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The essential role of reconfiguration capabilities in the implementation of HIV-related health information exchanges

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ABSTRACT

Purpose: To understand the dynamic capabilities that enabled the six demonstration projects of the Information Technology Networks of Care Initiative to implement health information exchanges (HIEs) tailored to their local HIV epidemics and regional care systems.

Methods: We conducted 111 semi-structured interviews with project staff and information technology (IT) specialists associated with the demonstration projects, staff from community-based organizations and public health agencies collaborating in the design and implementation of the HIEs, and providers who used each HIE. The dynamic capability framework guided analyses. In the context of a HIE, the framework's components include *information systems* (the actual technological exchange systems and capacity to update them), *absorptive capacity* (the ability to implement an operating HIE), *reconfiguration capacity* (the ability to adapt workflows and clinical practices in response to a HIE), and *organizational size and human resources* (characteristics likely to affect a clinic's ability to respond).

Results: Across the projects, we found evidence for the importance of three dynamic capabilities: information systems, reconfiguration capacity, and organizational size and human resources. However, of these three, reconfiguration capacity was the most salient. Implementation outcomes at all six of the projects were shaped substantially by the degree of attention dedicated to reworking procedures and practices so that HIE usage became routine. **Conclusion:** Electronic information exchange offers the promise of improved coordination of care. However, implementation of HIEs goes beyond programing and hardware installation challenges, and requires close attention to the needs of the HIEs end-users. Providers need to discern value from a HIE because their active participation is essential to ensuring that clinic and agency practices and procedures are reconfigured to incorporate new systems into daily work processes.

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1. Introduction

Electronic technologies have been heralded as important innovations for healthcare settings [1], but their implementation is fraught with pitfalls. The potential barriers are numerous and span technological (e.g., complicated hardware or software systems), attitudinal (e.g., resistance to change among providers and staff), functional (e.g., systems that are not useful or practical), managerial (e.g., needing to keep projects within budget, schedule or quality parameters) and political domains (e.g., impact of power relationships within institutions) [2]. Successful implementation requires hospitals, clinics, and agencies to tackle challenges that go beyond the programing of software code and installation of computers to include interpersonal and institutional dynamics that pre-date and may be unrelated to the technology itself.

Although such complications exist when introducing any new technology, the potential obstacles are especially salient when a system is intended to foster the electronic sharing of patient health information across provider organizations or healthcare systems. Health information exchanges (HIEs) require a synthesis of goals, protocols, data formats, and infrastructure within and across organizations. The partners in a HIE are likely to think of, and govern themselves as, stand-alone entities and may have very different institutional cultures and practices [3–5]. When the data to be exchanged happen to be HIV-related, the potential barriers are further complicated by legal and organizational precedents that place primacy on the protection and limited distribution of health information in light of historical—and, to a lesser degree, continuing—stigmatization of the disease [6].

The Health Resources and Services Administration HIV/AIDS Bureau (HRSA/HAB) sponsored a four-year Special Project of National Significance (SPNS) known as the Information Technology Networks of Care Initiative. It consisted of one cross-site evaluation center at the University of California San Francisco (UCSF) and six unique demonstration project sites implementing HIEs tailored to the local HIV epidemic and regional care systems. The cross-site evaluation team was charged with synthesizing data across the projects to document successes and derive recommendations, particularly for providers supported by the Ryan White HIV/AIDS Program. For purposes of the initiative, success was examined on multiple levels, and encompassed both implementation (establishing effective data sharing through electronic HIEs) and impact (HIEs' effects on clinical services or patient health).

In this paper, we focus specifically on the former, seeking to understand the practices and dynamics that enabled sites to implement systems that were not only technologically functional, but also utilized for the purposes for which they were developed. For our analysis, we sought to identify a theoretical orientation that could encompass the ever-changing environments in which many of the HIEs were created. We chose to adopt the framework of “dynamic capability,” which is defined as “the capacity of an organization to purposefully create, extend, or modify its resource base” (p. 4) [7]. This framework has particular relevance because its underlying assumption is that an environment is perpetually changing

and, hence, a critical factor in understanding an organization's evolving strategies for success. In a recent paper, Leung (2012) reviewed the exiting literature on dynamic capabilities, identified four key factors that have been shown to be critical for predicting an entity's implementation success, and then demonstrated how the framework could be applied systematically to the analysis of technologies to improve healthcare, using as examples electronic medical records, telemedicine, and social media [8].

The four specific factors identified by Leung are: information systems, absorptive capacity, reconfiguration capacity, and organizational size and human resources [8]. The category of *information systems* includes not only the technology itself, but also the capacity to respond and adjust those systems to changing demands and circumstances. The emphasis here is on the adaptive nature of the systems. The technology must be capable not only of meeting a specific need but of changing as the need itself changes over time. *Absorptive capacity* is the “limit of an organization's ability to process and/or store information in various forms to increase the knowledge of the organization” (p. 46) [8]. In the context of a HIE, it is essentially an organization's ability to implement an operating exchange system. This includes having the capacities to store and work with the information in the HIE. *Reconfiguration capacity* is an organization's capacity to reorganize work flows, behaviors, and other resources and transform existing resources into new ones [9]. Within a HIE, this capacity can be thought of as a site's ability to change its operational procedures and clinical practices in response to a new exchange system. A HIE is not likely to be effective unless clinical operations are altered to make meaningful use of the information in the HIE. Finally, *organizational size and human resources* refer to attributes of an organization that may influence its capacities and abilities to respond [8]. There are fewer clear-cut predictions for this factor [8]. For example, large organizations may benefit from economies-of-scale, leading to more absorptive capacity, but smaller organizations may be more flexible and adaptable, leading to better reconfiguration capacity. Furthermore, for information exchange technologies, it is important to remember that the “organization” is likely to encompass both the individual entities sharing the data, as well as any overall governing body intended to make decisions about the information being exchanged and the protocols for operating the information sharing system across the participating partners.

