participating managed care plans to make HIE connections as a condition of participation in a program or to receive resources/incentive payments. This mandate may require connection to an HIO, or it may be a requirement to share data outside one's system without the use of an HIO.
	State purchasing	State Medicaid agency specifies HIE connections in purchasing/contracting for health care services.
	Opt-out policy	State Medicaid agency employs an opt-out policy for HIE participation. States with opt-in or no identifiable policy are marked as absent for this lever.
	Payment models	State Medicaid agency encourages or requires HIE by providing financial incentives (outside the EHR Incentive Program) for a health care provider or organization to engage in data sharing. Examples include Medicaid accountable care organizations, medical home models, pay-for-reporting or pay-for-performance initiatives that have HIE requirements incorporated within them.

Study Aim 2. Coincidence Analysis

A coincidence analysis was used to assess how the Medicaid state policy levers identified in the document review related to an increase in data sharing among providers. Coincidence analysis is a mathematical, cross-case approach and a recently established subset of the Configurational Comparative Method family of inquiry.

Configurational comparative methods

Overview

Coincidence analysis is a Configurational Comparative Method (CCM), an analytic technique based on Boolean algebra and a regularity theory of causality.[80–83] As opposed to probabilistic statistics, CCMs take a "configurational" view of potential causal conditions, where the focus lies in the different ways in which conditions combine to produce an effect.[81] CCMs use a cross-case approach to assess which conditions or combinations of conditions are consistently present when an outcome of interest is present.[84,85] By placing a Boolean ordering on these conditions, CCMs are able to assess *causal complexity*, wherein multiple factors must jointly appear for an outcome to occur --- and which is a common characteristic of the "wicked problems" faced by society today.[81,82,86,87] Wicked problems are those that are difficult to solve given characteristics such as lack of a definitive formulation, involvement across different stakeholders and sectors, and a multifaceted and complex nature.[88] Through Boolean minimization and optimization, CCMs identify solutions that are minimally necessary and sufficient, or *difference-makers,* for the outcome.[84,85]

Conceptual underpinnings

CCMs draw upon what is known as the INUS theory of causation, part of a regularity theoretic framework in which INUS conditions are "**I**nsufficient but **N**ecessary parts of a configuration of conditions which is itself **U**nnecessary but **S**ufficient for the outcome."[84–86] Mackie illustrates this theory using an example of a house fire.[86] In this example, a short circuit conjoined with the presence of flammable material and the absence of a sprinkler constitute a set that is sufficient to start the fire. The short circuit is indispensable within the set but requires the two additional conditions (including the absence of one) in order for the house fire to start. The short circuit is, however, "unnecessary" by logic terms, as there are other conditions that could also start a fire (e.g., an unattended candle). In this way, the short circuit is considered an INUS condition.

Boolean algebra, also known as the algebra of logic and sets, provides the framework for understanding and describing how the conditions combine.[84,89] Ragin uses the example of the collapse of military regimes to illustrate the concepts of Boolean addition, multiplication and minimization as they relate to CCM methods.[89] Ragin presents three factors that may bring about a regime failure (F): conflict between older and younger military officers (A), death of a powerful dictator (B), or U.S. government dissatisfaction with the regime (C). Upper case denotes the presence of a factor, and lower case denotes its absence.

- *Boolean addition* describes alternative paths and is equivalent to the logical operator "OR." The formula $A + B + C = F$ states that the presence of any of the three factors can lead to a regime failure.
- *Boolean multiplication* generates a product that is a specific combination of causal conditions and is equivalent to the logical operator "AND." The formula $Abc = F$ states that the presence of officer conflict conjoined with the absence of both dictator death and U.S. government dissatisfaction creates a set that leads to a regime failure.
- *Boolean minimization* states that if two Boolean expressions differ in only one causal condition yet produce the same outcome, then that differentiating causal condition can be considered redundant and removed. For example, the formulas $ABC = F$ and $AbC = F$ differ only in dictator death. As regime failure occurs any time officer conflict and U.S. government dissatisfaction are conjoined, regardless of whether the dictator dies, the dictator's death is irrelevant. The formula can therefore be minimized to $AC = F$.

Rationale for use

Compared to traditional analytic approaches, CCMs are better suited to address causal complexity and heterogeneity.[81,87,90] Traditional approaches that have relied on correlational techniques assess problems as linear relationships in which an independent variable X is measured for its effect on a dependent variable Y.[91–93] In such a schema, alternative or counterfactual explanations are held constant in order to isolate the incremental effect of X.[94] While rigorous for many purposes, these methods are challenged in capturing causal complexity given their focus on the contribution of a particular explanatory variable rather than how multiple factors may combine in complex ways.[87]

Two primary concepts comprise causal complexity and are inadequately addressed by traditional correlational methods. The first is *conjunction*, which states that different factors may combine in order to jointly bring about an outcome.[95] This concept is insufficiently captured by correlational methods given their need to isolate the unique contributions of individual explanatory variables towards an outcome.[87] The second concept is *disjunction* – also known as *equifinality* – which states that multiple paths may lead to the same solution.[96] Correlational theories treat alternative explanatory paths as conditions that should be controlled.[87]

While CCMs do not necessarily suggest a configuration of factors will always lead to the outcome of interest, they do allow for the examination of the joint effect of multiple factors, and multiple pathways to a solution.[97] This reorientation of theorizing towards configurations enables thinking of causes as "multidimensional constellations of attributes orchestrated together by central themes or integrative mechanisms."[87] Further, CCMs recognize that, in addition to its presence, the *absence* of a factor may also be consequential in explaining a phenomenon.[98] In Mackie's house fire example, the absence of the sprinkler system was a key condition within the set. Last, a useful aspect of configurational theorizing is its use of iterative modeling, which permits an inductive analysis of a set of factors. This process allows for a comprehensive approach in which emerging observations, insights and findings can be considered as part of the process of understanding the connections and themes of a phenomenon.[87]

Given these attributes, CCMs are ideal for studying complex social structures such as national or state policy strategies.[99] For example, Roberts and colleagues used CCMs to examine how different combinations of state policies related to human papillomavirus vaccine uptake.[100] The authors found that no single policy effectuated high vaccine uptake; rather, adoption of all policies except parental education materials was needed. For this study, CCMs are an optimal method for assessing the diverse and multifaceted strategies that were implemented by Medicaid agencies across the country in an effort to stimulate meaningful use of EHRs and participation in HIE.

State Medicaid policy levers coincidence analysis

This study used coincidence analysis (CNA) to assess which state Medicaid policy levers or combination of levers could be considered important for HIE participation among providers. CNA incorporates the principles described to identify *Boolean difference-makers*, minimally necessary or sufficient conditions that uniquely distinguish between cases with and without the outcome.[84,90] CNA generally involves a three-part procedure wherein the researcher 1) identifies deterministic dependencies of sufficiency and necessity within the data, 2) minimizes these dependencies to eliminate redundancies, and 3) interprets the findings.[84] Within a CNA, the *outcome* is the phenomenon of interest; *factors* are event types that are examined for relevance to an outcome; the *factor frame* is the set of investigated factors; and *conditions* are factor values (i.e., presence or absence of a particular factor).[84] CNA then uses a bottom-up approach that begins with testing single-factor values for sufficiency and necessity and proceeds to testing combinations of two, three, four, and so on.[84,90] The 20 states in the sample served as the cases for this study. The outcome and factors used for this analysis are described below.

Outcome

The outcome of *Proportion of providers who report sharing data electronically* was dichotomized to describe states as either HIE present or HIE absent. Based on the range and distribution of values, a threshold of 50 percent produced two sets of states with sufficient variation between them. The threshold resulted in ten states above that were characterized as *HIE present*, and ten states below that were characterized as *HIE absent*. For the highest-ranked state, 71.3 percent of respondents reported sharing data electronically; for the lowest-ranked state, the number was 31.7 percent. Nine and a half percentage points separated the state just above the threshold from the state just below.

Factor frame

State levers collected during the document review in Study Aim 1 (see Table 3.2) served as the initial factor frame for the CNA. Factors were included as dichotomous conditions (i.e., either present or absent), and all factors were considered candidates for the initial analysis.

Data analysis process

The CNA analytic process includes reducing the candidate factor list to an analytic data set, iterative model development, and selecting a final model based on defined criteria. This process was conducted using the *cna*[101] package within the R v4.1.0 and R Studio statistical software programs.[102] Data collected from the Document Review in Aim 1 were converted into a .csv data set and imported into R. Presence of the outcome and of a state policy lever was represented as a “1” in the data set; the absence of these items was represented as a "0.”

Analytic data set

An analytic data set, a smaller subset of candidate factors for modeling, was identified in order to address the problem of limited diversity. Limited diversity occurs when factors included in a CNA are too numerous, which results in a ratio of observed configurations to all possible configurations that is too small from which to draw conclusions.[90] The 16 factors in this study could be combined into over 65,000 logically possible configurations, which could not be covered appropriately by the 20 cases in the sample and would likely result in “noise” rather than meaningful patterns. Therefore, a process was undertaken with the goal of reducing the number of dichotomous factors from 16 to a smaller set.

At the outset, any factors with minimal to no variation across states in the sample were dropped. These factors by their consistent presence would not be considered Boolean difference-makers, which by definition distinguish between cases with and without the outcome.[103]. CNAs identify Boolean difference-makers in order to generate a minimal theory in which factors that are mathematically redundant are removed because it is unclear whether they contribute anything substantial to the outcome or are passively omnipresent.[96]

Next, following a method used by Yakovchenko, Miech and colleagues[104] and detailed in additional published literature,[97,105,106] the *minimally sufficient condition (msc)* function of the *cna* package was applied in order to further reduce remaining factors using an empirical process. This process used a configurational approach to look across the candidate factors for the 20 states in order to identify configurations of conditions with strong connections to the outcome of electronic data sharing.

First, configurations were generated to meet specified consistency and coverage thresholds. Consistency and coverage are two parameters of fit used to assess the strength of the dependence between conditions and the outcome.[90] *Consistency* describes how reliably a configuration yields an outcome and is calculated as the number of cases with the configuration and the outcome divided by the total number of cases with the configuration.[90,97] *Coverage* describes how broadly a configuration accounts for an outcome and is calculated as the number of cases with the configuration and the outcome divided by the total number of cases with the configuration.[90,97] Both are measured on a score of 0 to 1, with higher values generally supporting a model's empirical importance based on the available data.[90] Starting with a consistency of 1.0 and coverage of 0.25, consistency was lowered by increments of 0.05 until configurations that met the specified thresholds were identified. The *misc.* process was set to explore configurations up to a complexity maximum of five objects (i.e., all possible 1-condition, 2-condition, 3-condition, 4-condition and 5-condition configurations were explored).

Next, configurations that met these criteria were placed into a condition table in order to organize the Boolean output. Within the condition table, rows were configurations that met the consistency level, and columns were the outcome, condition, consistency threshold, coverage threshold, and complexity. The table was sorted by complexity and used to identify candidate factors for the analytic data set. Candidate factors for the analytic data set were those that met the specified consistency level and a coverage level of at least 0.40.

Iterative model development

Once the analytic data set was identified, an iterative modeling process was conducted. Iterative modeling, wherein results of analyses are reviewed, interpreted and used to redefine model inputs before finalizing a model set, is a key aspect of CCMs.[107] Using the *cna* function, factors from the analytic data set were selected based on theoretical plausibility. Different combinations of 4-5 factors at a time were explored. Factors were modeled starting at a consistency and coverage threshold of 1.0; thresholds were lowered in 0.05 increments if no model was identified. Configurations were evaluated based on consistency and coverage thresholds and aimed to minimize model ambiguity, which occurs when competing models explain the outcome equally well as reflected by similar consistency and coverage scores.[108] Given the importance of understanding state Medicaid policy levers that contributed to the occurrence of data sharing as well as lack of data sharing, the factors from the analytic data set were used to separately model both the presence and absence of the outcome of interest. A final model was selected if it met all of the following criteria:

1. Overall model consistency and coverage $\geq$ 0.80
2. Minimal model ambiguity

3. The same factors could explain both the presence and absence of HIE
4. Aligned to theoretical knowledge

Model interpretation

The final step included interpretation of the results. Four recommendations put forth by Furnari and colleagues to reorient thinking towards configurations were useful in this endeavor.[87]

> *Think conjunctively*. Consider the interdependence and interaction of the factors shown to be important in a causal recipe.
>
> *Think equifinally.* Consider why different causal pathways may have an effect on the outcome.
>
> *Think about absence.* Consider why attributes may combine in both their presence as well as their absence to produce an outcome.
>
> *Capture the whole*. The overarching narrative should capture the "logical structures" of a theory as a whole.

Human Subjects Protection and Confidentiality

The dissertation proposal was approved by the University of North Carolina's Institutional Review Board (IRB #19-2845, 1/11/2021).

