An Assessment of State Public Health Information System Database Integration Project Success Factors

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DISSERTATION

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PREFACE

The purpose of this study is to identify factors that most contribute to successful intra-state public health information system database integration projects. The study is not designed to examine inter-state database integration, such as that which might occur from one state to another state. Rather, it focuses on how successful database integration projects (such as integrating an immunizations registry with an infectious disease surveillance system) were brought about within a state health department. This dissertation includes two manuscripts which have been formatted according to the specific guidelines of their intended journals.

I would like to acknowledge several individuals who supported me throughout this long journey. First, I would like to recognize my committee chair and advisor, Patrick Lenihan. Dr. Lenihan worked very closely with me for the better part of a decade to ensure that this research met a high standard, and I am thankful for his mentorship. I would like to thank Dr. Eve Pinsker for her expertise and guidance in developing the qualitative methods used in this study. I thank Dr. Seth Foldy for providing thoughtful feedback throughout the dissertation process, along with welcome general encouragement. I thank Dr. Edward Mensah and Dr. Kee Chan for their valuable input. I also thank the study's participants for their insight and wisdom.

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MWR

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LIST OF ABBREVIATIONS

AKC	All Kids Count
ASTHO	Association of State and Territorial Health Officials
CDC	Centers for Disease Control and Prevention
CHARM	Child Health Advanced Records Management
CHIS	Child Health Information Systems
CSTE	Council for State and Territorial Epidemiologists
HIE	Health Information Exchange
HIT	Health Information Technology
HITECH	Health Information Technology for Economic and Clinical Health
HRSA	Health Resources & Services Administration
IDPN	Informatics Directors Peer Network
IT	Information Technology
I-TIPP	Informatics – Training in Place Program
JPHMP	Journal of Public Health Management Practice
MOHSAIC	Missouri Health Strategic Architecture and Information Cooperative
NACCHO	National Association of County and City Health Officials
PHII	Public Health Informatics Institute
PHIS	Public Health Information Systems
RWJF	Robert Wood Johnson Foundation
TMS	Top Management Support
WIC	Women, Infants, and Children

SUMMARY

To examine which public health information system database integration project success factors are most important and explain how they impact project success, the author implemented a cross-case study design. The author surveyed, interviewed and analyzed documents from state health department personnel involved in successful public health information system database integration projects.

The participants reported that organizational leadership factors predominate in project success importance, while financial support and management, project management, and integration technologies also impact project success. Project leadership, including meaningful involvement of an executive sponsor, program directors, and informatics staff, most impacts project success.

Financial support and management appears to serve as an important catalyst for initiating the project. Project management, and the utilization of the Agile software development methodology in particular, impacts the day-to-day operation of the project. Source data systems and the data integration technology impact the data quality and technical ability to integrate the data.

I. INTRODUCTION

Overarching Study Theme, Questions, and Hypothesis

The United States public health infrastructure includes those components that comprise the public health system, including health departments, community partnerships, and the workforce. Public Health Information Systems (PHIS) are critical components of public health infrastructure, providing the means by which health departments collect and maintain public health data for various purposes (1). These data support services such as applying communicable disease control measures or targeting health promotion programs based on infant mortality rates. States possess the legal authority for establishing many PHIS, and those administered at the state level directly impact public health programs and service delivery at the local level (2). States are responsible for collecting health data such as vital event records (births and deaths), reports of communicable diseases (sexually transmitted infections, tuberculosis and West Nile virus), cancers, and adverse pregnancy events (3). State health departments develop and maintain PHIS to collect and manage information about these important public health events and to coordinate service delivery (4), which is primarily operationalized at the local level.

An essential element of PHIS is information technology (IT), the application of computing to manipulate data (5). A critical piece of information technology includes databases that store and maintain data. Advances in information technology over the past few decades have allowed for cheaper and easier database development to suit specialized, individual program needs (6). Specialized state public health databases have proliferated because of both this database development ease and due to increased categorical funding that has incentivized the development of program-specific databases.

Information technology advancements in the past thirty years not only provided for the ability to easily establish databases, but also readily allowed for database integration (7). While formal definitions vary, database integration can be considered to include the development of a central data repository that consolidates operational data from multiple sources (8). The data exchange is facilitated through information system interoperability, whether foundational, structural, or semantic (9). Semantic interoperability, in particular, ensures the automatic ability to meaningfully consume and interpret information exchanged so that it consistently produces useful results. This occurs by adhering to pre-specified data and messaging definitions established by the end users of the systems. Through semantic interoperability, a common language or vocabulary ensures consistent interpretation of data. This unambiguous data sharing facilitates the interface development required for meaningful database integration (10).

When databases are integrated with one another, they create more complete or comprehensive records by piecing together different data elements from multiple sources (11). Access to complete records can lead to improved coordination of program activities, better performing public health operations, and reduced costs (12). Database integration benefits the health department by improving the value of the agency's information, one of the department's most strategic assets (13). To be a truly effective national public health system, intra-state databases must integrate across the public health enterprise (14). The Joint Council of Governmental Public Health Agencies has agreed that 1) public health agencies at all levels must work to establish integrated databases, and 2) these databases must meet information needs at the client service level (15).

Efforts to integrate intra-state child health information systems (CHIS) serve as a practical example of a PHIS database integration business case, the methods used to execute a database integration initiative, and how these initiatives have been studied previously (16). Leaders in the public health and healthcare communities began efforts to integrate CHIS databases in the early 1990s. CHIS generally include the following: 1) immunizations registries, 2) vital events records (birth and death registries), 3) newborn screenings (dried blood-spot screening and the hearing and vision registries), and 4) the Women, Infants, and Children (WIC) program databases. Many child health databases were adversely siloed, and over the course of a decade leaders sought to connect these individual intra-state databases. These efforts serve as a practical historical example and business case for successful public health database integration. Findings from CHIS integration studies should inform further research in related areas.

Program-specific public health databases have proliferated but are often not integrated. Isolated, siloed databases contain data elements that meet individual program needs but fail to address broader needs of other programs within the organization (17). Maintaining distinct databases across the business leads to expensive redundant computing operations, such as duplicate keying in, reformatting, and storing of data across the multiple data systems. In addition, these duplicitous databases lead to many indirect costs. If the database in one program cannot interact with the database in another program – when a clear business case to do so exists – then both programs' personnel operate without a detailed understanding of the collective records. Fragmented databases lead to a fragmented organization. Use of a centralized database streamlines the flow of data throughout the organization. The centralized database pulls data from the distinct databases, combines the data, and feeds data back to applications supporting varied business activities across the agency. Information entered in one place is automatically updated in related areas throughout (18).