2. Methods

The six demonstration projects of the HRSA-SPNS Initiative were charged with implementing HIEs to enhance HIV care; promote the flow of HIV-related health information across clinical settings, community-based organizations, and public health agencies; and improve patients' access to their health records. With those goals in mind, each project created different kinds of electronic platforms to share patient data among collaborating medical settings and agencies. Table 1 briefly summarizes the projects sites' goals and partners.

The cross-site evaluation utilized multiple methodologies to evaluate the implementation and impact of the HIEs. The

Table 1 – Brief description of the six demonstration projects of the HRSA-SPNS information technology networks of care initiative.

Demonstration project	Partners	Goals and scope	Description of information exchange
Site 1	1. Primary care clinics 2. Support services 3. Testing sites	Exchange among providers in a local region to enhance efficiency, continuity, and quality of HIV care	Patient information exchanged through a Web-based system in real time. System also provides tools for monitoring service delivery.
Site 2	1. Hospital based HIV specialty clinic 2. Support service providers	Exchange among providers in a local region to improve coordination of care and health outcomes	Exchange system built within the hospital's electronic medical record. Information exchanged bi-directionally in real time. System features: reminders to medical providers about clinical tasks/priorities; patient clinical indicators exchanged with case management and medical support service agencies.
Site 3	1. Emergency departments, and outpatient and inpatient clinics in 7 public hospitals 2. State's Department of Public Health (DPH)	Public health exchange across much of the state to improve HIV case reporting, identify and link to care HIV+ individuals out of care or lost to care	Real-time, bidirectional information exchange between a statewide public health office and a health care delivery system. New database and connectivity to hospitals newly created as part of the demonstration project. New database populated with names of individuals known to be out of care for HIV. Upon check-in at hospital, patient name sent to new database at DPH. If patients' name matched a name in the database, alert sent to public hospital to apprise providers that person was out of care for HIV, and to provide instructions for how to link individual to care.
Site 4	1. Primary care clinic 2. Laboratory 3. Pharmacy	Exchange between clinic and local service providers to improve patient quality and efficiency of care	Bidirectional exchange built within clinic's electronic medical record. Patient laboratory requisitions and results, as well as medication prescriptions and refills, exchanged among clinic, laboratory, and pharmacy staff to avoid duplication of services and facilitate communication.
Site 5	1. Hospital based primary care clinic 2. AIDS Service Organizations (support services)	Exchange among providers in the central region of the state to enhance efficiency, continuity, quality and delivery of HIV care among partner agencies	Information uploaded and shared through a regional server. Exchange system built within existing data management system. Patient clinical indicators exchanged among a medical clinic and AIDS service organizations.
Site 6	1. HIV care providers 2. Support services 3. Publicly Supported Health Care Plan (insurer)	Shared access to database detailing services received by patients in a publicly funded health plan. Goal: to improve coordination and increase quality of care	Web-based platform for viewing a record of all services received by patients in the health plan. System developed by the health plan. Providers could obtain an account to view information about patients that was contained in the system. Portal permitted patients direct access. In addition, patients were given access cards that could be given to providers to give them immediate access (e.g., in emergency situation).

data presented in this paper are drawn specifically from 111 semi-structured interviews conducted over the course of the initiative. UCSF investigators experienced in qualitative research conducted the interviews either face-to-face during site visits or over the phone. All procedures were reviewed and approved by the Committee on Human Research at UCSF, and all participants gave voluntary consent to be interviewed.

2.1. Participants

Interview participants were drawn from three categories: (1) project staff and information technology (IT) specialists associated with the demonstration projects ($n=36$), (2) staff from community-based organizations and public health agencies collaborating in the design and implementation of the HIEs ($n=15$); and (3) users of each HIE ($n=60$), such as medical providers, staff in clinical settings, social workers, and case managers. To ensure diversity of perspectives, we collaborated with project staff to identify stakeholders to be included in our sample. The sample size at each demonstration project varied according to the scope of the project and the number of stakeholders involved in the HIE (range 14–21). In order to understand experiences over the course of the initiative, we conducted interviews at two different time points: (1) as demonstration projects were developing their HIEs and training providers to use them, but prior to the actual exchange of patient health information and (2) one to two years after each HIE had become operational. Whenever possible, we sought to interview the same individuals across time points to permit comparisons between initial expectations and ultimate HIE experiences. However, given staff turnover on project teams and in clinical settings, repeated interviews with the same individuals were not always possible.

2.2. Interview content

Using semi-structured guides parallel in content for each of the three types of participants, the baseline interviews focused on understanding the development of the HIE systems, the planning process and preparatory work, and the expected benefits, as well as the technological, attitudinal, and structural barriers and facilitators to the acceptability of data sharing. The follow-up interviews focused on changes and evolution in the systems, users' experiences with the HIEs, challenges and benefits of operating the exchanges, and prospects for sustainability once the SPNS initiative was complete. Probes were used to prompt for information that was not spontaneously offered by the participants and further inquire into topics of interest. All interviews were audio-recorded and transcribed.