CHAPTER 4. RESULTS

Aim 1. Document Review Results

The purpose of the document review was to collect levers implemented by state Medicaid agencies in order to understand how states sought to promote HIE. State Medicaid HIE policy levers were documented across all states in the sample. No levers were completely absent; all levers were found in at least three states. With some exceptions, most levers showed variation across states. The results of the document review are displayed in Figure 4.1. A dot denotes the lever’s presence in documents that were reviewed. The absence of a dot denotes lack of documentation.

Figure 4.1. Presence or Absence of State Medicaid Health Information Exchange Policy Levers

	EDUCATE AND ASSIST		ESTABLISH INFRASTRUCTURE AND CONNECTIONS								MOTIVATE AND REGULATE					
Prop. of States with Doc.	**TA**	**MU**	**SHIO**	**RHIO**	**PH**	**RX**	**LAB**	**CLM**	**QM**	**NUM**	**CLIN**	**HOSP**	**PLAN**	**PUR**	**OPTO**	**PAY**
	1.00	*1.00*	*0.75*	*0.25*	*0.95*	*0.95*	*0.75*	*0.55*	*0.50*	*0.35*	*0.25*	*0.15*	*0.20*	*0.25*	*0.70*	*0.60*
AL	●	●	●		●	●		●	●						●	
AK	●	●	●		●	●			●						●	
AZ	●	●	●			●	●				●	●		●	●	●
CA	●	●		●	●	●	●	●								
CT	●	●	●		●	●	●								●	●
DE	●	●	●		●	●		●							●	
FL	●	●		●	●	●	●	●								
ID	●	●	●		●	●	●	●	●	●	●		●	●	●	●
LA	●	●	●	●	●	●		●	●	●						●
MD	●	●	●		●	●	●		●	●	●		●		●	●
MN	●	●			●	●		●	●	●	●	●			●	●
MO	●	●	●		●	●	●	●							●	●
NJ	●	●		●	●	●	●								●	
NY	●	●		●	●	●	●									●
NC	●	●	●		●	●	●	●							●	
ND	●	●	●		●	●	●								●	
OK	●	●	●		●	●	●	●	●	●					●	●
OR	●	●	●		●		●		●	●				●	●	●
VT	●	●	●		●	●	●		●			●	●	●		●
WA	●	●	●		●	●	●	●	●	●	●		●	●		●

Key

● Documentation of the lever was present

TA	Technical assistance	QM	Electronic quality measures submission
MU	Meaningful Use assistance	NUM	Quality measure numerator provision
SHIO	Statewide HIO	CLIN	HIE mandate for clinicians
RHIO	Regional HIO	HOSP	HIE mandate for hospitals
PH	Public health connections	PLAN	HIE mandate for health plans
RX	e-Prescribing connections	PUR	State purchasing
LAB	Laboratory connections	OPTO	Opt-out policy
CLM	Electronic claims provision	PAY	Payment models

Domain-specific findings

Educate and Assist

All sampled states had documentation of both levers within the *Educate and Assist* domain. For *Technical Assistance*, States frequently partnered with Regional Extension Centers. These centers are organizations that provide on-the-ground HIT-related technical aid to individual- and small-provider practices, low-resource practices, and those that provide primary care services in public and critical access hospitals, federally-qualified health centers and other settings that serve populations with inadequate medical coverage.[109] In all cases, states also assisted providers with signing up for the Medicaid EHR Incentive Program and sought to help them to achieve at least the first stage of Meaningful

Use. For example, California noted that many Medicaid providers found providing proof of eligibility for the EHR Incentive Program to be challenging. To address this barrier, the state sought and received permission from CMS to prequalify providers by using existing data available from Medicaid claims payments and encounters.[110]

Establish Infrastructure and Connections

Sampled states frequently directed resources towards HIT infrastructure. Most states (14 of 20) chose to establish or buttress a statewide HIO rather than regional HIOs. In most cases, states that supported statewide HIOs did not invest in regional HIOs, and vice versa. Exceptions were Louisiana, which invested in both, and Minnesota, which invested in neither. In the case of Louisiana, the state used a $10.6 million grant to design and implement the statewide Louisiana Health Information Exchange. However, the state also invested $30 million in a regional HIO that connects rural hospitals to specialists for remote consultations.[111] Minnesota, on the other hand, opted to promote a market-based approach to HIE. Rather than investing directly in either statewide or regional HIOs, the state focused on certifying HIOs to encourage standardized approaches to data sharing.[112]

Most states also focused resources on establishing connections among public health entities (19 of 20), pharmacies (19 of 20) and laboratories (15 of 20). About half of states in the sample each shared electronic claims data with providers and assisted with the submission of electronic clinical quality measures (eCQMs). A third of states assisted Medicaid providers by sharing information on health care services that their patients had accessed.

Motivate and Regulate

Regulation-related levers were less frequently documented in comparison to levers in the other two domains. Most state plans (about three-fourths) had no documentation of mandates to clinicians, hospitals or health plans to make HIE connections. However, the use of payment models and opt-out policies were documented in a little over half of state plans (12 and 14, respectively). Payment models often consisted of programs that provided financial incentives to make data connections with outside entities. For example, Arizona paid a 0.5% increase to Medicaid providers who met requirements for having achieved Meaningful Use Stage 2 and who submitted data to the statewide HIE.[113] Most other states that used payment models incentivized providers to implement the Patient-Centered Medical Home model and integrated data sharing requirements into the model standards (8 of the 12).[114]

Aim 2. Coincidence Analysis Results

A mathematical, cross-case approach in the form of a CNA was used to analyze how the documented Medicaid state policy levers related to HIE among providers within the state. Results for each step of the CNA process are detailed below. Steps included narrowing the original data set to an analytic data set and identifying a final model for each the presence of HIE and the absence of HIE.

Analytic data set results

The initial data set of 16 factors was reduced to nine factors for the analytic data set. First, four factors with minimal to no variation across states in the sample were dropped. *Technical Assistance* and *Meaningful Use Assistance* were present across all states and so were removed from the analysis. Similarly, *Public Health Mandate* and *ePrescribing Mandate* were each present in all states but one and so were removed.

The remaining 12 factors were analyzed using the minimally sufficient condition process. The final Condition Table (Table 4.1) shows the results of this process, including the configurations of conditions, consistency, coverage and complexity of each configuration. At a consistency of 1.0 and coverage of 0.4 or higher, ten factors were identified. Six factors were from the *Establish Infrastructure and Connections* domain; four factors were from the *Motivate and Regulate* domain.

Table 4.1. Condition Table

Configuration of Conditions†	Consistency	Coverage	Complexity
CLM*NUM->OUT	1.0	0.5	2
NUM*plan->OUT	1.0	0.4	2
QM*PUR->OUT	1.0	0.4	2
CLM*QM*PAY->OUT	1.0	0.5	3
QM*clin*PAY->OUT	1.0	0.4	3
QM*plan*PAY->OUT	1.0	0.4	3
rhio*clm*LAB*clin->OUT	1.0	0.4	4
SHIO*clm*LAB*clin->OUT	1.0	0.4	4

† Upper case indicates the condition of *factor = 1* in the configuration
Lower case indicates the condition of *factor = 0* in the configuration

Regional HIO (RHIO) and Statewide HIO (SHIO) acted as inverses of one another (i.e., the absence of RHIO was present in a configuration that exactly matched one with the presence of SHIO). Therefore, only Statewide HIO was used. The final analytic data set thus included nine factors, described in Table 4.2. The nine factors were used for iterative modeling during which up to five factors at a time were modeled and evaluated against the criteria of sufficient consistency and coverage; minimal model ambiguity; explanatory capacity for presence and absence of HIE; and theoretical alignment.

Table 4.2. Final Analytic Data Set

Domain	Code	Factor
Establish Infrastructure and Connections	SHIO	Statewide HIO
	LAB	Laboratory connections
	CLM	Electronic claims provision
	QM	Electronic quality measures submission
	NUM	Quality measure numerator provision
Motivate and Regulate	CLIN	HIE mandate for clinicians
	PLAN	HIE mandate for health plans
	PUR	Purchaser mandate
	PAY	Payment models

Final models

The model iteration process and CNA revealed one model each for states with HIE present, as measured by electronic data sharing among providers, and states with HIE absent. Both models met all four selection criteria: consistency and coverage levels were at or above the threshold of 0.8; there was no model ambiguity; factors explained both the positive and negative models; and the results aligned with theoretical knowledge. Appendix 3 displays the configurations instantiating both models, shown within the full data set of factors that were initially considered. Specific results for the two models are described below.

Solution configurations for states with HIE present

A model consisting of two distinct solution paths for states with presence of the outcome was identified at 90% consistency and coverage. In this model, four conditions were consistently present among states with HIE in the following configuration:

QM*PAY + SHIO*LAB*pay <-> OUT

In words, the model is expressed as follows:

States had HIE if, and only if, they

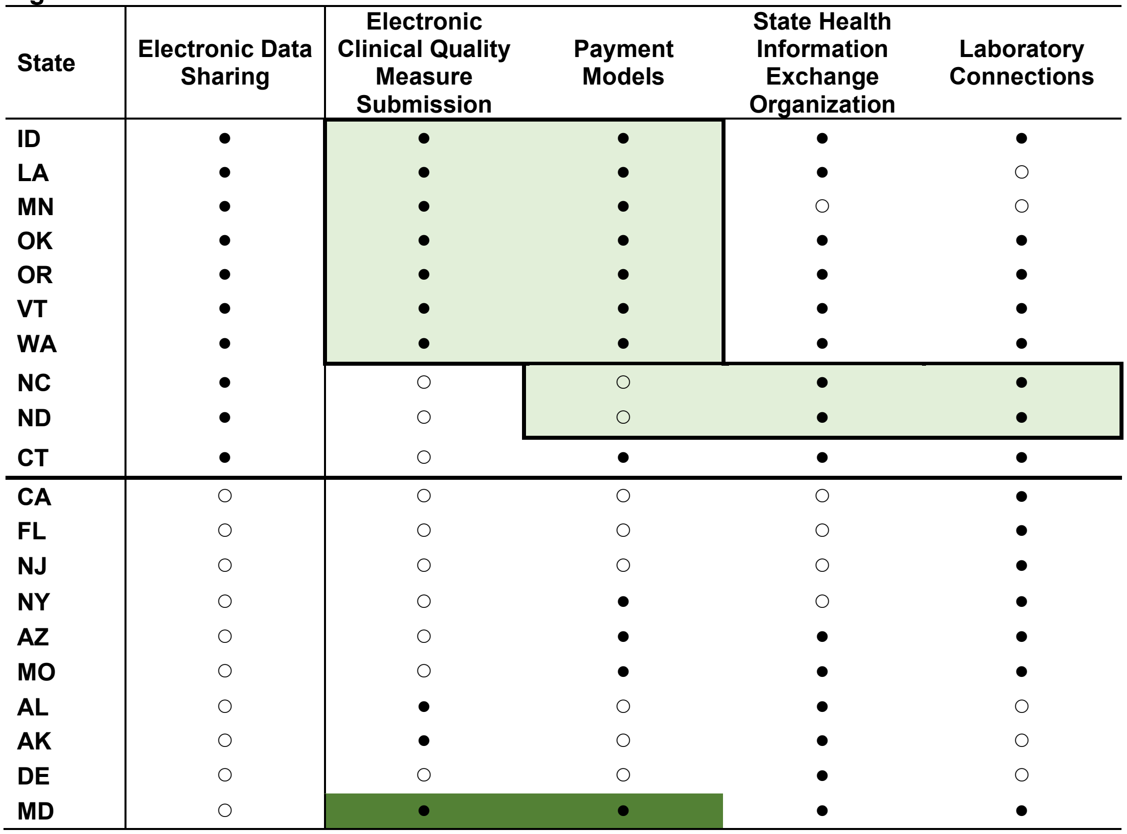
Path 1: *assisted with eCQM submission AND used payment models to incentivize HIE*

OR

Path 2: *had a statewide HIO AND incentivized lab reporting AND lacked payment models*

Figure 4.2 illustrates the configurations instantiating this model. Solution path 1 is shown in the top light-green box; solution path 2 is shown in the bottom light-green box. The two solution configurations appeared with the outcome for nine of the ten states that demonstrated HIE (all except Connecticut), which suggests the model broadly accounts for the outcome. This yields the coverage of 90% (9/10), i.e., of the ten states with HIE, nine of these also exhibited at least one of the solutions. There was one inconsistent case (Maryland), which had used eCQM submission assistance and payment models but did not have HIE present (dark-green box). This yields the consistency of 90% (9/10), i.e., of the ten states exhibiting the solutions, nine of these also had HIE present. The data set included a case exhibiting every combination of the INUS conditions in the solution set, which suggests the configurations found to be present with the outcome may be Boolean difference-makers (i.e., they distinguish states with the outcome from those without). In addition, the model included two configurations that together uniquely covered each of the nine states, demonstrating the concept of multiple pathways to success.