Many public health program managers have developed specific databases without considering broader integration across the enterprise, resulting in duplicate data management and narrow program perspectives that fail to address holistic client needs. CHIS database integration has occurred, somewhat, but beyond this, few PHIS database integration initiatives have been successfully executed and documented. It is not known which integration project factors are most important and how they impact public health database integration projects.

The purpose of this study is to identify factors that most contribute to intra-state public health information system database integration projects. Drawing from the researcher's experience and the literature review, there are several factors that impact database integration projects. Organizational factors, such as agency leadership and internal collaboration impact whether the agency is sufficiently prepared to embark on these projects. Project-specific factors impact whether the project has effective governance, formal project management techniques, and financial management. Factors somewhat outside the agency's direct control can also influence the project's success, such as state privacy or program authorization laws, or the actions of external stakeholders. And technological factors, such as the quality of the source data from each of the databases, directly impact how smoothly the databases will operate once developed. These factors were studied by examining intra-agency database integration projects at state health departments and explaining why certain factors prevail over others in their importance.

The study hypothesis is that certain factors, primarily organizational, contribute to the success of database integration projects. The researcher proposed that staff from state health departments with successful database integration projects would cite organizational factors as the most important contributors to the projects' success. This study sought to show how among the organizational factors, agency leadership is essential to bringing the supported changes necessary to successfully implement database integration projects (19). The primary research question is, of states integrating internal public health information system databases, are the prevailing integration project enablers technical, organizational, project-specific, or external in nature and why? Which factors most impact the success of these projects and why? Do organizational factors prevail over the other grouped factors? Of the organizational factors, is meaningfully engaged agency leadership most important? How do leaders contribute to the project's success?

This study has importance since few studies of state PHIS database integration exist. Additionally, findings will help illustrate success in PHIS database integration and define factors facilitating progress toward project success. This will provide decision makers with an understanding of the associated strategic issues and will provide public health information technology practitioners a narrow slice of others' progress from which to gauge their relative efforts. Leaders, who are navigating an increasingly complex world, will be able to use findings to inform any future PHIS database integration projects. These projects will in turn help leaders articulate value of public enterprises and goods to stakeholders (20). Moreover, after leaders further their informatics understanding through this study and related research, they will be able to improve their operational activities by effectively translating growing public health data into meaningful information (21).

Leadership Implications

Since the public health activities of today transcend social and political systems, these activities cannot derive innovation from individual field staff. Rather, the transformation of complex public health services requires the involvement of visionary senior leaders who identify opportunities and possess the ability to remove project obstacles (22). Public health managers and leaders must possess expertise in managing information development projects, including acquiring, maintaining, and analyzing data, translating data into information and knowledge that when applied leads to effective public health changes and policies (23). To ensure that new data systems have the desired impact, public health leaders must direct the systematic assessment of each opportunity where database integration can improve process and outcomes (24).

Information technology specialists develop databases and the connections among databases. These specialists are trained in computer science, management of information systems, database design, system architecture, structured message formats, health data vocabularies, networking protocols, and data security requirements. They receive direction from federal partners and grantors, international specifications organizations, agency-specific business plans, and agency leadership. For the most part, the technical work needed for today's database integration requirements, while challenging, is not beyond the capabilities of available trained specialists. If the technical needs are not insurmountable, then other factors must be contributing to the bulk of the barriers in PHIS database integration.

Available literature points to leadership as one of the greatest contributors to failed integration initiatives. Effective data systems and the technology used to produce them are conceivable and replicable (25). Hence, the development of strong, integrated public health databases is largely a public health system problem, and therefore, a leadership issue. The initiative hinges not on the availability of skilled technical specialists; rather, it requires vision, strategic planning, agency-wide resource alignment, consistent executive support, capable project oversight, and sustainable funding (26). All of this requires agency leadership to commit to these and related initiatives.

Some leaders have embraced this through allocating requisite resources and support, while others have not. To achieve an informatics-savvy health department, leaders must assess current information management capacities, and develop the required components—such as governance, vision, and a coordinating office for informatics activities—to promote the agency's strength through better data systems (27). Leaders making the most progress in public health informatics possess a detailed understanding of the data flows and needs of public health practitioners, engage with IT staff and vendors to address gaps, generate energy and enthusiasm among staff for informatics, and place importance on these activities to ensure that they succeed (28).

Truly, unfortunately, informatics is unfamiliar territory to many public health professionals as well as their leaders. Many in the public health workforce do not understand the term "informatics" and how this field interacts with public health practice. Further conflating this understanding is the blurred distinction between informatics and health IT, with informatics concentrating on the architecture of public health information systems, and health IT focusing on the development and implementation of these systems (29). Public health professionals recognize the need to integrate data systems, acknowledging that public health operations require timely and accurate information in the hands of practitioners. But public health professionals do not fully understand the role informatics plays in ensuring that data systems meet programmatic needs such as thoroughly designing and integrating information systems. The result is limited support for necessary components of successful data system development and integration (30).

Only recently have very few business and public health schools begun providing formal informatics training (31). Thus, these leaders, responsible for technology decisions and resource allocation, are often not aware of basic information science requirements. Although technical public health informatics experts are gradually emerging, executive buy-in provides critical support to sustain data system development and integration projects. This leadership gap has contributed to the national patchwork of nonintegrated data systems (32). But improved management of public health information is both desirable and inevitable. Many leaders now seek to understand the capabilities of PHIS and collaborate and leverage PHIS to improve public health activities and demonstrate value (33).

For many of them, it is difficult to know where to begin, especially since a base level of public health informatics understanding is not well established. Moreover, no clear, accessible, and replicable nationwide analysis of state-specific PHIS database integration projects exists. As a contrasting example, considerable resources are annually expended in describing national public health emergency preparedness efforts through the Trust for America's Health "Ready or Not" report.

Leaders' involvement in health IT projects can ensure complex factors – workflows, culture, social interactions, and technologies – are successfully navigated by ensuring these factors are central to the design and implementation of the new technology (34). The executive leadership role is mostly that of project sponsor or champion. One important champion's function is to develop and promote the vision for integrated health information—not only at the state and local governmental levels, but also nationally. Executive leaders should inspire and sponsor innovation in the context of database integration as it supports the ten essential public health services as a core cost of doing public health business. Leaders need to be in-tune with the experiences of program managers who are likely aware of these systemic gaps. Finally, executive leaders should ensure continuous system evaluation and ongoing improvement of these efforts (35). The introduction of performance and quality improvement as a benchmark of public health department accreditation may facilitate the secondary use of integrated data, serving as a business case for improved data management within organizations.