2.3. Analysis

Interview transcripts were entered into Atlas ti®, a software program designed to organize qualitative data and facilitate analysis. Data analysis procedures followed an open-coding process developed by Corbin and Strauss [10]. During the initial phase of analysis, three analysts individually read a subset of interviews and developed preliminary codes based on domains from the interview guides and emerging concepts and categories. The analysts refined those preliminary codes,

and discrepancies in coding were solved during team meetings. The final version of the codebook consisted of 16 coding topics, which the analysts then applied across all the interviews. Each interview was coded by a primary analyst and verified by a secondary analyst. Coded data were summarized within each of the six sites. Convergent and divergent perspectives were then examined within and across sites. Given our open coding approach, our original labels were not created with one specific theoretical model in mind. However, many of the codes proved directly relevant to the dynamic capability framework. Specifically, information systems were captured by the codes, “functionality” and “sustainability.” Absorptive capacity was seen in text coded by “buy-in” and “institutional resiliency.” Reconfiguration capacity was evidenced under the codes, “provider impact,” “buy-in,” and “lessons learned.” And organizational size and human resources were reflected under the codes, “sustainability” and “institutional resiliency.”

3. Results

Given the complexity of the demonstrations projects, the interviews at all sites inevitably touched on numerous factors that facilitated or hindered implementation. In the sections that follow, we seek to describe briefly the circumstances, project design, or project practices that proved to be key determinants of whether or not providers used each of the new HIE systems.

3.1. Project Site 1: formalizing a process to facilitate buy-in and HIE usage

The first site in the initiative provides an example of a project that placed particularly heavy emphasis on ensuring that providers and staff at the HIE partners were invested in the system and would make use of it. The project team chose an implementation strategy that relied on the use of an active and involved advisory group, made up of individuals from all participating agencies. This group engaged in a substantial and ongoing dialog with the team of programmers responsible for creating and refining the local HIE system.

The advisory group was formed early in the development of the HIE and hence guided its initial design and features. By involving health care providers and clinic administrators early in the system's creation, the project team was able to foster buy-in and collective ownership of the system among project partners, including individuals on the advisory group and other providers working in the partnering agencies:

I'm going to refer back to the fact that Project Director was very smart from day one when she brought the folks from [IT Organization] in and she got buy in. I think if she had created the instrument and then given it to us as the grantee and said, “Here, this is what you have to do from now on,” there would have been a lot more resistance. But because the providers were a part of it from the beginning we all had a vested interest in seeing it work. The medical providers and the two counseling and testing sites have been in on it from the beginning and we've made these decisions. Sometimes they're long discussions. And it's always by

consensus. It's always by consensus. –Director of HIV services at collaborating support services agency

Throughout the development of the HIE system, providers shared input, feedback, and recommendations on system adaptations. This high level of involvement ensured that the transformations were compatible with the kinds of reconfigurations that the partnering clinics and agencies were willing to make in their own practices and protocols.

We've made some, you know, we've been able to [the HIE system] has been able to make some advances on some really good things, alerts, for instance, and other features that are really helpful to us. It's been going great. I mean, they're really great in terms of giving us the opportunity to make suggestions. I like the alerts, personally, because they help remind me what I need to target, and keep me on top of things. And they always ask for – they have a little blurb on the bottom, "if you wish to suggest a new alert click here." It's like an email, and it sends it to them. So, they respond back. It goes on the wish list, and...there's a whole channel that it has to go through, but at least I'm able to make suggestions. And I've seen quite a few of my suggestions come on the program. So, it's made it really nice, 'cause I definitely feel a part of it, so it's grown with us. –Medical Case Manager

Right at the beginning we were just doing the TB test, CD4 and the viral load. Then little by little they started adding more things. So that's actually a good thing. I was one of the ones saying they should be adding more things. I wanted to be able to manage more things from one site, like one screen. –Nurse

The continued engagement of stakeholders around the project's common vision helped the site's collaborators persevere through ongoing external challenges to project implementation—most notably, loss of key personnel:

The biggest barrier was in fact turnover. I mean literally whole-sale turnover of key stakeholders [...] I think that if we hadn't put that extra time in up front and continued to, we'd have more problems and would have to be spending extra time dealing with problems. So if you look at it as a return on investment of time with the people and the process, I think absolutely it was definitely worth it. –IT Director

In addition, the continued use of the advisory group allowed for flexibility in both system design and in protocols for using the system:

Another benefit is flexibility. It's hard to plan three years out. You don't even know what the themes of HRSA are going to be in terms of where the programs should be running. You don't know what the emerging population needs are, so flexibility is, we can say, okay, based on today, where we are today, we want to prioritize this feature or invent this whole new feature that we didn't even consider when we wrote the grant proposal. –IT Director

3.2. Project Site 2: disaggregating the development of exchange processes and exchange technologies

At the outset, the project at the second site had no existing infrastructure for electronic information exchange among its HIE partners, and the project's primary purpose was to build and implement a system that would allow for data

sharing between the primary hospital-based HIV medical clinic and support service providers in the local area. Originally, the team had planned to build its HIE within an electronic medical record (EMR) in use when the local team submitted its grant application for the initiative. However, shortly after the project received funding, the hospital decided to implement a new EMR, which rendered unusable the original planning and system design efforts. The team was thus compelled to find new ways to meet the goals of their project within the confines of changing organizational realities. Ultimately, this involved a two-pronged response: (1) waiting for implementation of the new EMR and then building the technological capacities within it to share data with the support service agencies and (2) in the interim, focusing substantive attention on developing new clinical practices to incorporate data sharing activities.