Figure 4.2. Positive Model Solutions



State	Electronic Data Sharing	Electronic Clinical Quality Measure Submission	Payment Models	State Health Information Exchange Organization	Laboratory Connections
ID	●	●	●	●	●
LA	●	●	●	●	○
MN	●	●	●	○	○
OK	●	●	●	●	●
OR	●	●	●	●	●
VT	●	●	●	●	●
WA	●	●	●	●	●
NC	●	○	○	●	●
ND	●	○	○	●	●
CT	●	○	●	●	●
CA	○	○	○	○	●
FL	○	○	○	○	●
NJ	○	○	○	○	●
NY	○	○	●	○	●
AZ	○	○	●	●	●
MO	○	○	●	●	●
AL	○	●	○	●	○
AK	○	●	○	●	○
DE	○	○	○	●	○
MD	○	●	●	●	●

Key

● Presence of lever or outcome

○ Absence of lever or outcome

☐ Solution path consistent with presence of outcome

🟩 Solution path inconsistent with presence of outcome

Solution configurations for states with HIE absent

A model consisting of three solution paths for states with absence of the outcome was identified at 82% consistency and 90% coverage. In this model, five conditions were consistently present in states without HIE. The conditions were configured as follows:

shio + qm*PAY + num*lab <-> out

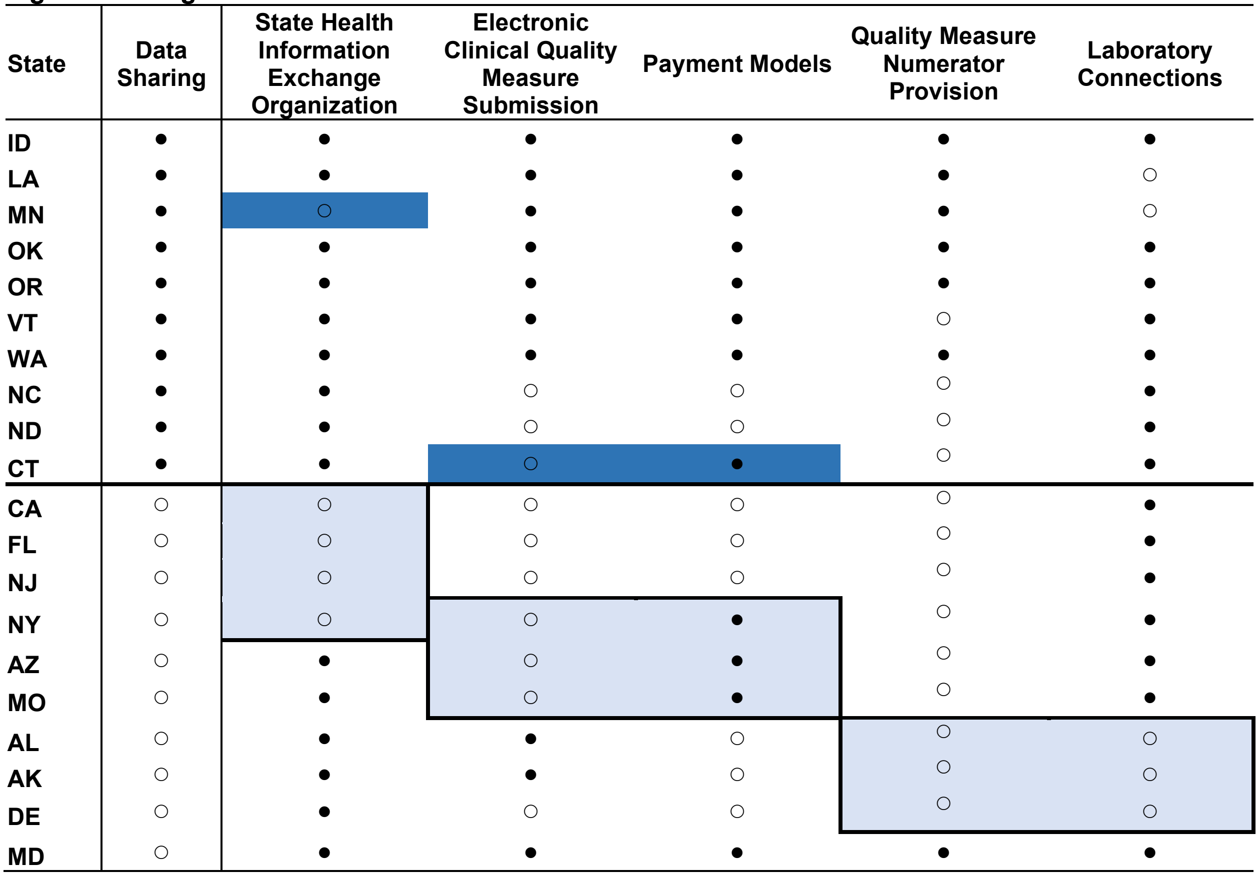
In words, this model is expressed as follows:

States lacked HIE if, and only if, they

Path 1: *lacked a statewide HIO*
OR
Path 2: *lacked assistance with eCQM submission AND used payment models*
OR
Path 3: *did not provide quality measure numerator data AND did not incentivize lab reporting*

This model is shown in Figure 4.3. The configurations appearing in states without the outcome of HIE are shown in the three light-blue boxes. These configurations appeared without the outcome for nine of the ten states (all except Maryland, which had not implemented the strategies yet still had HIE absent). This yields the coverage of 90% (9/10), i.e., of the 10 states with HIE absent, nine of these also exhibited at least one of the configurations. There were two inconsistent cases (dark-blue boxes). Minnesota lacked a state HIO yet had HIE present. Connecticut lacked eCQM submission assistance and used payment models yet had HIE present. This yields the consistency of 82% (9/11), i.e., of the 11 states that used at least one of these strategies, nine had HIE absent. As in the HIE-present model, every combination of conditions was instantiated in the model. In addition, the three configurations each uniquely covered most states without HIE (all except NY).

Figure 4.3. Negative Model Solutions



State	Data Sharing	State Health Information Exchange Organization	Electronic Clinical Quality Measure Submission	Payment Models	Quality Measure Numerator Provision	Laboratory Connections
ID	●	●	●	●	●	●
LA	●	●	●	●	●	○
MN	●	○	●	●	●	○
OK	●	●	●	●	●	●
OR	●	●	●	●	●	●
VT	●	●	●	●	○	●
WA	●	●	●	●	●	●
NC	●	●	○	○	○	●
ND	●	●	○	○	○	●
CT	●	●	○	●	○	●
CA	○	○	○	○	○	●
FL	○	○	○	○	○	●
NJ	○	○	○	○	○	●
NY	○	○	○	●	○	●
AZ	○	●	○	●	○	●
MO	○	●	○	●	○	●
AL	○	●	●	○	○	○
AK	○	●	●	○	○	○
DE	○	●	○	○	○	○
MD	○	●	●	●	●	●

Key

● Presence of lever or outcome

○ Absence of lever or outcome

☐ Solution path consistent with absence of outcome

■ Solution path inconsistent with absence of outcome

Both models performed at high consistency and coverage. Solution pathways in each model covered nine of ten cases, with few inconsistent cases. These parameters suggest the solutions identified are meaningful and reliable. In addition, the solutions demonstrate causal complexity: several conditions combined to form a set that was consistently present with the outcome of interest, and multiple pathways to success were identified. In the case of the negative model solutions, one state exhibited two of the three solution pathways that were associated with absence of HIE: New York lacked statewide HIOs and also lacked eCQM submission help with use of payment models.

CHAPTER 5. DISCUSSION

HIE promotes the collection and sharing of patient health information in a coordinated and purposeful way. Given the fragmented nature of the U.S. health care system, HIE can enable improved clinical decision-making, care coordination and a better understanding of the patient's full health situation. This benefits payers, providers and -- most critically – patients. Understanding that many key drivers of HIE would need to be addressed at a more local level, HITECH provided states with substantial funding to activate their policy levers to stimulate electronic data exchange.

The results of this research showed that state Medicaid agencies did implement a variety of policy levers aimed at promoting HIE. Many states implemented statewide HIOs. As shown by the literature review, HIOs have generally demonstrated improved data quality over traditional forms of data exchange. In addition, states typically accounted for their unique HIT landscape and built upon existing efforts when developing their HIE strategies. For example, North Dakota placed heavy emphasis on the ability to access patient data that were present in other state and regional HIOs given its large population of migrant oil workers and "snowbirds" (residents who frequently spend winter months in other states). North Dakota's strategy thus focused on connecting to a national HIE spine that supported access to patient data across the country.[115] California, on the other hand, opted for a decentralized HIE infrastructure that combined public and private initiatives in order to account for its geographic span and the size and diversity of its population.[110]

Similarly, states frequently built upon existing investments. For example, rather than establishing statewide HIOs, California, Florida, New Jersey and New York had well-established regional HIOs and sought to broaden these organizations' connections to health care providers.[110,116–118] As another example, New York focused on e-prescribing in order to build on a 2010 Medicaid program that provided financial incentives for facilitating such connections.[118] Nearly all states within the sample focused on connecting providers to immunization information systems, which were the focus of intense national efforts to improve their quality, use and position within the HIT infrastructure.[119]

For several states, leveraging system-wide Medicaid transformation activities provided a basis and momentum for integrating HIE requirements. Medicaid transformation typically emphasized improved care coordination for Medicaid members. Given this, HIE requirements, which facilitate patient tracking and care management, were natural accompaniments. For example, Oregon in 2012 received approval of an 1115 waiver[1] that authorized the use of Coordinated Care Organizations, which integrated physical, behavioral and oral health care for its Medicaid population. Oregon embedded four HIE-related requirements into its pay-for-performance quality metrics for these organizations: one addressed EHR adoption and three required reporting of electronic clinical quality measures to demonstrate Meaningful Use.[120] Vermont similarly built on its extensive health reform initiatives, which had expanded the use of patient-centered medical homes for care coordination and had established a Vermont Health Information Technology Fund.[121]

Overall, this research suggests that while states did seek to address the general drivers of HIT use as envisioned by the HITECH Act, policies often were more intensely focused on adoption of EHRs rather than the more ambitious goal of HIE. Strategies were typically dedicated to building up the base of HIT users, establishing some form of HIE infrastructure – most often a statewide HIO -- and facilitating connections among diverse entities. All states in the sample engaged in education and technical assistance for providers, and most states established connections with pharmacies, laboratories and public health agencies – all of which primarily addressed drivers of EHR adoption, such as product support and practice integration.[18] Fewer levers that had the potential to address drivers of HIE were documented in state HIT plans. Most states avoided direct mandates to hospitals, providers and Medicaid plans to share data, which could have increased data harmonization and provider participation.[18] Few

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[1] Section 1115 of the Social Security Act gives the Secretary of Health and Human Services authority to approve experimental, pilot, or demonstration projects that are found by the Secretary to be likely to assist in promoting the objectives of the Medicaid program. The purpose of these demonstrations, which give states additional flexibility to design and improve their programs, is to demonstrate and evaluate state-specific policy approaches to better serving Medicaid populations (https://www.medicaid.gov/medicaid/section-1115-demonstrations/about-section-1115-demonstrations/index.html).

states provided information about health care services (i.e., numerator data), which could have supported population health management and patient care.[18]

The substantial attention given by states to EHR adoption is expected given providers' limited use of EHRs during the early stages of HITECH, and HITECH's building-block approach to HIE. Nevertheless, several combinations of policy levers were found to be consistently present in states with HIE, as demonstrated by the CNA.

The CNA revealed that combining state Medicaid policy levers in at least one of two ways made a difference for HIE. Interestingly, the success of specific forms of infrastructure investment appeared dependent on the use or absence of payment programs. The two solution pathways representing these combinations of conditions are illustrated using a visual depiction designed by Miech and colleagues[97] and shown in Figure 5.1. Each pathway included the use of payment programs in different ways. When use of payment programs was present (Pathway 1), it was accompanied by the state Medicaid agency's assistance to Medicaid providers with the submission of eCQMs. When payment programs were absent (Pathway 2), the use of a statewide HIO and connections to laboratories were present.