The Healthcare Information Technology (HIT) field is currently experiencing tremendous change, much due to the investments made through the Health Information Technology for

Economic and Clinical Health (HITECH) Act of 2009. Healthcare leaders continue to develop frameworks to understand reasons for success or failure in implementation of healthcare information systems (36), such as degree of mismatch between system design and the environment into which the technology is deployed (37). Parallel principles apply in the public health informatics field. Through the introduction and expansion of Healthcare Information Exchanges (HIEs), the healthcare sector can expect incremental improvements in the interoperable transmission of patient information across healthcare delivery networks both for the treatment of the patient and for broader health purposes (38). This activity in the healthcare community will illustrate public health informatics weaknesses in two ways: 1) inability to cope with the expanding volume of patient information with potential public health use (e.g. laboratory reports and syndromic surveillance data); and 2) a recognition among public health leaders that improvements in healthcare information management are steadily occurring while public health information management progresses relatively slower (39). Public health continues to lag in the HIT revolution, despite unprecedented opportunities to improve population health through leveraging expanding clinical data (40).

Failure to adopt a PHIS database integration strategy could reduce the public health system's ability to effectively carry out essential public health services, and may impact the ability to respond to threats such as bioterrorism (41) and emerging infectious diseases (42). This may result in an overall sluggish public health response system, simultaneously providing poor value to the public, which is a necessary challenge for public health leaders. Failure to keep pace with the technological advances of the private sector will no doubt have an adverse impact on public perception of governmental public health services. For the public health enterprise to maximize health information technology advancements, leaders will need to improve coordination across programs, reinforce the need for consistent standards (43), work to implement new solutions for data systems, and provide more attention to the governmental public health informatics workforce (44). The Public Health Community Platform or Digital Bridge may serve as such a system to achieve these goals. Regardless of framework, concerted efforts must begin in earnest, with alignment of funding to support this cause (45).

Surprisingly few resources are dedicated to informatics despite its criticality (46). The ability for the public health system to employ contemporary informatics technologies to address public health problems will always have relevance and a central role to public health operational needs (47). Further analysis may add needed clarity about progress on public health information system database linkage and can also help propel public health informatics concerns into the executive leadership realm.

Literature Review

The following four groups are the literature relevant to the study. The first group pertains to public sector child health information systems (CHIS), and the efforts to integrate the databases containing this data. The second includes studies of private sector database integration projects, specifically in the context of developing data warehouses. The third describes organizational factors of leadership and strategies in the context of how they impact integration projects. The fourth describes the Agile software development methodology and its role in health software development.

CHIS literature has relevance as it illustrates prior public health database integration use cases and successful attempts to integrate CHIS databases including establishing a listing of factors impacting project success. However, these studies do not provide a comprehensive grouping of these projects, nor do they describe some of the underlying database integration technologies. The data warehouse studies build on the CHIS literature as they present the prevailing database integration technologies used today while logically grouping database integration project success factors. These groupings are useful in that they facilitate the delineation of common categories affiliated with integration project success. As will be illustrated later, organizational factors predominate in the importance of successful project factors. As such, this domain requires further description. The organizational domain literature defines the organizational factors of interest for this study: leadership, and the organizational and technical strategy. Finally, the Agile development methodology literature explains emerging software development methods and the promise these techniques offer to the public health field. The Agile movement has grown in response to drawbacks of traditional software development and project management techniques, such as the waterfall technique. The healthcare sector has successfully utilized the Agile methodology for healthcare IT projects, and those activities will be described as they have relevance for this study. First, the child health information system database integration study literature will be illustrated.

CHIS Literature

A review of Child Health Information System (CHIS) studies separated into two groups will illustrate a specific Public Health Information System database integration example. The first group illustrates five successful examples of CHIS database integration initiatives, demonstrating integration project feasibility. This group's cases involve the following jurisdictions: New York City, Michigan, Missouri, Utah, and Rhode Island. The second group describes studies conducted between 2003 and 2009 that evaluated the impact of initiatives propelling the development of CHIS database integration projects and factors associated with their success. A summary of the first group of studies follows, beginning with New York City.

Papadouka et al. describe New York City's successful efforts in integrating two CHIS databases. In 2004, the health department staff integrated the child blood lead and immunization registries. Doing so linked siloed data from both systems, improving the completeness of the patient record and lowering administrative costs (48).

Hoyle and Swanson illustrate how Michigan built on previous CHIS database integration efforts with an internal and external stakeholder assessment designed to inform future database selection. The Michigan Department of Community Health had already established an integrated data warehouse when it decided to assess its greatest integration needs. Through interviewing stakeholders, health department staff identified the following top priorities: 1) data-driven health care decisions and operations; 2) linkages among disparate data resources; and 3) elimination of duplicated efforts. This informed their database integration selection process (49).

Land et al. describe Missouri's MOHSAIC initiative, which is widely accepted as one of the best known and most successful CHIS database integration projects. The MOHSAIC initiative sought to integrate more than sixty siloed public health databases serving individual programs. A contractor inventoried and assessed all existing systems, drafting an integration strategy that required a decade to complete. Project leaders engaged local stakeholders, managed project resources and planning, and obtained executive support that led to the project's success (50).

Hinman et al. describe Utah's CHARM database integration initiative in the broader context of the All Kids Count program that will be described more thoroughly later. The CHARM database consolidates child health records into integrated access for healthcare providers and public health program personnel. Launched under Utah's Data Integration

Initiative, CHARM provides real-time data sharing for "screening results, immunization status, referrals, follow-ups, assessment, treatment, and outcomes for children" (51).

Lastly, Artz, while developing a detailed database integration guide for Utah's CHARM initiative, illustrates Rhode Island's KIDSNET integrated CHIS database as a model to be employed in other states. KIDSNET integrates many child health information systems using a 2-pronged architecture: some programs periodically submit data to KIDSNET via electronic exchange whereas others directly use the KIDSNET database for data entry and storage, and KIDSNET applications to view and retrieve records and reports (52). These studies show how several states have overcome challenges to successfully develop well-integrated CHIS databases.

The second group of CHIS studies describes efforts to formally evaluate these and other CHIS database integration projects. The formal CHIS evaluation began with two qualitative studies and concluded with a quantitative study.