During the transition period from the old to new EMR, the project team decided to create a temporary paper-based, exchange system between the hospital clinic and the support service agencies. This focused most of the attention on figuring out how providers could most effectively make use of information being shared between sites. During this transitional time, the team was able to establish functional exchange specifications that facilitated the eventual use of the electronic HIE. Examples of such specifications included narrowing down the range of displayed results for mammograms and pap smears so that the system only showed normal or abnormal; dividing patients' medications by whether or not they were used for treating HIV; and improving the organization of information displayed in reports to make them easier to read.

From the time we were designing the idea of the grant and then got awarded the grant, [the hospital administrators] decided to go to [the new EMR]. So, instead of going directly electronic, we had to go to paper first, because we didn't want to make a huge programming effort on [the old EMR]. We didn't want to do a huge programming issue and spend a lot of resources on that and turn around and then throw it away when we went to the new system...So, it [the paper-based exchange system] was a very good transitional object, and the fact is, we had really good specifications because we had this paper thing first. So, the specifications that we handed off to the programmers went really well. –Project Director

And so one of the big challenges was figuring out how this new health information system [the new EMR] will work and then how will our project fit into it...I think now our current challenge is designing the specifications to include as much of the feedback that we've received as possible. So we're trying to make this useful for our providers. And in that sense, I receive feedback from every single person and sometimes [it is] conflicting – so some people want to see these results but not those, and then someone else has the opposite view. And so the challenge is to reconcile all the different perspectives into one report or one vision of how this should look. –IT Expert

The following quote from a medical doctor provides corresponding agreement that the reconfiguration process was indeed successful:

[The HIE system] is extremely effective at pulling information from multiple areas into one place, which is very time efficient for me. I find that it really is the direction that an EMR should be going because typically electronic health records are sort of duplicating paper workflows and what this does is simplify a paperwork flow, using what a computer provides. –Medical Provider

3.3. Project Site 3: implementing prescribed protocols to shape HIE-related practices

The initiative's third site was unique among the projects in that its purpose was highly circumscribed. Specifically, it sought to connect public hospitals with the public health system in order to flag and intervene with patients, known to be out of care for HIV, when they happened to present to emergency departments (ED), outpatient clinics, and inpatient units, typically for care unrelated to HIV. Specifically, the hospitals' information systems were connected to a database in the public health surveillance department that kept a database of all patients known to be HIV positive but for whom there was no evidence of active care (e.g., receipt of CD4 or viral load testing within a 12 month period). Upon registration for an ED, outpatient, or inpatient encounter, patients' names were securely matched against this database. If there was a match, the system sent an alert to the patients' electronic medical record, noting that he or she was known to be out of care for HIV and recommending the treating physician complete steps to help refer the patient back into care.

Because the system's purpose was so specific, the project was able to design the HIE so that its alerts to treating providers laid out concrete steps that should be taken. The providers quite literally ran through a checklist, clicking boxes next to the steps in the alert that they had completed. In this sense, the alert specified how clinical practices should be configured to facilitate a successful referral back into HIV care. Furthermore, because alerts could be received by clinicians without infectious disease expertise, the providers were satisfied with the prescribed steps.

It'll make our work a lot easier because it streamlines a process that, for whatever reason over the years, has become very laborious where we have people walking to hospitals to pick up records so that they can be entered into a secure database. So sometimes we don't get records on people who have communicable diseases like HIV for several weeks. I mean it's really ridiculous and it makes providing care very difficult... So I think it could make a really big difference in the lives of a lot of people. –Medical Director for Public Health

I think the providers are receptive and they seem enthusiastic about receiving the information and I think they just want to know the information they're acting on is real. And they seem to be comfortable with the information that they have or at least the way it's set up is they will know clearly what they need to do with the information in the pop up [alert] that comes up there for them. So it's not just, "Hey, this person might have HIV. Figure out what to do." It says, "Hey, they might have HIV. Could you please do these five educational activities and these five actions?" So I think that it's providing them with the language and the crutches

there that they need to be able to act on it. –HIV Surveillance Program Manager

Oh it's desperately needed. We used to you talk about the need to have a system where we could link patients at the health department with the hospital patients. Because we have this statewide hospital system and then the office of public health is statewide. Before, I was in a statewide position... and probably 60 percent of our patients originated through [the public hospital system]. So I used to have to get permission to go in the hospital and get permission to get records and review records and do all the paperwork so that if we had an electronic system it would be heaven. –Provider

3.4. Project Site 4: implementing simple structures to promote HIE usage

The fourth site successfully achieved two of its stated HIE-related goals: (1) establishing electronic linkage with the laboratory facilities to submit electronic orders and (2) establishing electronic linkage with local pharmacies. In this clinic, reconfiguration was achieved largely by restructuring the environment, via new technological capabilities, to simplify clinic practices. Prior to the initiative, providers would input prescription or lab orders, hit a computer's "print" button, leave the exam room, walk down the hall to retrieve the paper copy, and sign the orders. The inefficiencies inherent in these procedures made them unpopular with providers. As part of the demonstration project, the processes of ordering labs and submitting prescriptions became part of the functional capacities of the EMR, allowing providers to place these requests in the same system where the patient's health records were stored.