Figure 5.1. Summary of Configurational Findings for States Demonstrating HIE

		Solution Pathway 1	Solution Pathway 2
Establish Infrastructure and Connections	Statewide Health Information Exchange Organization		●
	Laboratory Connections		●
	Electronic Clinical Quality Measure Submission Assistance	●	
Regulate and Motivate	Payment Programs	●	○
	States Positive for Data Sharing Covered by the Solution Pathway *Each state is uniquely covered by the solution*	ID LA MN OK OR VT WA	NC ND
	Model Consistency	90% (9/10)	
	Model Coverage	90% (9/10)	

Key ● Presence of lever ○ Absence of lever

There are several possible explanations for these findings. Payment programs offer providers both a structured framework and financial resources for integrating electronic clinical data into practice. This lever may be triggering a mechanism for providers to more regularly enter and use electronic clinical data during the patient encounter, which may in turn promote initial provider acceptance and understanding of the value of meaningfully using EHRs – the first steps towards HIE. However, demonstrating that the requirements of payment programs have been met can be burdensome for providers. While there are many different forms of payment programs, the document review revealed that when states used this policy lever, they frequently used patient-centered medical home certification or close variants of this model, and then integrated HIE requirements within them.[111,114,118,121–126] The medical home is a model of the organization of primary care that typically provides performance-based rewards and requires demonstration of five core functions: comprehensive care, patient-centered care, care coordination, accessibility, and quality and safety.[127,128] There are a number of formal certifications that demonstrate a practice operates as a medical home.[129–131] However, such certifications have been found to be exceedingly burdensome to achieve.[132,133] The state's assistance with the submission of eCQMs, which complement the use of payment programs to incentivize electronic data use and sharing, may have served to counteract this burden and enable HIE.

On the other hand, the absence of payment programs represents a lack of financial incentives and resources to participate in HIE. In this scenario, it may be the case that the statewide HIO conjoined with laboratory infrastructure assistance may be serving as the needed mechanism to trigger providers to access and use data outside their own systems when payment programs are absent. However, it may also be the case that payment programs create a burden on providers, which distracts from real-time data use, and therefore must be absent if providers are to focus on accessing statewide HIOs and laboratory data. This finding would align to previous studies that suggested participation in payment models increased burden on clinicians engaged in multiple quality improvement initiatives at once, which resulted in less HIE.[134,135]

Three solution pathways uniquely distinguished states without the outcome of HIE from those with HIE. Figure 5.2 summarizes these pathways. For these states, each solution configuration specified the absence of a particular form of infrastructure or connectivity support. This finding suggests that the absence of these activities means mechanisms that encourage external data seeking and real-time data use are not triggered. Similar to findings for the positive model, payment models appeared to play a role in potentially adding burden to providers. The presence of payment models without eCQM submission assistance resulted in lack of HIE.

Figure 5.2. Summary of Configurational Findings for States not Demonstrating HIE

		Solution Pathway 1	Solution Pathway 2	Solution Pathway 3
Establish Infrastructure and Connections	Statewide Health Information Exchange Organization	○		
	Laboratory Connections			○
	Electronic Clinical Quality Measure Submission Assistance		○	
	Numerator Provision			○
Regulate and Motivate	Payment Programs		●	
	States Negative for Data Sharing Covered by the Solution Pathway *Bolded states are uniquely covered by the solution*	**CA** **FL** **NJ** NY	**AZ** **MO** NY	**AL** **AK** **DE**
	Model Consistency	0.82 (9/11)		
	Model Coverage	0.90 (9/10)		

Key ● Presence of lever ○ Absence of lever

These results align with theoretical understanding of HIE mechanisms, and measures of consistency and coverage across both the positive and negative models suggest results are robust. Nevertheless, there were two inconsistent cases. Connecticut was a state that demonstrated HIE according to the outcome measure yet did not exhibit either of the solution pathways. Maryland, on the other hand, was a state that did not demonstrate HIE according to the outcome measure, yet it exhibited the strategy of eCQM submission conjoined with payment programs. Thus, there may be additional unmeasured factors occurring.

Limitations

Several limitations of this study are important to highlight. First, this analysis is based on a sample of 20 states. As noted, states were handpicked based on geographic region, Medicaid-expansion status and two measures of data innovation (broadband rank and open-data policy scores). While care was taken to include a diversity of states, it is nevertheless possible that states included in the sample are not representative of states across the U.S. Similarly, states lacking a sufficient number of responses to the outcome measure (electronic data sharing among providers) were removed prior to purposive sampling. It is possible that these states may have systematically differed from those with sufficient responses to the outcome measure.

Second, policy levers were assumed unused if there was a lack of documentation in the SMHP or related documents. It is possible that levers were used but insufficiently detailed within the state documents that were located. However, because SMHPs required states to provide a comprehensive listing of their HIE activities as a condition of funding, it is expected that most states erred on the side of including any and all levers used to promote HIE. Indeed, many SMHPs reviewed were documents of 150-200 pages, with detailed information regarding state actions, budgetary justifications and measures of success to date. Further, when plans were insufficiently detailed, CMS requested resubmissions to address information gaps. Related, the document review required discerning between state policy levers that had been implemented versus merely planned. However, as noted, care was taken to confirm that actions listed in these plans had been implemented as of December 31, 2016. For any cases in which SMHPs were unclear, actions were cross-checked with additional documents.

In addition, "HIE" was defined as the proportion of providers who electronically shared patient health information with external entities. This was defined by NEHRS as electronically sending or receiving patient health information through problem lists, medication and allergy lists, imaging reports, laboratory results, registry data or referrals. Though fairly comprehensive, this definition may miss other forms of data sharing, such as hospital or emergency department admission notifications. Related, the outcome of HIE, as well as the policy levers, were dichotomized. Dichotomization may inhibit the ability to capture more detailed or multifaceted conditions that could affect an outcome. However, dichotomization within CCMs can provide for more interpretable results.[136] Perhaps more importantly, the definition of data sharing does not necessarily capture whether the information was used in a substantive way – such as for patient or population health management. Nevertheless, the electronic exchange of patient health information is a necessary first step in the sequence towards use of information to improve health outcomes[38] and can serve as a reasonable measure.

With regard to the CNA, there are limitations to the method. One potential limitation is the possibility of "overfitting" a model, in which configurations show high consistency and coverage but do not represent meaningful results. However, including a criterion stating that results should align to theoretical understanding can help to alleviate this issue. In addition, several policy levers were removed at the outset due to minimal to no variation across states (e.g., Technical Assistance). This is because CNAs seek to identify Boolean difference-makers, and factors that are omnipresent across cases do not distinguish cases with the outcome from those without. However, it should be noted that such factors by their consistent presence cannot be tested by the CNA. Thus, their absence from the final configurations should not be interpreted to mean they are irrelevant.[90] Such factors could be further explored using other methods, such as qualitative inquiry.

Conclusion

State participation in Meaningful Use initiatives was a crucial component of the plan to achieve HIE. HITECH anticipated the need to engage states in order to address the impact of variation in state policy environments and local market forces on HIE.[18] Furthermore, for providers with a high volume of Medicaid patients and a low volume of Medicare patients, and for safety-net providers such as federally-qualified health centers, the state Medicaid-based programs were the only means of participation to receive HIT incentives.[31]

This research demonstrated that states within a 20-state sample utilized various tools within their sphere of influence to promote HIE. States accounted for their unique needs, capitalized on past or ongoing efforts, and often tied HIT transformation to broader Medicaid transformation goals. Many states explicitly noted the linkages between HIE and improved care coordination and population health management of their Medicaid enrollees. However, states more frequently relied on "carrots" versus "sticks" to coax providers into electronic data sharing. Furthermore, in the 5-7 years immediately following the passage of HITECH, most states focused on the primary building blocks of EHR use and infrastructure establishment. This finding aligns to the overall funding structure of HITECH, which allocated large portions of its funding towards technical assistance that supported adoption.[137] It also helps to explain other research that found progress from HIT adoption to more meaningful use of that technology was slower than projected.[12,18]

Nevertheless, several actions taken by states did appear to make a difference for HIE. States that combined the use of payment programs with assistance for reporting eCQMs demonstrated HIE. In addition, those that focused on the use of statewide HIOs and laboratory connections without the distractions of payment programs demonstrated HIE. By and large, states without HIE also lacked these levers. No single policy-lever condition alone explained the states that demonstrated HIE or those that did not demonstrate HIE. Rather, specific combinations of conditions were needed. In addition, multiple solutions across state policy strategies could result in HIE. Thus, this study supports the notion that the problem of HIE is one of causal complexity, and that identifying policies and strategies to promote HIE must account for the multifaceted nature of the problem.

While this study shed light on whether and how state policy levers might synchronize to improve HIE, a deeper understanding of the mechanisms that are being activated by these levers would be useful. Therefore, a Medicaid stakeholder panel was convened to review these results and provide input in order to inform a plan for change for improving HIE.

CHAPTER 6. PLAN FOR CHANGE

This study identified Medicaid policy levers implemented by states, and specific configurations of conditions present in states with HIE. In order to help contextualize the results of this study, a Medicaid Stakeholder Panel was convened to review results and provide input into how the identified configurations may be interacting to produce HIE. The results of this discussion were used to inform a plan for change that state Medicaid agencies and other health care entities could use to improve HIE.

Causal Pathway Models

Causal pathway models were developed in order to hypothesize mechanisms that potentially are being triggered by the state strategies that were identified. Causal pathway models are diagrams that illustrate the interrelations among variables and outcomes of interest in a given context.[138] Used within the framework of implementation science, causal pathway models can help to elucidate how theorized mechanisms affect proximal and distal outcomes, and how contextual factors may moderate the causal process.[138]

Table 6.1. Causal Pathway Model Terms and Definitions

Mechanism	Process or event through which an implementation strategy operates to affect desired implementation outcomes
Precondition	Factor that is necessary in order for an implementation mechanism to be activated
Determinant	Commonly referred to as ’barriers’ and ‘facilitators,’ a factor that enables or hinders the strategy from eliciting the desired effect
Mediator	Intervening variable that may account for the relationship between the strategy and the outcome
Moderator	Factor that increases or decreases the level of influence of a strategy
Proximal outcome	The product of the strategy that is realized because of its specific mechanism of action; the most immediate, observable outcome in the causal pathway
Distal outcome	Outcomes that the implementation processes are ultimately intended to achieve; not the most immediate outcome in the pathway

Lewis CC et al., From classification to causality: advancing understanding of mechanisms of change in implementation science. Front Public Health. May 2018.

A modified version of a four-step process proposed by Lewis and colleagues[138] was used to develop five causal pathway models that potentially explain the results of the CNA. Terms are defined in Table 6.1, and the modified process is described below. The first four steps align directly with the process proposed by Lewis and colleagues. The fifth step was adapted from Causal Loop Diagramming methods[139,140] and added to this process.

1. *Specify implementation strategies.* Each of the five State Medicaid agency strategies identified by the CNA were used as the strategies for the causal pathway models (two for the positive outcome and three for the negative outcome).
2. *Generate strategy-mechanism linkages*. Mechanisms that may have been activated by the strategies were identified.
3. *Identify proximal and distal outcomes*. Proximal and distal outcomes that were hypothesized to have resulted from the mechanisms were linked to the mechanism. While proximal outcomes varied, the distal outcome across all models was HIE.
4. *Articulate effect modifiers*. Moderators and preconditions were then identified and linked to the pathways between the strategy, mechanism and proximal outcomes.
5. *Consider feedback loops.* This step was adapted from causal loop diagramming methods[140] and added as a final step to the process in order to reflect how achievement of certain components of the causal pathway may "loop back" and affect other components. In addition, as is done in causal loop diagramming, "same" or "opposite" values were added to the arrows linking the components of the causal model. These values characterized the direction of movement different components may exhibit when activated by one another (e.g., for components with opposite values, an increase in one produces a decrease in the other).

The causal pathway models depicted hypothetical sequences of events that were described in the Discussion section of Chapter 5. The full set of models is shown in Appendix 4. Causal models can be particularly revealing for complex problems when individuals with in-depth knowledge of the variables participate.[139] Thus, these models were shared with a Medicaid Stakeholder Panel in order to solicit input on how policy levers may lead to HIE.

Medicaid Stakeholder Panel

Medicaid agency staff were recruited to participate in the stakeholder panel from an existing affinity group managed by the National Committee for Quality Assurance (NCQA), a not-for-profit organization that seeks to improve health care quality, and the study author's place of employment. The Medicaid Quality Network is a voluntary group composed of Medicaid agency staff who are interested in connecting with other state Medicaid agencies around health care quality.[141] Recruitment aimed to enroll 4-8 Medicaid agency staff who represented states with a range of perspectives. A preliminary list of Medicaid staff who were involved with data quality efforts was compiled. Staff represented states from a variety of regions. States were not restricted to those from the 20-state sample used in the study (i.e., staff from states outside the sample were also invited to join). Medicaid staff were then contacted by an NCQA public policy staff person via email to gauge their interest in participating in the stakeholder panel. The email indicated that a study assessing state policy levers related to HIE was conducted by an NCQA staff person as a University of North Carolina doctoral student. Those who indicated interest were then contacted by the study author, and a consent procedure was followed to reiterate that this study was conducted by the author as a University of North Carolina doctoral student; that participation was voluntary; and that responses would not be attributed to individual participants or their states.

Four Medicaid agency staff members from different states participated on the panel. Panel members were from states representing the Northeast, Mountain and Pacific regions of the U.S. Three of the four had a statewide HIO, and all had expanded Medicaid as of January 1, 2016. Two of the four states had been part of the study sample. All of the panelists were directly involved with Medicaid HIT efforts, as well as quality monitoring and improvement of the Medicaid program.