Wild et al. (2004) describe the origins and initial analysis of the national CHIS database integration initiatives. They proceed to describe The Sourcebook, a core product derived from a 2001 qualitative study conducted by the Robert Wood Johnson Foundation (RWJF). The Sourcebook lists key database integration elements, successful implementation approaches, and important lessons learned. The authors write that in 1991 the RWJF established the All Kids Count (AKC) program in response to a series of measles outbreaks associated with low child immunization rates. AKC lasted through 2004 having worked with thirty-eight state and local health agencies via grant programs and a coordinating program called *Connections*. In 2001, AKC conducted site visits and interviewed seven states given special integration project grant funding through the Health Resources and Services Administration's (HRSA) Maternal and Child Health Bureau. The purpose of the site visits was to evaluate nine key non-technical elements associated with successful database integration projects. These nine elements were identified by AKC staff through review of health information systems management literature and by drawing on their own experience. The AKC evaluators described their findings in The Sourcebook, a technical publication that illustrates integration project best practices (53). This Sourcebook describes best practices for the nine elements and presents five lessons learned, such as the importance of change management and ensuring effective communication during project implementation. One of these primary lessons learned found that organizational issues supersede technical problems (54). As such, organizational issues will be described more thoroughly later.

Fehrenbach et al. (2004) describe an exploratory AKC study conducted two years after the 2001 RWJF study. They describe how in 2003 AKC conducted qualitative interviews of twenty-two state and local health departments, chosen through previous HRSA State Systems Development Initiative grant and *Connections* involvement, to gather information about CHIS database integration projects. Although this was an exploratory survey with some limitations, it served as the first substantial attempt to describe the database integration efforts among health departments. This study illustrated steady progress toward realistic database integration goals and suggested future analyses should explore benefits of integrated data systems. It also organized integration project strengths or challenges into five groups: organizational commitment, external political environment, confidentiality and security needs, funding, and technical challenges; this grouping has relevance for future research and practice (55).

Finally, at HRSA's request, Bara et al. from the Public Health Informatics Institute (PHII) conducted a quantitative study in 2007 to update and expand upon prior characterizations describing the degree to which agencies were integrating CHIS databases. Bara et al. administered a survey to fifty-nine public health agencies to assess CHIS database integration activities. The study profiled the status of integration of select CHIS databases, and also assessed integration project maturity through a series of factors associated with project planning, project funding, and internal and external factors influencing project initiation. See Figure 1 (adopted from Bara et al, 2009) for an illustration of the top five internal and top five external factors influencing project initiation, as indicated by study participants. Many internal factors drove the

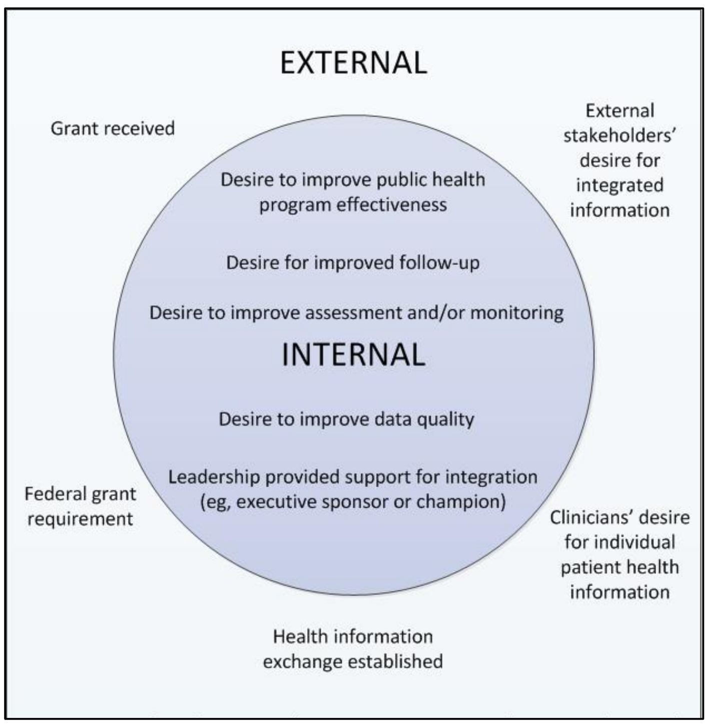

Figure 1 - Top five factors influencing integration

initiation of the projects, such as interest in improving program effectiveness or improving overall data quality. Many external factors were cited, such as receipt of a grant (whether local, state, or federal), specific federal grant requirements, or stakeholders' requests to access integrated data. The authors found that the number of health departments undertaking database integration efforts had grown since 2004, and some agencies had developed robust, consolidated health records and data exchange with stakeholders (56).

These CHIS studies collectively illustrate examples of successful child health information system database integration projects, how the projects came to be, and how project success factors were analyzed. The following studies describe technical approaches to database integration and organize project success factors into logical groups.

Data Warehouse Literature

The use of data warehouse technology to integrate siloed databases extends back to at least the early 1980s. Several studies illustrate the theory behind and factors associated with successful implementation and adoption of the technology. The study authors tend to organize these factors into logical groupings, such as organizational factors, project planning factors, external factors, and technical factors. Hwang et al. studied critical success factors that the Taiwan banking industry considered before and during the development of data warehouses. The authors arranged the factors associated with the development of data warehouse technologies into three domains: organizational, project-specific, and environmental (57). Wixom and Watson surveyed chief information officers' data warehouse projects and they grouped the project success factors according to organizational, project-specific, and technical domains (58). Joshi and Curtis studied data warehouse project successes and they grouped factors according to planning, technical architecture, data, and user access (59).

The data warehouse studies identified which factors were most associated with project success. All studies concluded that organizational factors predominate, and the following studies illustrate these conclusions. Hwang et al. identified the following as being most important: "size of the bank, top management support, and [the] internal needs," goals, and objectives (Hwang, 2004). Wixom and Watson suggested management support, an executive champion, and proper aligning of resources all had the greatest impact on project success. Watson et al. examined data warehousing at Blue Cross of North Carolina. Their findings suggest good governance with a broad base of multiple stakeholders is required to address organizational and technical problems (60). In their data warehouse project studies, Ramamurthy, Sen, and Sinha found that the following factors are the most important factors associated with data warehouse adoptions: organizational size; organizational commitment; absorptive capacity (ability to create and maintain an environment to nurture the skill base needed to fully realize an innovation's potential); relative advantage (the technology will confer a competitive advantage and produce benefits to the organization); and low project complexity (61).

In 2013 Rizi and Roudsari described a public health surveillance data warehouse initiative that transpired in Canada following the 2009 H1N1 influenza pandemic. They found the following most critical database integration project success themes, all according to organizational and technical challenges: addressing technical factors, using data warehouses as a catalyst for improving data quality, appropriately engaging senior management support, and establishing effective project governance. The authors relate how addressing each was critical for the project to complete on time and to the satisfaction of the system users (62).

Markus studied information technology adoption more broadly, and found that obtaining top management support and obtaining user involvement in the design process as the chief factors in project success. She also identified important technical factors such as designing quality databases that meet technical standards and are user friendly. Finally, she identified additional organizational factors of importance including employing change management techniques and ensuring that the benefits of developing the technology outweigh the costs (63).