The new information exchange features were designed with multiple potential benefits in mind: mitigating the tedium associated with some of the clinic's operations, reducing errors, and creating clinic efficiencies. In fact, the IT team prioritized these interventions in part because they knew that they would be of great benefit to the providers and clinic staff: *"From my perspective I feel like my job is to make the [work of the] clinic personnel easier"* (IT director). Creating new functionality within the existing EMR illustrated the IT team's sensitivity to the workflows of the clinic staff.

All of the information is stored and it's all inside the EMR. So the doctors can check their task box inside of the EMR instead of going to an outside application... The medical director and the clinic manager are both really comfortable with the EMR and understand what we're trying to do. Fortunately there's so little actual different work that these interventions are going to require of the users... So you know they have to get used to looking in their task box for things, so that'll be a change but fortunately there aren't like a large amount of steps for the users. –IT Director

During a follow-up interview, we learned that, as anticipated, providers' workflows were effectively streamlined by the straightforward, user-friendly nature of the new tools.

From the user standpoint, I think it [implementation] went very, very well. The process itself, the workflow is just absolutely mind-numbingly simple. The providers, all they have to do is just press a different button on the same screen. So, they'll prescribe the medicine, and there's a print button, a fax button, and an eRx

[electronic prescribing] button. And now, they press eRx, and that literally is the only thing they have to do. –IT Director

Unsurprisingly, providers also reported a high degree of satisfaction. They noted that there was greater accuracy (no lost papers, no forgetting to call in a script, fewer numbers of patients at pharmacy calling the clinic about an order that hadn't yet been prescribed), and a feeling that, when a patient's appointment came to an end, the work associated with delivering care to the patient that day had been taken care of (i.e., no lingering responsibilities).

If you were to compare [the eRx button] to what we were doing before, it definitely has saved us a lot of time because you don't have to print. You don't have to sign it. You don't have to have the nurse or the medical assistant fax it to the pharmacy. Over 50%, 70% of the prescriptions are sent directly to the pharmacies. So, I do like that system. It's much easier than it used to be. –Clinic Provider

[The new eRx feature] makes things a lot faster. It's definitely a big plus, to not have to print out prescriptions and then fax them in is a huge waste of paper and time. And so, it's nice to be able to send things directly right from in their chart. Because before I would click the print button. Then I would have to go find the prescription in the printer, and sign it. And then somebody else would send it over. But now, once I just click this print button, then I'm done. So, it's actually less work. I don't have to worry about forgetting to sign the prescription or find the prescription to sign. . . And the prescriptions are sent immediately, instead of waiting, sometimes for hours in a stack someplace before somebody faxes them. And so, we don't get nearly as many calls after hours, saying that you were going to send in a prescription, but the pharmacy said they didn't get it. –Medical Assistant

As a point of contrast, the project was less successful at reorganizing workflows around reviewing laboratory results. This task demands studying the values, keying in on abnormal results, determining the severity of the abnormality, and making a decision about next steps. Although the exchange system could display the lab results, choosing to read those results on the computer screen still remained up to individual providers. It was not a practice that the exchange could simplify as readily as the ordering of labs and prescriptions. Rather than undertaking efforts to develop new practices and habits for reading labs within the system, the providers continued to look at printouts of the results. One summed up the issue as follows:

To me it's efficient, because, like I said, I have the way I will do things and arrange it, and the computer doesn't do it that way. So, it's sort of like, maybe ultimately it would become more efficient, but at this point to me it's not. –Medical Director

3.5. Project Site 5: the influence of past experience on providers' motivations to use a HIE

The fifth site offers an example of site with mixed success at promoting HIE usage. The overall project goal was articulated by its principal investigator as follows: "we are planning to have an integrated network with the shared server amongst our sites, which is the main clinic and AIDS service organizations that provide

case management and other services locally to make a networked system of care." However, from the outset, there were doubts about the degree to which protocols and practices would be changed to make the HIE a central feature in the lives of all providers. In particular, project leadership anticipated that medical providers at the region's primary HIV medical care clinic would only use the HIE "as questions arise," whereas case management staff at the local AIDS Support Organizations (ASOs) would use the HIE routinely.

What I would see is that [our] nursing staff and our social worker and HIV coordinator can access more real time information about case management and services that might be provided from outside of our clinic setting, that it will work into our [work]flow to look up and see what's going on with people as questions arise. I think also that depending on how well the information goes back and forth I could see it being used more for the agencies [ASOs] to get more information from us. –Provider at the primary medical clinic

The differences between the primary medical clinic and the ASOs were related in part to history and capacity. The primary medical clinic, situated within an academic medical center, had significantly more resources than the ASOs, making it less reliant on any one particular grant to deliver new capacities. Furthermore, the new electronic exchange was built in a data management system already in use at the medical clinic for collecting and reporting data to state and federal funders. This created the challenge of taking a system previously used for one (unpopular) activity and repurposing it for a new function.

For the most part, [the hospital-based medical clinic] has looked at [the data management system] as a necessary evil because the state required them to use [it] to submit their data. So it hasn't been widely used. –IT technical assistance expert

Furthermore, providers within the medical center did not immediately see an identifiable benefit to system usage.