The meeting was conducted via Zoom video conference and lasted 90 minutes. After results were presented, participants provided input on the causal pathway models during a virtual whiteboarding exercise using Google Jamboard, a digital interactive whiteboard.

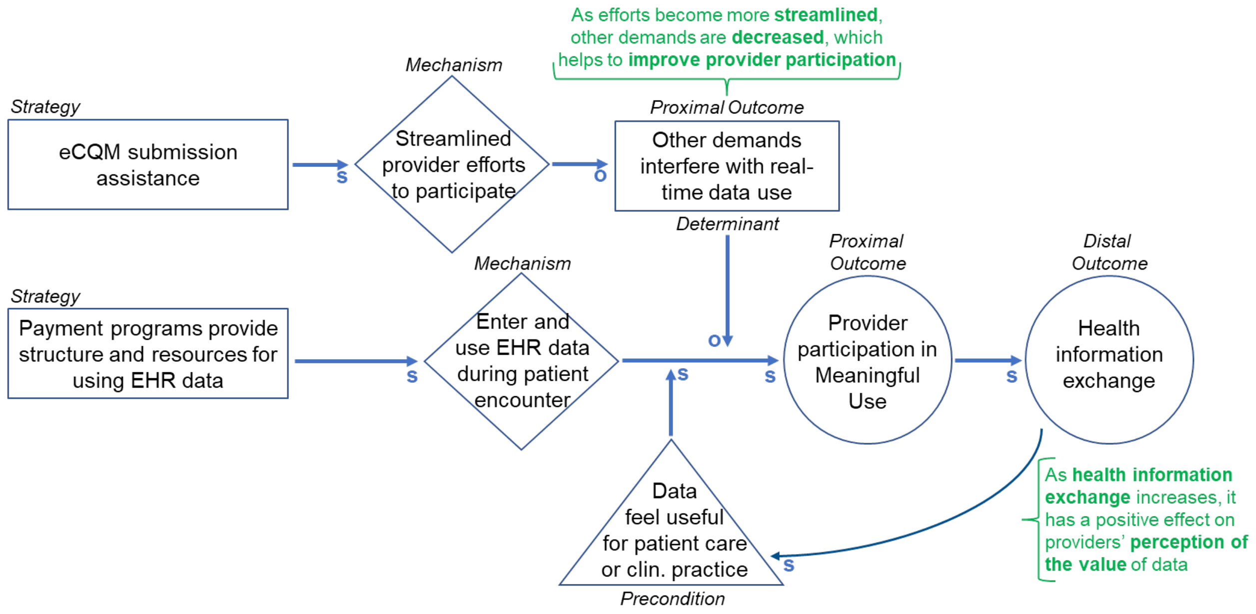
Results

Overall, state Medicaid participants considered results to be reasonable. Participants described the context in which many state HIT strategies were unfolding, offered additional thoughts on how strategies may (or may not) produce HIE, and delineated continuing challenges. There were no disagreements among the participants. Rather, participants reflected on their experiences, with most participants agreeing with the broader themes that emerged.

Input on strategies for HIE

In the first strategy, payment programs conjoined with eCQM submission assistance was consistently present in states with HIE. The mechanisms potentially triggered by these strategies are depicted in Figure 6.1.

Figure 6.1. Causal Pathway Model for Strategy 1: eCQM Submission Assistance with Payment Programs



As efforts become more **streamlined**, other demands are **decreased**, which helps to **improve provider participation**

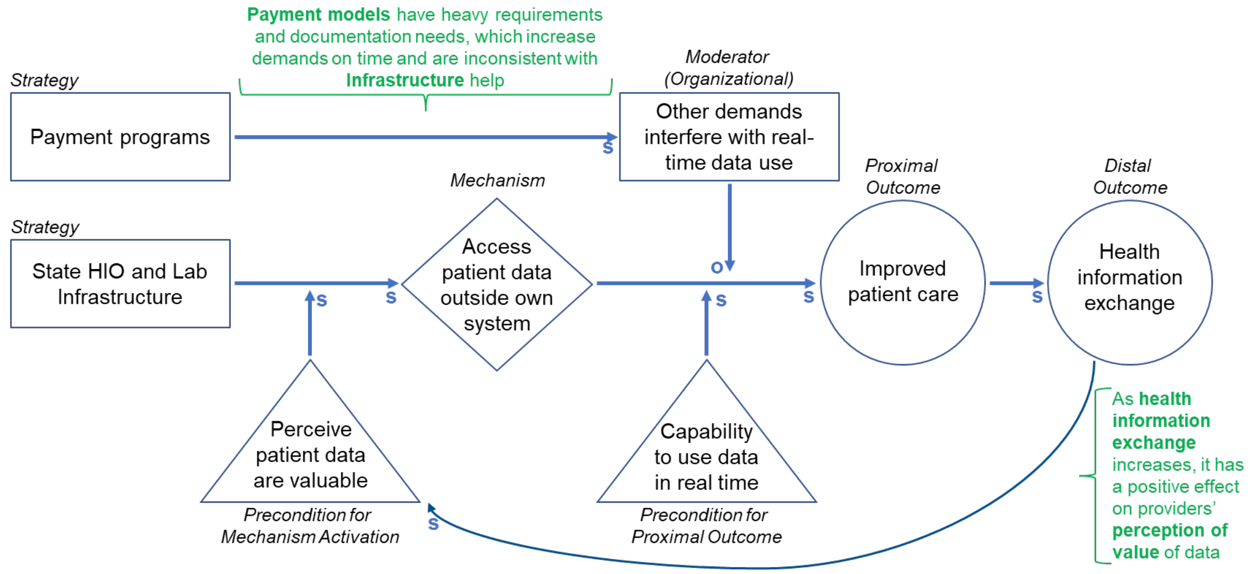
As **health information exchange** increases, it has a positive effect on providers' **perception of the value** of data

Key
s = same: as one element increases, the other increases and vice versa
o = opposite: as one element decreases, the other increases and vice versa

Participants felt the causal pathway model was plausible. One participant confirmed that in their state, these components are directly paired: value-based payment withholds are calculated using a provider's performance on eCQMs. Another participant suggested that providers must believe that quality measures are important, and that measures actually help to improve care. This could serve as a moderator to participation in the Meaningful Use Program. Another participant noted that their state has done extensive work helping providers to normalize their EHR data, which also enables eCQM reporting.

The second strategy consisted of the presence of statewide HIOs conjoined with laboratory infrastructure and the absence of payment programs. The mechanisms potentially triggered by these strategies are depicted in Figure 6.2.

Figure 6.2. Causal Pathway Model for Strategy 2: Statewide Health Information Exchange Organization and Lab Infrastructure without Payment Programs



Key
s = same: as one element increases, the other increases and vice versa
o = opposite: as one element decreases, the other increases and vice versa

Participants felt this causal pathway model also was plausible. Participants noted that statewide HIOs and laboratories may be playing a role to address nonstandard data, which are difficult or impracticable to exchange. Providers are subject to nonstandard data given excessive diversity across EHR vendor systems, which can be inconsistent both with other systems, and within the same system. Participants also discussed at length the issue of payment programs and were generally unsurprised to see results showing their dual effects across the strategies. Participants agreed with the hypothesis that competing demands encumber providers and impede HIE. One participant noted that, more specifically, misalignment of requirements is problematic. The participant emphasized that in many cases, both the measures as well as reporting mechanisms are misaligned, and that this situation increases administrative burden. Another participant agreed, noting that in their state, fragmentation also exists on the payer side: different managed care organizations are using different payment programs, which is confusing and onerous for providers.

Continuing challenges

Participants agreed that the set of models describing the absence of HIE (Figures A.4.3 - A.4.5 in Appendix 4) were reasonable, and that they essentially substantiated the positive models. The models confirmed many of the continuing challenges around HIE that participants proceeded to describe. Challenges centered around issues with data, provider burden and trust, vendors, and resources.

Unstructured electronic clinical data. The participant who described helping providers to normalize data indicated that the state's original intent was to onboard providers for the Medicaid EHR Incentive Program. However, the state's post-monitoring review revealed that poorly structured data prevented required information from being pulled into the queries that populate eCQMs. Therefore, the state halted onboarding in order to focus on data fidelity. But this was consequential: once HITECH ended, the state lost funding prior to onboarding many of its providers.

Insufficient resources for sustainability. Participants noted that resources available to states are insufficient to sustain HIT efforts. One participant described that while the state was able to assist with the purchase of EHRs, funding was insufficient for EHR integration and continuous IT support. This is particularly problematic for smaller practices, which often are operating at a loss and cannot pay for ongoing maintenance. Furthermore, the participant noted that in many cases, when problems arose, practices felt it was easier to purchase different EHR systems rather than fixing existing ones, and the state was then required to start the onboarding process anew.

Provider burden and lack of trust*.* Misaligned HIE initiatives and their cost have contributed to provider burden and failed to engender trust. One participant noted that some providers, particularly rural providers, view state efforts as a "soft takeover" of their systems. Further, a lack of cost transparency from vendors and HIOs leads to a reputation problem within the community. Given these issues, HIE efforts are seen as high cost – both in terms of money and time -- and the benefits are unclear.

Poor vendor cooperation**.** Several participants described challenges with EHR vendors that continue to obstruct HIE. Vendors continuously fail to standardize data; a participant noted that even within one vendor system, data are incapable of flowing freely. Further, the lack of cost transparency from both EHR vendors and, in some cases, large HIOs, prevents the state from determining sufficient resources for assisting providers. Participants described a power imbalance when dealing with vendors: while the state holds the resources, the vendors hold political influence through lobbying and other efforts.

Plan for Change

The results of this study have important implications for HIE efforts, particularly as they relate to the use of value-based payment strategies, quality measures and infrastructure support, which figured prominently in state strategies and address issues such as data quality and motivation to participate in data exchange.

Recommendations and action steps to promote HIE

Recommendations and action steps that can assist Medicaid agencies and other entities that are interested in promoting HIE are summarized in Table 6.2. Several of the action steps reflect my work developing and implementing quality measures at NCQA, and as a lead for the organization's digital quality measures initiative. In these roles, I am ideally situated to disseminate findings and encourage the uptake of recommendations. It is important to note that these recommendations are my own and do not necessarily reflect the policy or viewpoints of NCQA. However, as HIE has the potential to improve patient care, its attainment aligns to NCQA's mission to improve health care quality.

Table 6.2. Recommendations and Action Steps to Promote Health Information Exchange

Recommendation	Action Steps
1. Address the problem of unstructured data by promoting data standardization and quality	Leverage digital quality measurement efforts
	Encourage data validation of HIOs for quality measurement
2. Address provider burden by aligning HIE efforts across programs	Present alignment framework to federal and state policymakers
	Support alignment of measures across programs
3. Maximize HIE efforts by aligning with strategic priorities for Medicaid	Assist with efforts to improve measurement of Medicaid priorities

Recommendation 1. Promote data standardization and quality

Medicaid stakeholders indicated that poor data quality continues to be a challenge that impedes interoperability and HIE. While HIOs represent an important step towards electronic data exchange, HIOs have struggled to establish and communicate the various uses cases that produce benefits for providers. For example, state Medicaid agencies have reported that it has been challenging to use HIOs for reporting quality measures.

Action Steps

- *Leverage digital quality measurement efforts*. Measures can align incentives, behavior and action among the various actors across the health care system. The use of digital quality measures, including eCQMs, as part of value-based payment programs can provide the motivation and framework for standardizing data. Digital quality measures require the use of *structured* electronic clinical data.[142,143] Such data use standardized formats and standards-based data models, which allow health information to be captured and transmitted electronically and via interoperable systems.[144] In addition, digital quality measures used in NCQA's health plan measurement program include a requirement that plans ensure care teams can access data at the point of care.[145] With my teams, I have led the development of several digital quality measures. Specifically, we have developed two measures assessing the receipt of immunizations among adults and pregnant persons, and two measures addressing perinatal depression screening and management.[146] These measures assign health plans accountability for ensuring their members receive these interventions. The reporting and use of such measures in accountability programs can encourage the collection and use of structured data, which in turn will make data more readily accessible for HIE. My work to further NCQA's digital measurement strategy has moved all four of these measures into public reporting in a staged approach. In addition, I will work with state and federal program leads to encourage the measures' use in programs. This work also aligns with the CMS Meaningful Measures Framework.[144]
- *Encourage data validation of HIOs for data quality*. Stakeholders expressed frustration upon learning that data oftentimes existed in systems but were not structured for queries and

exchange. Efforts to ensure data are correctly collected and stored can facilitate exchange and demonstrate that documentation efforts are worthwhile. Further, ensuring data from HIOs can meet the needs of additional use cases will help demonstrate the value of such organizations. One use case, which also aligns to data standardization efforts, is use of data for quality monitoring and reporting. To this end, NCQA has launched a Data Aggregator Validation program, which evaluates the ingestion, transformation and output of clinical data from HIOs and other data aggregators for use in quality evaluation programs.[147] Such a program may be useful for states seeking to encourage the use of structured, shareable data for quality measurement. Given this, I will highlight this program to state Medicaid agencies that may be interested in having statewide HIOs undergo this validation process.