Collectively these studies describe the foremost technology used in database integration—data warehouses—and groupings of factors associated with project success (see Table 1 for a summary). The third literature group provides more thorough context of the organizational factors involved in database integration project success.

TABLE I - PRIOR DATABASE INTEGRATION PROJECT SUCCESS FACTOR GROUPING

Grouping	Factors	Authors
Organizational	-aligned procedures, priorities, exec support	Fehrenbach
	-champion existence, top management support	Hwang et al.
	-management support, resources	Wixom and Watson
	-size and related features	Ramamurthy et al.
	-top management support	Rizi and Roudsari
	-securing executive support, governance	Markus
	-top management support, user involvement	
Technical	-standards, de-duplication, data quality	Fehrenbach
	-source systems, development technology	Wixom and Watson
	-database selection, data loading, access, etc.	Joshi and Curtis
	-data quality	Rizi and Roudsari
	-quality databases that meet requirements	Markus
Project-oriented	-project team skills, resources, engaged users	Hwang et al.
	-user participation, team skills	Wixom and Watson
	-project plan, business needs, management	Joshi and Curtis
	-lower complexity is better	Ramamurthy et al
External/Environmental	-supportive community stakeholders	Fehrenbach et al
	-competitive advantage, vendor selection	Hwang et al
Confidentiality	-HIPAA concerns	Fehrenbach et al
Funding	-HRSA funding	Fehrenbach et al
Absorptive Capacity	-nurturing skill base	Ramamurthy et al
Relative Advantage	-the technology confers an advantage, benefit	Ramamurthy et al

Organizational Dimension Literature

The third group of literature delves deeper into two organizational aspects that impact integration project success according to the factors within HRSA's Sourcebook: these are 1) Leadership, and 2) Organizational and Technical Strategy. The Sourcebook defines leadership through the role of the executive sponsor and a champion. The "executive sponsor is a high-level official who works for institutionalization of the project, [fosters] a work environment that [welcomes] risk-taking and innovation", communicates well, has influential contacts, and is in tune with the political landscape (64). Through a multiple-case study design following replication logic, Young and Jordan studied executive sponsors and other top management support in the context of information system projects. The authors describe that which constitutes top management support (TMS) and how TMS impacts the success of IT projects. Examples include sponsorship, CEO involvement, and top manager interest. They conclude that TMS is the most important factor, not simply one of many critical success factors needed for project success (65).

The project champion has a passion for the project; is respected among agency staff and executives; has "access to leadership; and is willing to [contribute] significant effort to see the project succeed" (PHII, 2003). Boyer describes the champion as an executive manager who is solidly behind the project and can present return on investment and cost/benefit scenarios to bring others on board (66). Within a qualitative study of the future of local health department informatics, Leider et al. identify perceptions in the role that leadership can have in developing informatics. Participants state that departmental leaders can work to understand informatics, develop the vision for it, and be champions for it; this was especially relevant for larger local health departments (67). In describing healthcare change management and the roles of leadership, Golden illustrates four stages of change management and underscores the importance of change leaders to serve in the role as a champion to wield their influence, skill, and relationships to effect the successful project implementation (68). Nilakanta, Scheibe and Rai describe how management support is the most difficult component to overcome in a government venture, and securing key people to serve as the project champion provides the opportunity for the project to succeed (69). In their study of the dynamics involved in the establishing of a health information exchange for public health reporting, Merrill et al. identify a direct relationship among the number of champions supporting a project and the number of deliverables reached. The authors assert that consistent champions propel the project forward (70). Chenoweth, Corral and Demirkan studied data warehouse development success as it pertains to the interaction of technology and social context. They note that absence of a project champion is not a death sentence for the project, in that the users of the technology may serve as champions and convince management of its benefits. However, the authors note that these users must convince their leadership to support the initiative (71). These studies illustrate the essential role of meaningful leadership engagement in successful project outcomes.

Organizational and technical strategy includes many facets, most of which are beyond the scope of this study. Some of the core components as defined in The Sourcebook include "funding, organizational structure, the strengths of the organization, stakeholder beliefs and values, and the political environment. The strategy is customer-focused, developed through a legitimate process involving stakeholders and based on business processes" (PHII, 2003). Strategic plans are tools organizations can use to assess capacities and realign resources. Bryson's writings on strategic planning are frequently used by organizations to guide plan development. He illustrates how strategic planning is a useful tool for assessing organizational strengths and stakeholder needs, and aligning organizational resources such as human and financial (72). The other organizational core components are also necessary pieces of public health programming. Frieden defines elements of successful program implementation and describes how partnership development, communication, and securing political commitment are three of the six components (73). These organizational factors can be assessed and evaluated for their presence and potential role in public health tool development such as public health information system database integration projects. The final literature group describes an emerging software development project management technique.

Agile Methodology Literature

The use of the Agile software development methodology in public health practice is poorly understood. Agile software development, or simply "Agile", is emerging as a popular software development project management alternative to more traditional approaches such as the widely-used Waterfall methodology. The Waterfall model entails a prescriptive stage-oriented software development process characterized by exhaustive initial requirement collection and design phases (74). Agile is considered a "lightweight" method for developing software, with principles that focus on intensive collaboration and rapid software iteration versus extensive up-front system requirement documentation and highly-regimented planning (75).

Many technology companies utilize Agile to rapidly iterate software products and gain a competitive advantage. Organizations have utilized Agile to create software for healthcare applications (76) and others have modified aspects of the organizational culture by adopting Agile practices for managing other types of projects (77). Researchers have studied their experiences in utilizing Agile to create and maintain biomedical software, and found the Agile approach to be a good fit for these projects (78). Following the failed rollout of HealthCare.gov, some departments of the United States federal government immersed themselves in Agile methodology with some success (79). Implementing Agile does not come without its risks for failure, but its success factors have been studied (80). The role of Agile in the PHIS database integration projects identified in this study will be illustrated further.

In summary, the literature describes the following areas relevant for this study: child health information system database integration project success stories and efforts to formally evaluate those projects; data warehouse project success factors and logical groupings of those factors; organizational dimension context; and the Agile software development methodology. Whereas the private sector data warehouse literature describes integration project factors of primary importance, the public health literature does not (see Box 1).

Box 1
Gap: The public health literature lists relevant success factors for child health database integration projects. Data warehouse literature logically groups factors and describes private sector factors of primary importance. Public health literature does not indicate the most important integration project success factors.

II. CONCEPTUAL FRAMEWORK

Conceptual Framework

Database integration projects are challenging initiatives that when successful, yield improved information generation that benefits the organization. Many factors influence the launch of a database integration project. CHIS database integration began as a result of an effort to improve information sharing among stakeholders involved in meeting the health care needs of children. CHIS leaders conducted a series of studies to assess the integration projects and describe factors contributing to successful implementation. The CHIS evaluation formulates the basis for understanding similar PHIS database integration project success factors.