Since I don't really use it a whole lot, I would need to know what I'm being trained to do and what the benefit for me is going to be. I mean, we're pretty busy during the day, or during clinic, and like I said, in some ways, it's easier just to get the communication by phone, more so than in [the HIE system] or having to type it up again in a different format. –Medical clinic social worker

By contrast, the project brought new technologies and new capabilities to the ASOs, which were described by the principal investigator as "small community-based organizations whose operating reserve oftentimes is so slight that any kind of increase in efficiency or increase in capacity can make a significant difference." The unique opportunity to enhance their resources was energizing for the agencies. At the outset of the initiative, ASO staff were making phone calls or writing emails to request patient information. And although they were equipped with computers to process this information, this technology was of little help in actually collecting patient health data. A HIE offered the promise of having patient health information centralized and reported into one location, reducing the burden of acquiring data needed to coordinate care. In essence, the system fulfilled the ASOs' long-standing wish, as seen in the comment of one agency executive director reflecting on conversations within her agency: "We have brainstormed many times what

would make the information better between different colleagues that you work with and who you collaborate with.”

The fifth site's project, much like the one describe at Site 1, operated a planning group. But the energy for and investment in this group was evidenced most strongly in the interviews with the ASOs.

I think our meetings are very helpful that we do meet and we are able to understand where we're going from Point A to B and then where it's headed up. I think if we weren't meeting then that would be I think a big issue because I wouldn't know fully what was really going on. –Executive Director of a Partnering Agency

3.6. Project Site 6: the challenges of relying on individual HIE-related behavior change

The project at the sixth site was also unique in its design. Unlike most of the other demonstration projects, the HIE system at this site was designed and implemented by a health insurer, specifically a local publicly funded health plan for people living with HIV. As part of the project, the health plan created individual electronic profiles of each of its patients, which contained information about the services the patient had received (i.e., for which the health plan had been billed). Each profile included the names of providers and case managers the patient had consulted, medication lists, laboratory results, and dates when prescriptions were filled. The profile could be accessed by medical providers, case managers, and social workers who were providing care to the patient, but doing so required receipt of a login account and password. The project also launched a patient-controlled feature that enabled access to the profile via a disposable pin number. Patients could give the pin to another medical provider who might need quick access to the profile (e.g., in an emergency room).

The HIE ostensibly was built to facilitate easy access and alleviate the work required of social workers, case managers, patients, and clinicians when exchanging data in more traditional ways (e.g., face-to-face meetings, faxing information requests, phone calls to request files). Medical providers were targeted as possible users so that they would have a more comprehensive understanding of the care a patient was receiving from all providers connected with the health plan. However, the relationship of this HIE with the providers was very different than that of the providers involved in other demonstration projects. The site's HIE was built from the perspective of a funder that was financing the care of individual patients. As a result, its HIE was less centered on specific agencies seeking to exchange information with one another, and more focused on providing a portal to comprehensive health information that could travel with a patient wherever he or she might seek care. The net result was that providers had to invest more of their own energy in understanding the system's potential utility. And while some providers found use for the HIE, many others did not.

What follows is a case of a provider who had not successfully incorporated the steps necessary to gain access to patient chart info into his workflow. His example helps to highlight the

challenges that occur in the absence of formal reconfiguration efforts:

I still haven't [begun to use the system]. . . . I can't recall exactly, but . . . I got an envelope that didn't have the password and then we went back and forth over email and telephone and then finally set up a time and got the password. And as so often happens, I mean I wrote it down somewhere and I think I actually logged in to try it out and then the next time I thought of it, it was one of those things, I hadn't changed the password to something I could remember and you know, that was it. . . . So you know it was one of those details of life where the activation energy to redo the password or figure it out, it wasn't so pressing to me that I put the time and energy into doing it.

Secondarily, this provider was not surrounded by peers who were engaged with the HIE system (“I haven't heard anyone talking about it”). This resulted in the absence of not only supportive peer norms, but also of the informal instruction that comes from providers sharing stories with one another about their use of a system. In addition, the provider pointed out the numerous thought processes that would “all need to come together at once to get you up and running so that you bring it into your routine.”

You need to connect everything in your head at the right time. To have a patient come in, to be aware that they are [members of the health plan], to have your user login and have done it a few times so you can do it quickly. And then the last piece of it, of course, is being familiar enough with it to know that “Oh, there's a piece of information that I'd really like to get that I know I can get in [the HIE].”

The design of the project's HIE also introduced other challenges. Because the profiles were only available for those individuals enrolled in the health plan, the system was not one that providers could use with all of their patients. Hence, providers were often making use of other electronic record sources. Although the data in these other sources may not have been drawn from the same range of providers as the information in the HIE, the other sources provided enough data to meet the needs of the providers.

There are two reasons why I don't go into [the HIE records] as much, the first reason was, because I'm involved in some more administrative stuff, I'm not necessarily accessing a lot of the information. The other reason is [the local network of community healthcare clinics] now has electronic medical records. And so as one of the supervisors within the case management program, I have access to it, which means that whether the client is enrolled in [the health plan] or not, I'm able to go in and access all of their labs, the progress notes and things of that sort to get a census to what's going on, which has to a certain extent enabled me per se, because I can kind of access it through there.

Notably, during interviews with the project leadership, we learned that although the HIE system was developed with multiple end-users in mind (i.e., health plan members, case managers, social workers and medical providers), the development team implicitly recognized that it would be challenging to attract the attention of medical providers. Instead, they anticipated that HIE usage would likely increase over time as

medical providers were repeatedly exposed to the system by their own patients.