Recommendation 2. Align HIE efforts across programs and levels of the health care system

Medicaid stakeholders agreed with study results suggesting that payment programs could have a detrimental effect when misalignment of requirements increases burden. Alignment of HIE efforts across major reporting programs that operate across payers and/or different levels of the health care system should accompany data standardization and interoperability efforts. For example, an evaluation of multi-payer PCMH transformation initiatives concluded that a multi-payer design, while more financially robust, will be burdensome unless the payers coordinate to harmonize their requirements prior to implementation.[148] A recent framework proposed by Olin and colleagues emphasizes coordination, shared goals and aligned incentives across three levels: the macrosystem (federal/state entities with regulatory authority), mesosystem (health plans/systems), and microsystem (providers).[149] The framework recommends the use of common incentives to encourage collaboration and moving from a compliance-driven mindset to an improvement-driven one.[149]

Action Steps

- *Discuss policy recommendations with federal and state stakeholders*. It will be important to distribute recommendations resulting from this study more widely, in particular the recommendation to align measure reporting requirements across major quality monitoring programs. Federal and state policymakers must understand the landscape of requirements being imposed upon clinicians and other health care entities. There are numerous opportunities for me to present these findings. NCQA maintains several affinity groups and advisory councils for state and federal policymakers. NCQA's Medicaid Quality Network, Medicaid Data Quality Group and Public Policy Advisory Council will be ideal platforms to share recommendations and encourage uptake. In addition, NCQA holds several annual meetings, including the Digital Quality Summit, during which study findings can be shared with stakeholders from across the health care system, including CMS.

- *Support alignment of measures across programs.* While influencing federal and state governments and other organizations to align their use of measures is a longer-term goal that will require cooperation at a broader level, I can help to ensure that the alignment of measures in NCQA programs is a consideration during program development. NCQA uses measures in several evaluation programs, including accreditation and ratings of health plans. In addition, because NCQA measures are used across other programs, such as the CMS Medicaid Core Set and several state quality programs, NCQA has a platform to share the importance of alignment.

Recommendation 3. Align HIE efforts with strategic priorities for Medicaid

Medicaid stakeholders described several strategic goals that have been recently prioritized across many states. Chief among these priorities are addressing health equity and social determinants of health (SDoH). The information needed to assess SDoH and achievement towards health equity goals is poorly standardized or, in some cases, wholly unavailable.[150–152] Such information includes data on race/ethnicity, gender identification, language preferences, socioeconomic status, food insecurity, and housing insecurity. Focusing on improving the documentation and quality of this information could align efforts and amplify effectiveness towards both these and HIE goals. There have been several efforts to improve documentation of SDoH information. For example, the Gravity Project, funded by the Robert Wood Johnson Foundation, seeks to identify coded data elements to represent SDoH data documented in EHRs across four clinical activities: screening, diagnosis, planning and interventions.[153] Phase 1 includes activities such as development of SDoH data use cases and development of an implementation guide; phase 2 will move towards working with terminology suppliers to address coding gaps and testing new SDoH coding sets.[153]

Further, HIE will be useful in addressing the current COVID-19 vaccination efforts. For example, state Medicaid agencies can share Medicaid immunization claims and information on children and providers participating in the Vaccines for Children program with state-level IIS.[154] Such data sharing can facilitate creation of patient vaccine reminders, vaccine forecasting and coverage assessments.[155]

Action Step

- *Assist with efforts to improve measurement of Medicaid priorities*. The development of measures to facilitate assessment of SDoH, health equity and COVID-19 vaccination may assist in data standardization efforts and meet needs that are of immediate concern to states. This is an area where ongoing work at NCQA and other organizations, such as the Gravity Project, may align with such efforts.

Conclusion

It is important to note that, in addition to the recommendations listed here, Medicaid Stakeholder Panel participants made several larger-scale recommendations that would best be addressed at a legislative or regulatory level. Participants expressed a need for additional funding similar to HITECH's in order to sustain the progress that has been made. Participants also noted that additional policy solutions, such as regulation of data vendors, are needed in order to mitigate the power imbalance between for-profit and public actors, and to compel interoperability. One participant suggested creation of a public EHR option for providers. These suggestions for more extensive changes reflect deeper issues within the U.S. health care system, such as the severe resource limitations of state Medicaid programs and the pitfalls of applying a market-based approach to HIE.

On an encouraging note, policy solutions are ongoing. At the federal level, CMS and ONC released in 2020 and 2021 complementary final rules to confront interoperability challenges.[156,157] Implementing provisions set forth in the 21st Century Cures Act,[158] CMS now requires state and federally supported health plans to provide enrollees with free electronic access to their personal health information.[156] This requirement applies to Medicaid, the Children's Health Insurance Program, Medicare Advantage plans, and Qualified Health Plans participating in the Health Insurance Marketplace ---

together which cover approximately 125 million individuals.[156] ONC's final rule supports this requirement by prohibiting health care providers, HIOs, and developers of HIT from undertaking practices that interfere with HIE.[157] The rule also encourages EHR vendors to voluntarily adhere to certification standards and to abandon proprietary features that have long obstructed data exchange.[157]

In addition, there have been several promising state initiatives. For example, North Carolina passed legislation in 2017 that mandates Medicaid providers to participate in HIE.[159] In addition, as part of Medicaid transformation efforts, the state will work with the statewide HIO to provide the necessary electronic clinical data to report a prioritized list of eCQMs.[160]

Data sharing limitations highlighted by the COVID-19 pandemic has spurred additional action. For example, the pandemic made clear the need to improve data sharing across IIS in order to track COVID-19 vaccination series coverage. In response, the Association of State and Territorial Health Officers, Network for Public Health Law and American Immunization Registry Association collaborated to develop and issue an Interjurisdictional Memorandum of Understanding, which supports secure, electronic exchange of immunization data among governmental entities that operate a population-based IIS.[161] As of early 2021, the document had been signed by over 30 jurisdictions.[162]

How to effectively facilitate HIE in the U.S. is a complex and dynamic problem. Successful exchange of information involves the cooperation of many diverse actors across a health care system that operates in a highly heterogeneous manner. The recommendations and action steps resulting from this work have the potential to assist states and other health care entities to improve HIE, and thereby improve patient health and health care outcomes. The barriers preventing the flow of health information are diverse and complex. As federal and state policymakers continue to build off the immense efforts launched under HITECH, it will be important to note that a combination of tools may be most effective, but also that one must be mindful of overburdening providers with excessive and misaligned requirements.

APPENDIX 1. LITERATURE REVIEW TABLE OF FINDINGS

Table A1. Literature Review Results

Source	Location	HIE Type	Setting	Study Type	Comparison	Outcomes	Findings	Direction	Bias Risk
Adler-Milstein J et al., 2016	National	Community and state HIOs	NA	Quantitative	NA	Provider ability to meet Meaningful Use requirements	77% of efforts supported summary of care record; 63% could transmit lab results; 15% met all Stage 2 MU	Positive	Medium
Chen M et al., 2019	FL	Various	Hospital	Quasi-experimental	Non-participant hospitals	Acute myocardial infection readmission rate	HIO: decline in 30-day readmissions by 1.3 percentage points; similar findings for other measures	Positive	Low
Dixon BE et al. 2017	IN	State HIO	Public health department	Non-experimental	Faxed lab reporting	Reporting rates, completeness, timeliness	Completeness varied across fields; HIO timelier than fax/manual	Mixed	Medium
Gernant SA et al., 2017	IN	Community pharmacy PBRN	Community pharmacy	Experimental	Normally derived information	1) identification of medication problems; 2) preventive care omissions; 3) perception	Intervention pharmacists identified more medication-related problems than usual care	Positive	High
Haque SN et al., 2017	NY - western	Regional HIO	Non-specific - public health reporting	Mixed methods	Outcomes prior to intervention	1) reported treatment rates of gonorrhea and chlamydia; 2) cost	1) reported treatment rates for both diseases increased significantly; 2) HIO use resulted in cost savings	Positive	Low
Hendrickson BK et al., 2015	AZ	IIS	Pediatric primary care site	Qualitative	Data derived from EHR and personal record	Data completeness	Completeness: personal record 90%, EHR 85%, IIS 72%; when newborns excluded, IIS 84%	Mixed	Medium
Hewner S et al., 2018	NY - western	Regional HIO	Primary care clinic	Quasi-experimental	2 matched sites	Hospitalizations and ER use, Inpatient and ED; outpatient follow-up post-discharge	Intervention site had greatest decline in inpatient and ED use and greatest increase in outpatient visits	Positive	Low
Hohmeier KC et al., 2017	TN	Regional HIO	Community pharmacy	Qualitative	None	1) workflow integration 2) perception of usefulness; 3) medication discordance	HIO access used for 60% of patients; pharmacists felt HIO provided information helpful to care	Mixed	Medium
Khurshid A et al., 2015	National	Various	NA	Qualitative	Non-HIO use	1) positive ROI, 2) improved quality of care	64% agreed HIOs improve quality; 76% do not use for measures	Mixed	Medium
Koepke R et al., 2015	WI	IIS	Organizations participating in Vaccines for Children	Qualitative	Medical record-(MR) derived data	1) Completeness 2) Accuracy	1) IIS had records for 98% of patients in sample; IIS contained 97% of vaccinations in MR 2) 99% of matched vaccinations had same admin. date in MR & IIS	Positive	Low
Lyle J et al., 2016	National	Veterans Health HIO	NA	Qualitative	None	Data quality as measured by a "richness score"	Richness scores ranged from 12%-82% (mean 55%, median 59%)	Mixed	High

Source	Location	HIE Type	Setting	Study Type	Comparison	Outcomes	Findings	Direction	Bias Risk
Massoudi BL et al., 2016	National	Various	NA	Qualitative	Non-HIO use	Quality measure use; barriers and facilitators to computing	30% computed at least one measure, 17% computed at least one of measures in question	Mixed	High
Melvin CL et al., 2016	SC – Charleston	Regional HIO	Emergency Department	Qualitative	Non-HIO use	1) usability; 2) functionality; 3) patient & clinical factors that prompt HIO use; 4) overall quality	Majority found HIO useful; strong agreement that HIO improved quality of care but concerns re data availability; Overall: majority positive	Mixed	High
Murthy N et al., 2017	National	IIS	NA	Qualitative	Hospital records, National Immunization Survey	1) data completeness 2) bidirectional exchange 3) clinical decision support 4) coverage	% with immunizations in IIS rose from 90% to 94%; 30 of 55 IIS had vaccine rates ≥10 %age pts lower than NIS	Mixed	Low
Nagykaldi ZJ et al., 2017	OK	Regional HIO	Region's hospital and clinics	Quasi-experimental	Outcomes prior to intervention	Number patients up to date on key preventive services	78% residents identified as needing preventive services; 35% mean increase in services	Positive	Medium
Painter I et al., 2017	IN	State HIO	Public health department	Quasi-experimental	Forms not pre-populated with HIO data	Time from receipt of case to inclusion in surveillance system to close of case	Mean Reporting Lag 2.7 days shorter than controls; Mean time to close 0.2 days shorter than control	Positive	Medium
Pitts SI et al., 2017	MD	State HIO	ACO	Quasi-experimental	Non-HIO use	1) % records updated 2) % not up-to-date on mammo. at visit; 3) % with mammo. addressed at visit; 4) % up-to-date 8 weeks post	Proportion with mammo. addressed at visit increased by 43 percentage pts; proportion up to date 8 weeks post increased by 12 percentage pts	Positive	Low
Popovich M et al., 2016	WA, 2 unnamed	IIS	Pharmacy	Non-experimental	None	1) Improved info at point of care; barriers to use 2) patient match rate and data completeness	1) 74% of patients found in IIS; 62% of total were due for vaccines; 2) Patients found in IIS 73% of time; 91% patients found were due	Positive	High
Reis J et al., 2016	ID	State HIO	NA	Qualitative	Non-HIO use	1) usability; 2) administrative and clinical impact	Improved care coordination, completeness most cited	Mixed	Medium
Shy BD et al., 2016	NY	Regional HIO	Emergency Department	Non-experimental	Site-specific data	Incremental difference in return visits	HIO showed 6.9% relative increase of return visits	Positive	Low
Swain MJ & Kharrazi H, 2015	Various	Not identified	NA	Quasi-experimental	Non-HIO use	Data completeness in order to predict readmissions	Variability in coverage and detail on items used in the predictive model; model not likely to be complete	Negative	High
Walker DM, 2018	National	Various	Hospital	Non-experimental	1) no HIO participation 2) no HIO participation	1) improved technical efficiency change, technological change, productivity; 2) efficiency change	1) HIO participants more likely in higher quintiles of tech efficiency; HIO not significantly related to tech. change; 2) longer participation not significantly related to efficiency but significantly related to productivity	Mixed	Medium