A common finding from the literature suggests that integration projects fail not because of information technology gaps, rather due to non-technical reasons. One of the primary products that emerged from the CHIS All Kids Count studies was The Sourcebook and its description of nine key non-technical elements associated with successful integration projects. While each is unique, these elements can be logically grouped into categories. In describing the most important factors associated with project success, the data warehouse literature authors logically group these types of factors. These groupings and those from Fehrenbach's and Rizi's research can be borrowed to assign The Sourcebook's elements into structured factor groupings.

The researcher grouped the Sourcebook's nine non-technical elements into the following three domains as informed by the data warehouse literature and the researcher's experience: organizational, project-oriented, and external; each element in its domain is listed here. The organizational domain's elements are leadership and the organizational and technical strategy. The project-oriented domain's elements include the following: project governance, project management, technical support and coordination, financial support and management, and evaluation. The third and final non-technical domain is the external domain; its elements include stakeholder involvement and policy support. The fourth domain is the technical domain, which includes the core information technology elements associated with the database integration projects, such as the source systems, data standards, and the development technology. Each of the four domains' factors is defined more thoroughly here (PHII, 2003).

ORGANIZATIONAL

Leadership
The project has an executive sponsor, a high level official who advocates for the project, and a champion, someone who is willing to devote a significant effort to see the project succeed.

Organizational and Technical Strategy
The project has a strategy that takes into consideration local issues such as funding, the political environment, organizational structure, the strengths of the organization, and stakeholder beliefs and values. The selected technical integration approach accounts for internal data governance and data sharing needs, which must conform to state and federal laws and agreements made with stakeholders.

PROJECT ORIENTED

Project Governance
The project is guided by a steering committee representing all key stakeholders. The steering committee develops the integration strategy, based on clearly defined business processes.

Project Management
The project has formalized management strategies and project management methodologies designed to assure consistent communications, accountability, and resource constraints.

Technical Support and Coordination
Technical information systems support and coordination is organized centrally to assure consistent support and a robust infrastructure capable of maintaining and complying with standards. A business analyst supports implementation.

Financial Support and Management
The project is adequately funded and has multiple funding sources.

Evaluation
The project has some form of qualitative and/or quantitative monitoring or evaluation that is performed regularly.

EXTERNAL

Stakeholder Involvement
Frequent communication with stakeholders and involvement of stakeholders in the integration project throughout the life cycle of the project contributes to its success and credibility.

Policy Support
Rules, regulations, legislation, and policy advisory or policymaking bodies are supportive or at least neutral to the integration of health information systems. Executive sponsors educate policymakers about sensitive issues to garner their support.

TECHNICAL

Source Systems
Databases contain quality program-specific data to be contributed to the database integration project.

Development Technology
Project managers select a particular technology to be utilized for the integration project including architecture, hardware, database software, data integration engines, user interface, etc. This can also include the development technique, whether agile, waterfall, etc.

What is not clear is which are the most important factors associated with public health database integration project success and why, whether they be technology-oriented or one of the three non-technical domains (Figure 2). This study will begin to answer which factors are closely associated with public health database integration project success and how these factors impact project success.

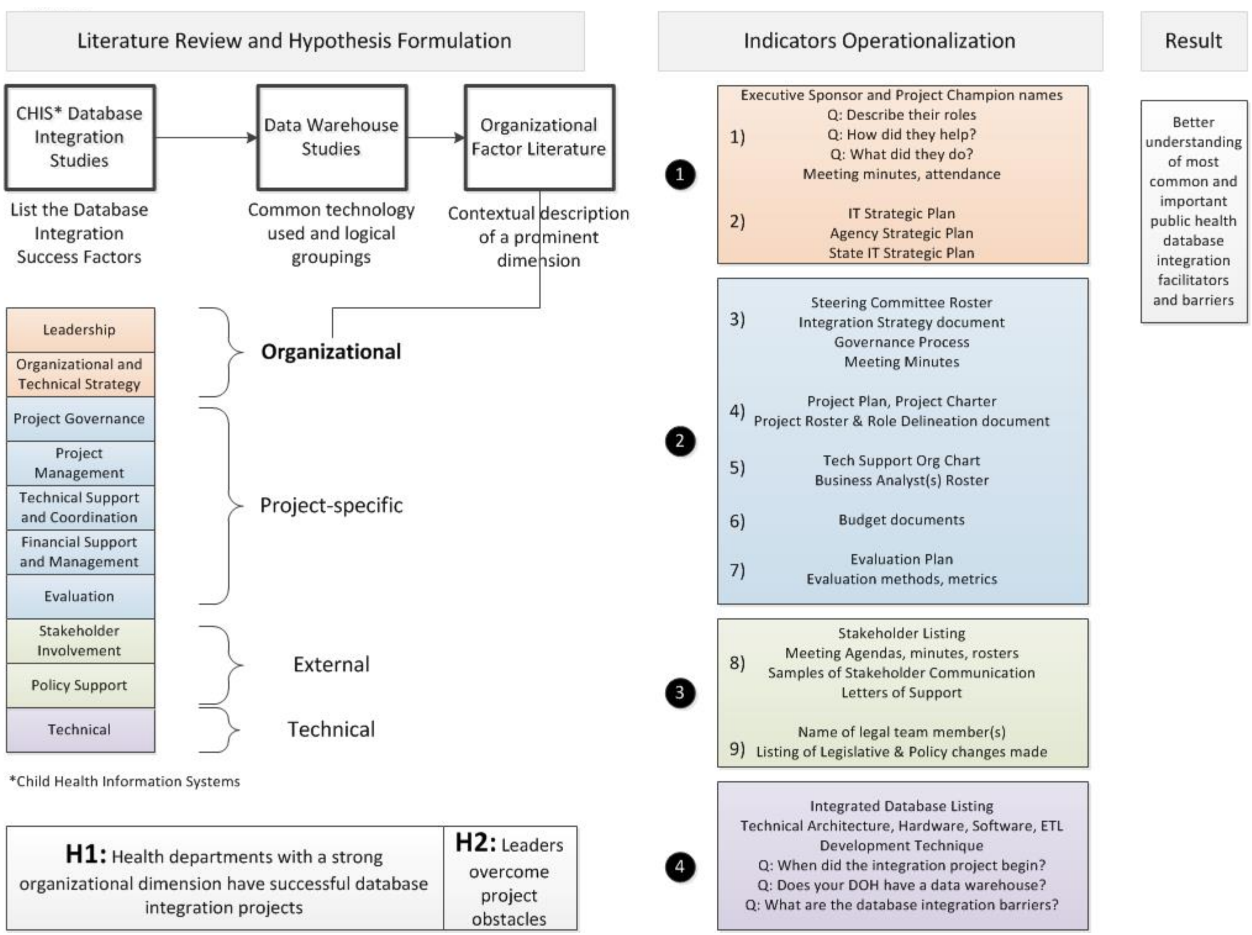

Figure 2 - Conceptual Framework

III. METHODS

Design

The overall study design is a cross-case study; this design was used for this study for two reasons. The first is the nature of the question, as it asks "how" or "why" a phenomenon occurs, rather than a more narrow "what" occurs or "who" is involved. The second is that this study is examining a complex phenomenon which is difficult to separate into discrete components suitable for study by other means such as quantitative methods. The state health department is the unit of observation, and the database integration projects themselves are the unit of analysis for this study.