Q: And so I'm wondering at what stage do you pause and say, "Well, is anyone accessing information?"

A: Well I think the fundamental difference is we're not offering the information – we're not limiting the access to just the primary care provider. When you change the user base to include case managers who have no access to medical information and to [health plan] members who have limited access to the medical information, you have a more interested group of participants. The case managers are drooling over the potential of receiving this data. We already know that through initial surveys. The members are yet to see the value of the data but actually have had difficulty keeping track of their clinical information that's important to them. So there's a health literacy issue around sharing information with members but I am confident that that group will have great interest in the data as well. I am not confident we'll get a different reaction from the primary care providers that we got when we offered them paper data. My guess is they'll say, "So what?"

Q: So you're building the system for the -

A: For the non-medical users. For the people who have no access to the medical records. And I think in some ways it's almost chicken and the egg. Watch what happens. So we're going to give it to the case managers, we're going to give it to the members, I would imagine members will go back to their providers and have a conversation with them about what they see on their profile. And then the provider will say, "Well wait a minute let me look at your profile ..." (chuckles) –Project leadership

4. Discussion

Across the six projects, we found evidence for the importance of three dynamic capabilities [7,8]: information systems, reconfiguration capacity, and organizational size and human resources. Of these three, reconfiguration capacity was the most salient. Implementation outcomes at all six of the projects were shaped substantially by the degree of attention dedicated to reworking procedures and practices so that HIE usage became a daily part of providers' lives. In Project Sites 1 and 2, as well as among the ASO partners in Site 5, providers were actively engaged in reconfiguration, determining how their work protocols could be altered to facilitate HIE usage. In Project Sites 3 and 4, the HIEs were designed so that their use did not require a provider to think through changes to his or her practices. Rather, reconfiguration was effectively automated. At Site 4, providers placed lab orders and prescriptions with the simple click of a button using their existing EMR, all but guaranteeing adoption and acceptance. In Project Site 3, embedded alerts gave specific directions to inform a provider of a patient's HIV status and need for follow-up referral in HIV care. By way of contrast, the providers with Site 6 and those at the medical clinic affiliated with Site 5 did not necessarily engage in efforts to reconfigure their practices or procedures, and hence made relatively less use of their HIEs. In both cases, the providers did not necessarily understand how the systems might benefit their work. And in the case of the medical clinic

in Project Site 5, the providers also held preconceived negative attitudes about the underlying data storage system, which they had previously used for mandatory reporting requirements.

Although reconfiguration capacity was critical to the implementation outcomes at each site, its influence was modified by other dynamic capabilities. For example, the important role of adaptive information systems was evident across several projects. In Project Site 1, the active and central involvement of the lead IT programmer gave the exchange system high levels of flexibility, allowing for modifications as providers' needs changed. This finding matches work in community health centers, which showed that the active and involved engagement of an IT expert was critical in ensuring that providers could extract information from electronic health record systems to improve care [11]. At Site 4, although there was little reason to adapt the lab ordering and prescription functions after implementation, the very design of those features was rooted in information system adaptability. The programmer chose to embed the exchange features in a pre-existing EMR to ensure easy use. It would also have been possible to implement whole new systems to conduct the exchange, but their usage would have been inherently more cumbersome to providers. At Site 2, the initial challenge of the hospital's decision to change its EMR ultimately resulted in fortuitous attention to exchange specifications. The paper-based temporary exchange process allowed the team to refine not only the practices of using exchange information, but also the specifics (e.g., content, display) of the final electronic system. By the time the electronic HIE was turned on, its design had been reworked and vetted several times, enhancing the overall functionality and user-friendliness of the system.

Organizational size also played an important role in system implementation. However, its exact influence was complicated, as predicted by Leung [8]. When looking across the six projects, it appears that it interacted with both information systems and reconfiguration capability. Three of the projects were relatively smaller in scale. Project Site 4 involved one primary medical clinic seeking to transmit very discrete information to local service providers. Sites 1 and 2 involved a limited number of partners in a confined geographic region. In all three cases, the projects benefited from the personalized attention that the teams were able to give their providers. They were able to create HIEs that responded to ongoing needs and hence were well received by the ultimate end users of the systems. At the other end of the spectrum, Sites 3 and 6 were relatively large in their reach. These systems were developed by a central unifying entity (the state public hospital system in the case of Site 3, a regional public health plan in Site 6) and affected numerous providers working in numerous locations. These projects could not give the same individualized attention to the providers that smaller projects did. Given the contrasting implementation successes in the two large projects, it would appear that the focus on carefully prescribed protocols (limited and relatively fixed reconfiguration rules) and highly specialized exchange purposes, as seen in Site 3, may better elicit provider engagement with a HIE.

The final dynamic capability, absorptive capacity, was least evident in our data. However, it is important to note that this finding may well be the byproduct of the initiative's design. All

of the sites experienced increased absorptive capacity upon receipt of grant money to create electronic HIEs. These grants provided the funds to develop a technological architecture for exchange and to train providers on how to use the new systems. Even with this limitation, the potential role of absorptive capacity could be seen indirectly in some of our findings. For example, the small ASO partners of Project Site 5 site were energized by the new HIE in part because it fulfilled long-standing wishes that the agencies had never before had the capacity to address. Furthermore, a large-scale project like the one at Site 6 may have reached the outer limits of what could be accomplished given the size of the grants. To achieve better implementation success, the team would have had to invest substantial personnel time into working with providers in the many different agencies, something that would have required additional monies.