APPENDIX 2. HEALTH INFORMATION TECHNOLOGY DOCUMENTS REVIEWED

Alabama
State HIE Strategic and Operational Plan Profile, 2012
State Medicaid Health Information Technology Plan, 2018

Alaska
State Medicaid Health Information Technology Plan Addendum, 2014
State Medicaid Health Information Technology Plan, 2018

Arizona
Arizona Health Information Exchange Operational Plan, 2011
Arizona HIT Roadmap, 2014
State Medicaid Health Information Technology Plan, 2019

California
Report to the Legislature: Medi-Cal EHR Incentive Program, Oct 2011 - Jun 2016
State Medicaid Health Information Technology Plan, 2018
State Medicaid Health Information Technology Plan, 2019

Connecticut
State HIT Implementation Advanced Planning Document, 2010
State HIE Strategic and Operational Plan Profile, 2011
State HIT Implementation Advanced Planning Document, 2017
Presentation: SMHP and IAPD Overview, 2019

Delaware
Delaware Strategic Operations Plan for HIE, 2012
State Medicaid Health Information Technology Plan, 2017
State Medicaid Health Information Technology Plan, 2018

Florida
State HIE Strategic and Operational Plan Profile
State Medicaid Health Information Technology Plan, 2014
State Medicaid Health Information Technology Plan, 2014 Update
State of Florida As-Is Assessment Health Information Exchange Study, 2018

Idaho
State HIE Strategic and Operational Plan Profile
Idaho Statewide Healthcare Innovation Plan, 2013
Medicaid Health Homes in Idaho: Review of Pre-existing Initiatives and State Plan Amendment for the State's First Health Homes under Section 2703 of the Affordable Care Act, 2013
State Medicaid Health Information Technology Plan, 2016

Louisiana
State HIE Strategic and Operational Plan Profile
State Medicaid Health Information Technology Plan v1.2
State Medicaid HIT Plan Addendum: Louisiana Medicaid EHR Incentive Program Modifications – Program Year 2017
Louisiana Health Information Technology Roadmap 2018-2021

Maryland
State HIE Strategic and Operational Plan Profile
State HIT Implementation Advanced Planning Document, 2014
State Medicaid Health Information Technology Plan v5, 2016

Staff Report: Maryland's Statewide HIE, the Chesapeake Regional Information System for our Patients: FY 2018 Funding to Support HIE Operations and CRISP Reporting Services, 2017
State Medicaid Health Information Technology Plan v7, 2018

Minnesota
State Medicaid Health Information Technology Plan Addendum, 2014
State Medicaid Health Information Technology Plan, 2017

Missouri
State Medicaid Health Information Technology Plan Update v2.0, 2017

New Jersey
State HIE Strategic and Operational Plan Profile
State Medicaid Health Information Technology Plan, 2016

New York
A Plan to Transform the Empire State's Medicaid Program, 2009
State Medicaid Health Information Technology Plan, 2011
State Medicaid Health Information Technology Plan Update, 2019

North Carolina
State HIE Strategic and Operational Plan Profile
North Carolina Senate Bill 257, 2017
State Medicaid Health Information Technology Plan v4.1, 2017

North Dakota
Medicaid EHR Program Requirements, 2014
North Dakota Health Information Network Environmental Scan Brief, 2016
North Dakota Health Information Network Future State Brief, 2016
North Dakota Statewide Information Technology Plan, 2015-2017
North Dakota Health Information Network Business Plan, 2016
Presentation: North Dakota Health Information Network: Building Capacity, Usage and Value, 2016

Oklahoma
State Medicaid Health Information Technology Plan, 2010
State Medicaid Health Information Technology Plan, 2010, Update
Implementation Advanced Planning Document, 2010
Oklahoma's Revised Strategic Plan for the State Health Information Exchange Cooperative Agreement Program, 2011
Oklahoma EHR Incentive Program Provider Manual, 2017

Oregon
State HIE Strategic and Operational Plan Profile
State Medicaid Health Information Technology Plan, 2013
State Medicaid Health Information Technology Plan, 2014

Vermont
State HIE Strategic and Operational Plan Profile
State Medicaid Health Information Technology Plan, 2011
State Medicaid Health Information Technology Plan, 2014
State Medicaid Health Information Technology Plan, 2016

Washington
State HIE Strategic and Operational Plan Profile
State Medicaid Health Information Technology Plan, 2017

APPENDIX 3. COINCIDENCE ANALYSIS SOLUTION SETS SHOWN IN FULL DATA SET

STATE	OUT	NUM	LAB	QM	PAY	SHIO	LAB	PAY	CLIN	HOSP	PLAN	PUR	OPTO	CLM
ID	1	1	1	1	1	1	1	1	1	0	1	1	1	1
LA	1	1	0	1	1	1	0	1	0	0	0	0	0	1
MN	1	1	0	1	1	0	0	1	1	1	0	0	1	1
OK	1	1	1	1	1	1	1	1	0	0	0	0	1	1
OR	1	1	1	1	1	1	1	1	0	0	0	1	1	0
VT	1	0	1	1	1	1	1	1	0	1	1	1	0	0
WA	1	1	1	1	1	1	1	1	1	0	1	1	0	1
NC	1	0	1	0	0	1	1	0	0	0	0	0	1	1
ND	1	0	1	0	0	1	1	0	0	0	0	0	1	0
CT	1	0	1	0	1	1	1	1	0	0	0	0	1	0
CA	0	0	1	0	0	0	1	0	0	0	0	0	0	1
FL	0	0	1	0	0	0	1	0	0	0	0	0	0	1
NJ	0	0	1	0	0	0	1	0	0	0	0	0	1	0
NY	0	0	1	0	1	0	1	1	0	0	0	0	0	0
AZ	0	0	1	0	1	1	1	1	1	1	0	1	1	0
MO	0	0	1	0	1	1	1	1	0	0	0	0	1	1
AL	0	0	0	1	0	1	0	0	0	0	0	0	1	1
AK	0	0	0	1	0	1	0	0	0	0	0	0	1	0
DE	0	0	0	0	0	1	0	0	0	0	0	0	1	1
MD	0	1	1	1	1	1	1	1	1	0	1	0	1	0

Key

1 = presence of outcome or factor; 0 = absence of outcome or factor

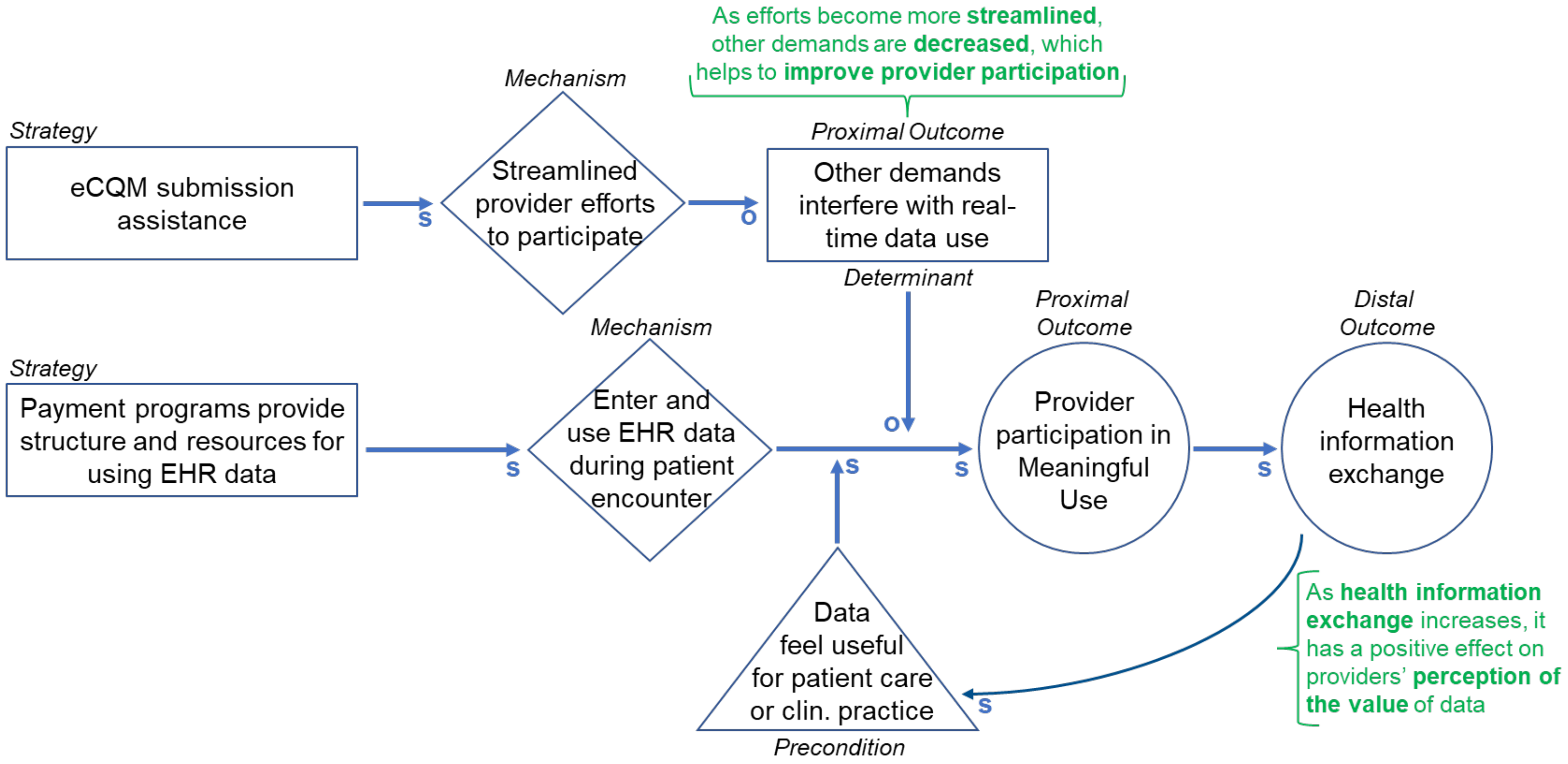
TA	Technical assistance
MU	Meaningful Use assistance
SHIO	Statewide HIO
RHIO	Regional HIO
PH	Public health connections
RX	e-Prescribing connections
LAB	Laboratory connections
CLM	Electronic claims provision

QM	Electronic quality measures submission
NUM	Quality measure numerator provision
CLIN	HIE mandate for clinicians
HOSP	HIE mandate for hospitals
PLAN	HIE mandate for health plans
PUR	State purchasing
OPTO	Opt-out policy
PAY	Payment models

🟩 Solution path for the positive model
🟩 Solution path inconsistent with presence of the outcome
🟦 Solution path for the negative model
🟦 Solution path inconsistent with absence of the outcome

APPENDIX 4. CAUSAL PATHWAY MODELS

Figure A4.1 Causal Pathway Model for Solution Pathway 1: eCQM Submission and Payment Models



As efforts become more **streamlined**, other demands are **decreased**, which helps to **improve provider participation**

As **health information exchange** increases, it has a positive effect on providers' **perception of the value** of data