Case selection followed literal replication logic, in that each case would predict similar results. Through literal replication logic, one establishes conditions under which a phenomenon is likely to be found, and cases are all selected based on meeting these conditions (81). Criteria for inclusion in the study as a case are detailed more thoroughly in the study protocol but summarized here: cases with successful PHIS database integration projects are evidenced by 1) long-standing, functional (mature) projects actively operational for three or more years; and 2) projects that have demonstrated a high number of integrated databases: minimally two, with ten or more integrated databases serving as exemplars.

A three-phase screening procedure was utilized: 1) administering a survey; 2) identifying cases through a literature review characterization of documented, successful PHIS database integration projects; and 3) through reputational case selection. The first phase involved conducting a survey, and the target recipients were state health department informatics staff identified through involvement in the Association of State and Territorial Health Officials (ASTHO) Informatics Directors Peer Network (IDPN). This body is the most regularly convened group of individuals that share this or related job titles and they tend to be among the most knowledgeable in their jurisdiction of public health information systems and any database integration projects. All IDPN members received the questionnaire and their responses were compared. Seven participants responded to the survey, and three of those respondents met the criteria for additional follow-up as a potential case.

For the second screening phase, the researcher identified additional cases based on criteria specified through the literature of frequently documented, successfully completed PHIS database integration projects. Peer reviewed journals, books, and federal agencies have published materials regarding the success of some state health departments in integrating PHIS databases. One substantive source includes the Journal of Public Health Management and Practice (JPHMP) 2004 Supplemental publication dedicated to CHIS database integration. This Supplement thoroughly characterizes the case studies conducted as part of the All Kids Count initiative that ultimately led to the development of the HRSA Sourcebook. The case studies from the JPHMP Supplement describe each state's experiences in successfully integrating CHIS databases. Additionally, the HRSA Sourcebook describes CHIS database integration best practices as identified through the experiences of seven states. Another substantive source of PHIS database integration research pertains to the Environmental Public Health Tracking initiative. These peer reviewed publications illustrate how states have established integrated databases that link environmental hazards, human exposures, and health effect surveillance records together to establish environmental public health tracking data systems to better monitor environmental health concerns. JPHMP in 2015 published a Supplemental issue that illustrated successful PHIS database integration cases that relate to the Environmental Public Health Tracking initiative (82). These states' projects are accepted as successfully established PHIS database integration initiatives, and the researcher contacted staff from these state health departments to inquire about inclusion in the study. Three cases were added to the study through this collective literature review characterization: two within their participation in both the CHIS initiatives and Sourcebook development, and one through the Environmental Public Health Tracking activities.

Finally, one case was included in the study through reputational case selection as referred by the Public Health Informatics Institute. Through these processes, the researcher retained seven distinct states to serve as cases that best fit the literal replication design, including individuals willing to serve as study participants and provide documentation for the document review analysis. The following states are the study cases (alphabetically ordered): Iowa, Michigan, Ohio, Oklahoma, Oregon, Utah, and Wisconsin. See Table 2 for a summary of these cases.

TABLE II - CASES BY PROJECT SCOPE AND TYPE DESCRIPTION

Case	Scope	Database Integration Type	Primary Database Content
State A	small	Business Intelligence Dashboard	Infectious Diseases; Vital Statistics
State B	small	Business Intelligence Dashboard	Environmental Public Health Tracking
State C	large	Extensive database integration	Immunizations; CHIS; EDSS
State D	large	Extensive database integration	CHIS; EDSS
State E	large	Extensive database integration	EDSS; Immunizations; MPI
State F	large	Extensive database integration	Immunizations; CHIS
State G	small	Middleware linkage of two databases	EDSS; Immunizations

Abbreviations: EDSS, Electronic Disease Surveillance System; MPI, Master Patient Index; CHIS

The researcher excluded an eighth potential case since only one respondent was successfully recruited from that state, and thereby his responses could not be triangulated with those of another participant. However, this individual is no longer employed by that state's health department under consideration and instead works for a national public health informatics organization. As part of his duties in working with other states on their informatics projects he has gained insight into the facets involved in projects like those under consideration for this study. Although the researcher excluded his quotations from the coding analyses, his quotations from the interview transcript were retained and possibly support others' claims.

Data Collection and Management

There are three sources of evidence for the study: survey responses, focused interviews, and document review. The survey (Appendix A) was initially launched via Qualtrics to facilitate case selection (as previously described under **Design**), and collect preliminary PHIS database integration project information. The survey questionnaire data addressed questions that pertain to the technical and project planning domains. Next the researcher conducted semi-structured focused interviews with state health department informatics directors along with referral follow-up interviews of program directors, bureau chiefs, system administrators, and technical staff. The interview guide (Appendix B) had been piloted in the summer of 2014 and it asks the following question types: Opinion and Values; Knowledge; and Background/Demographic questions. The researcher interviewed twenty-five participants through nineteen interviews (some interviews included two participants) from April to September of 2016 (see Appendix C for the interviewee legend). Associated survey data was paired with the interview transcripts.

Finally, for the documentation review, the researcher requested project documents from study participants, including copies of strategic information technology plans and operational plans for the database integration projects. Additional documents the researcher collected include agency budgets, project meeting minutes, project charters, progress reports, policy documents, and protocols. Some documents were obtained through publicly-available websites. See Table 3 for an overall illustration of the study constructs and data elements, and Appendix D for a data accounting log.