Taken together, these results have important implications for agencies seeking to implement HIEs, as well as funders interested in supporting the development of exchange systems. For agencies, the findings suggest that the HIE systems are likely to be implemented most successfully when the exchange at least initially involves a relatively limited number of partners and when the system developers can dedicate significant energy to understanding the needs of the providers at the agencies. This allows the information systems to be adapted flexibly to the needs of the providers and ensures that those providers have the motivation to adapt their work protocols to make use of the new exchange. If an exchange needs to go beyond a small number of initial partners, it is likely to have more success if the information to be exchanged is perceived as valuable, is limited in scope, and if the protocols related to use of the systems are more heavily prescribed. For funders, the results highlight the importance of supporting reconfiguration activities. HIEs are less likely to be successful if funds only support the development of technology (e.g., programing, purchase of computers). The partnering agencies in a HIE need to be given time and space to collectively identify their needs and to adapt internal policies and procedures to effectively fold HIE usage into daily life.

Our analysis has several limitations. First, the dynamic capability framework was adopted for purposes of the analyses and did not orient the interviews at the time that they were conducted. Although we found strong evidence in support of the framework, it is possible that our results would have been more robust had our interviews been designed more specifically to assess the framework's applicability. Second, the substantial variations in the six HIEs provided a diversity of experience from which we have drawn conclusions about the role of three dynamic capabilities; however, this diversity also makes it difficult to rule out completely the influence of other, unmeasured confounding differences. More precise conclusions about effects would have been possible if the HIEs had had more similar goals and operating procedures, with variations limited to only a few key characteristics.

Our analyses are also limited by the focus on project implementation activities during a period of specialized funding. A recent study of broader (non-HIV-specific) regional health information organizations (RHIOs) around the US found that two-thirds did not meet criteria for longer term financial viability, that is, being able to cover operating expenses with

revenues from participating entities [12]. Other researchers have reported sustainability successes among community-based health information technology alliances, but these successes were limited to securing additional grant funding, and do not necessarily constitute independent financial viability [13]. It is unclear to what degree similar sustainability challenges will affect the exchanges described in this paper. On the one hand, they too will face the need to secure new revenue streams or self-sustain through existing revenues in order to support continued HIE-related work. On the other hand, unlike the RHIOs and community-based alliance partners in other studies, the six projects of this initiative are centered on HIV care in the public sector. As a result, the exchange partners tend to draw their revenues from a discrete number of common sources (e.g., the Ryan White Program Medicare, Medicaid). And at least one of those sources (i.e., the Ryan White Program) supports services through grant awards to clinics and agencies, a funding approach that may better support care coordination and integration than the traditional fee-for-service reimbursement structure seen in other settings [14].

Electronic information exchange offers the promise of improved coordination of care. For patients living with HIV, and for the providers that care for them, such technology can ease the burdens of treating a disease that disproportionately affects marginalized populations and places people at risk of a range of comorbid conditions. However, implementation of HIEs goes beyond programing and hardware installation challenges, and requires close attention to the needs of the HIEs end-users, who are usually providers. The abstract goal of "information sharing" is not sufficient to motivate use. Providers need to discern value from a HIE. Their active participation is essential to ensuring that clinic and agency practices and procedures are reconfigured to incorporate new systems into daily work life.

Authors' contribution

Wayne T. Steward, PhD, MPH and Kimberly A. Koester, MA: (1) conception and design of the study (co-principal investigator: WTS; co-investigator: KAM), acquisition of data, and analysis and interpretation of data; (2) drafting the article and critical revisions of intellectual content; and (3) final approval of submission.

Shane P. Collins, MS: (1) analysis and interpretation of data; (2) drafting the article and critical revision of intellectual content; and (3) final approval of submission.

Andre Maiorana, MA, MPH: (1) conception and design of the study (co-investigator), acquisition of data, and analysis and interpretation of data; (2) critical revision of intellectual content; and (3) final approval of submission.

Janet, J. Myers, PhD, MPH: (1) conception and design of the study (principal investigator); (2) critical revision of intellectual content; and (3) final approval of submission.

Conflicts of interest

The authors have no conflicts of interest to report.

Summary points

What was known before the study?

- Health information exchange (HIE) has the potential to improve the quality and continuity of care delivered to HIV patients.
- The adoption and use of HIE is hampered by numerous pitfalls.
- Barriers to HIE implementation extend beyond technical challenges, and involve interpersonal and institutional dynamics.

What has the study added to the body of knowledge?

- The study found that reconfiguration capacity was the most critical dynamic capability affecting rollout of the HIEs. Implementation outcomes at all six sites were shaped substantially by the degree of attention dedicated to reworking procedures and practices so that HIE usage became a daily part of providers' lives.
- The findings suggest that the HIE systems are likely to be implemented most successfully when the exchange at least initially involves a relatively limited number of partners and when the system developers can dedicate significant energy to understanding the needs of the providers at the agencies.
- The findings also highlight the importance of supporting reconfiguration activities. HIEs are less likely to be successful if funds only support the development of technology (e.g., programing, purchase of computers). The partnering agencies in a HIE need to be given time and space to collectively identify their needs and to adapt internal policies and procedures to effectively fold HIE usage into daily life.

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