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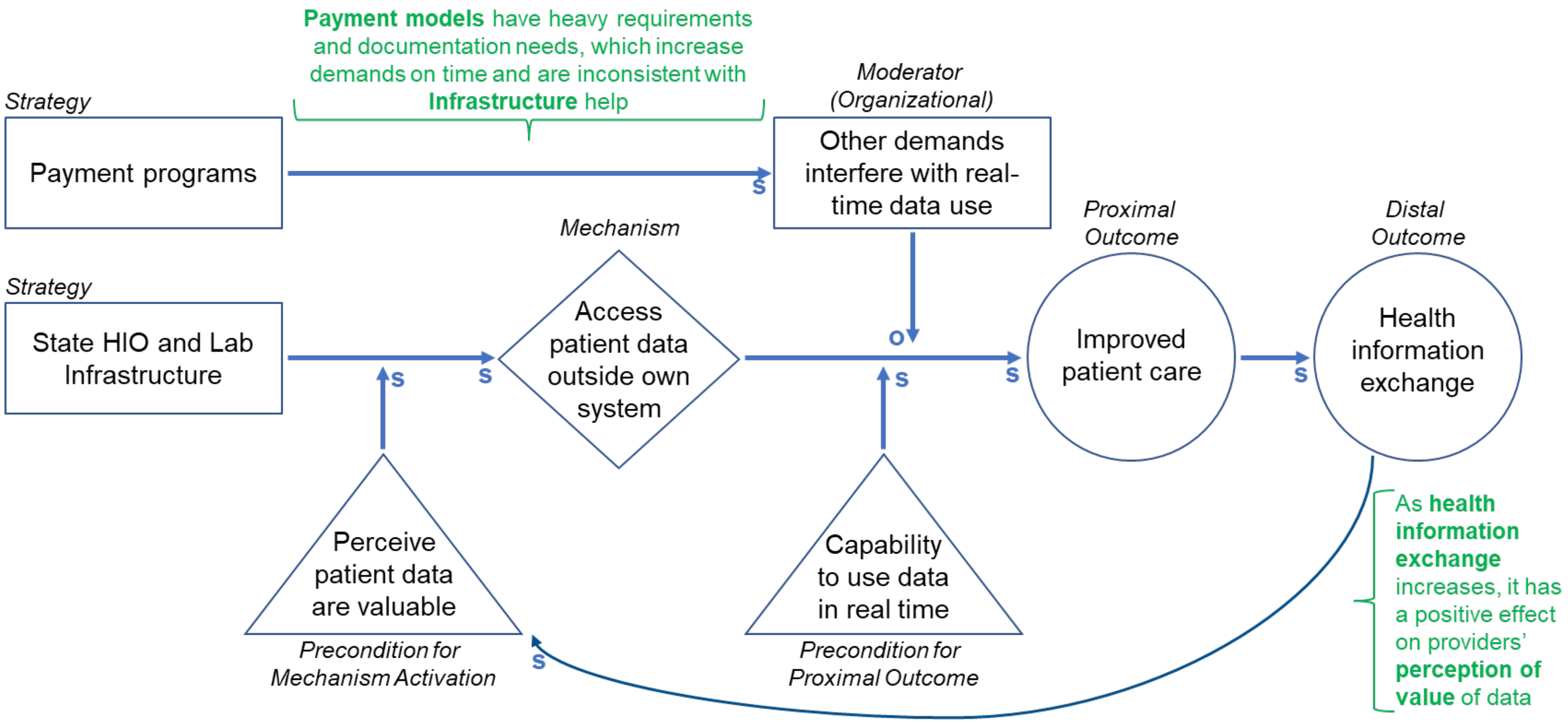
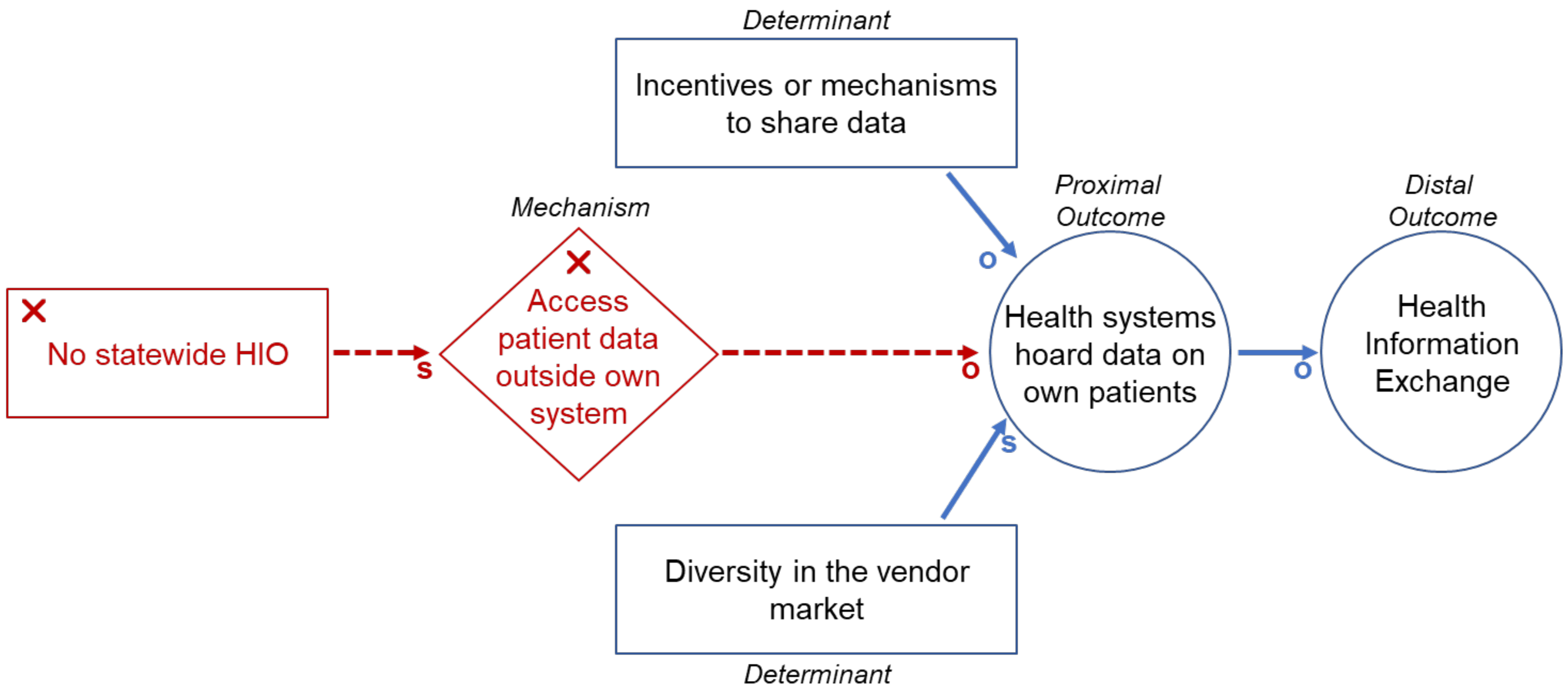
s = same: as one element increases, the other increases and vice versa
o = opposite: as one element decreases, the other increases and vice versa

Figure A4.2 Causal Pathway Model for Solution Pathway 2: State Health Information Exchange Organization and Laboratory Infrastructure without Payment Programs



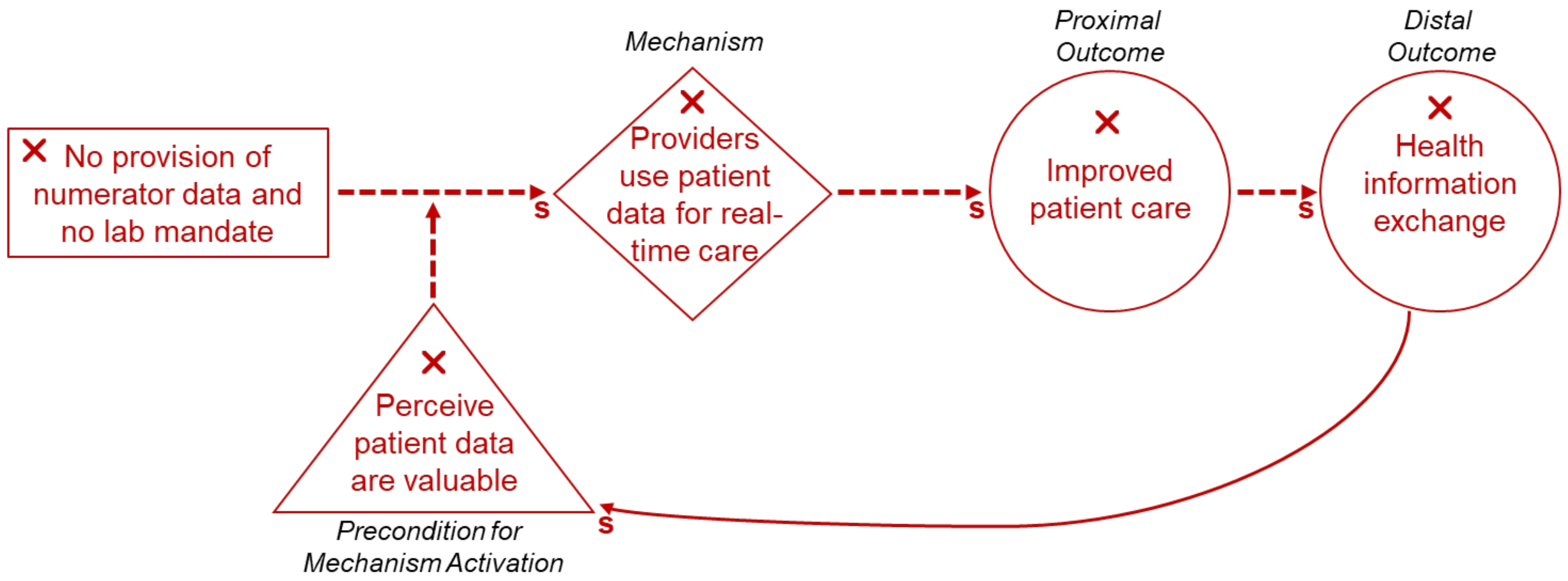
Key
s = same: as one element increases, the other increases and vice versa
o = opposite: as one element decreases, the other increases and vice versa

Figure A4.3 Causal Pathway Model for Negative Solution Pathway 1: Lack of Statewide Health Information Exchange Organization



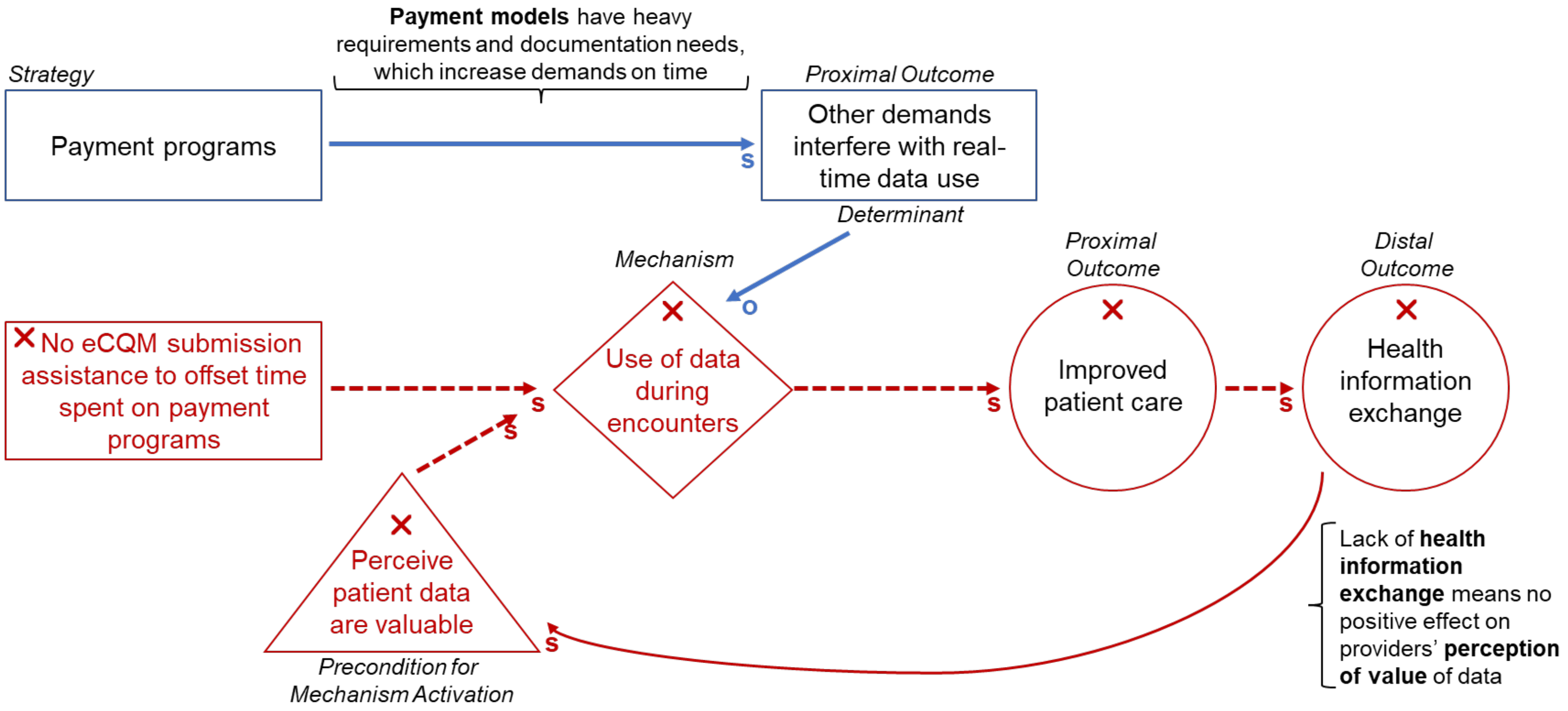
Key
s = same: as one element increases, the other increases and vice versa
o = opposite: as one element decreases, the other increases and vice versa

Figure A4.4 Causal Pathway Model for Negative Solution Pathway 2: No provision of numerator data and no laboratory assistance



Key
s = same: as one element increases, the other increases and vice versa
o = opposite: as one element decreases, the other increases and vice versa

Figure A4.5 Causal Pathway Model for Negative Solution Pathway 3: Use of Payment Programs without eCQM Submission Assistance



Key
s = same: as one element increases, the other increases and vice versa
o = opposite: as one element decreases, the other increases and vice versa

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