TABLE III - STUDY CONSTRUCTS AND DATA ELEMENTS

Indicators	Evidence Source	Data Item
Engaged senior departmental official Presence of individual(s) who propel the initiative forward	I DR	Top officials meaningfully engaged as evidenced in meeting minutes Roles description as related via interview
Presence of a Departmental Strategic Plan Presence of an IT Strategic Plan	DR S	Agency Strategic Plan Agency IT Strategic Plan State IT Strategic Plan Informatics Office org chart Number of informatics staff Readiness assessment survey items Barrier analysis survey items
Presence of a regularly convened steering committee Presence of an Integration Strategic Plan	DR I	Roster Committee Charter Meeting Minutes Integration Plan
Presence of a project manager(s) Presence of a business analyst(s) Presence of subject matter experts	DR I DR	Rosters Logic Model Data Plan Project documentation Planning duration (years) via survey
Presence of a central tech support center	I DR	Name of the business unit handling tech support Unit organizational chart
Funding sources	DR	Budget documents
Presence of an evaluation plan Metrics in place to measure success	I DR	Evaluation Plan Regular progress reports
Stakeholders are assessed Stakeholders are engaged regularly Stakeholders contribute to the project	I DR	Stakeholder listing Stakeholder assessment Meeting agendas Meeting minutes Communication samples Letters of Support
State laws support initiative State rules support initiative Internal agency policies support initiative Board of Health supports initiative	I DR	Name of legal team Roster Legislative changes made Letters of support
Presence of multiple source systems Description of development technology	S	Listing of databases integrated Technical architecture items Data Warehouse model

I = Interviews DR = Document Review S = Survey

Analytical Framework

The analysis included within-case analysis followed by cross-case analysis. The within-case analysis entailed comparing survey and interview responses, then contrasting these summaries with the document content analyses. Once these analyses were completed for each case, the cases themselves were compared.

Data were analyzed using initial a priori theory-based codes, entailing primarily deductive coding—assigning labels to data to summarize the basic topic of a qualitative data passage—with an initial list of codes based upon pre-existing theory, largely from the CHIS integration studies (83). Three additional codes emerged inductively through the analytical process: “cross-cutting projects”, “change management”, and “informatician leader”. The cross-cutting projects code was added because participants often discussed agency-wide projects that were relevant but unrelated to the main project of interest (especially during the introductory phase of the interview). The change management code was added since this concept regularly surfaced, regardless of context. This concept did not seem to fit neatly within the rest of the integration project factor listing, and seemed distinct from the other codes. The third code, informatician leader, emerged since participants remarked specifically about the contributions of informaticians on a regular enough basis to warrant its own distinct category.

All preliminary data analysis occurred through ATLAS.ti to thematically code and compare survey responses, interview transcripts, and the document contents (84). The document content analysis included contrasting database integration project documentation by categorically classifying text (85). The content analysis was used to further describe integration project objectives, activities, and estimate project results. The author utilized a common codebook for all content analysis, found at Appendix E.

The survey data, interview transcript and document analysis included the following tactics for readying the data for analysis and for generating meaning: noting patterns/themes; seeing plausibility; clustering; counting; making contrasts/comparisons; partitioning variables; subsuming particulars into the general; factoring; noting relations between variables; finding intervening variables; and making conceptual/theoretical coherence. The researcher utilized data display matrices to illustrate systemic relationships and the within-case and cross-case synthesis.

Qualitative analysis documentation forms (Appendices F-I) provide additional insight into the analytical techniques performed. A synopsis of the analytical process follows. Basic quote and word count frequencies were initially established to obtain a general representation of the coded data (Appendix J). Following these tables, nine additional matrices and tables were created to explore and evaluate the data for four purposes: to explore the data; describe participants and variability; explain interrelationship and change; and to summarize overall findings.

Three matrices were developed to explore the coded data: a partially-ordered meta matrix, an explanatory effects matrix, and a content-analytic summary table. The partially-ordered meta matrix (Appendix L) was organized according to each interview grouped by case, with columns illustrating the most frequently-coded factor from each interview transcript, a characterization of the interview's themes, the most important project integration factors as reported by the interview participants, and an overall explanation from the researcher's perspective. This matrix served as a useful starting point for obtaining an overall understanding of the interview data. Most importantly, it illustrated the need to partition the leadership variable into two aspects: the role of executive leaders versus that of program directors. The explanatory effects matrix (Appendix M) was then crafted to build on the partially-ordered meta matrix with the same groupings and a deeper inspection of the rationale behind the reported most important integration project success factors. This included the “why” as reported by the participants, with quotation-supported explanations, paired with the researcher’s explanation.

These two matrices suggested that while participants seem to discuss the technological aspects of the project the most, the participants overwhelmingly report leadership aspects as the single-most important factors impacting integration project success. To verify this conclusion, the researcher created the third exploratory display, a content-analytic summary table (Appendix N), to plot participants’ mentions of prominent integration success factors grouped by a new variable—the project scope (small-scale or large-scale projects). In the content-analytic summary table the researcher displayed any specific responses to the question asking about the single most important factor(s) involved in project success, and subsumed these responses into the domain-specific project factors. This table illustrated the overwhelming dominance of the Leadership factor and the Organizational Domain. It also showed the next most-frequently identified factors, such as project management and financial support and management. Importantly, it illustrated factors of less importance, such as project governance.

The next two descriptive matrices were designed to describe the study’s participants and describe variability: the role-ordered matrix and the conceptually-clustered matrix. The role-ordered matrix (Appendix O) was designed grouping participants according to their position in the organization and compares their reports about the role of leadership in integration project success. It is sorted by project scope within each position grouping, and includes the participant’s degree of involvement in the project. While no patterns seemed to emerge regarding the reported role of leadership by position, this matrix illustrated noteworthy characteristics, including identifying participants who did not provide substantial remarks regarding the leadership component.

The conceptually-clustered matrix (Appendix P) was then created to provide a thorough analysis of the influential leadership dimension. Organized by case, it excludes those participants identified in the role-ordered matrix who did not substantively contribute to the leadership factor discussion, and lists each participant's report of most important factors and the participant's report of the role of leadership, of the role of the informatician, and his or her stance on the contributions of the executive-level or program-level leadership (supported with quotations; see Appendix K for a case-specific overview). The reported role of leadership in general and that of the informatician specifically appear to be uniform across the participants; this aspect led to the creation of two explanatory matrices and a table, described in the next section.

The next two matrices were designed to explain interrelationship and change: a variable-by-variable matrix and the case dynamics matrix. The variable-by-variable matrix (Appendix Q) compares the leadership dimension attributes identified in the conceptually-clustered matrix (rows) and contrasts those features with the other prominent integration project success factors identified in the content-analytic summary table (columns), along with the respective project size/scope, to examine any interaction. After plotting case names according to participants' reports for the assorted features and factors, the researcher examined patterns across and down the matrix. The case dynamics matrix (Appendix R) includes a subset of the leadership features from the variable-by-variable matrix and contrasts summaries of those features as reported by participants and evaluated by the researcher. It explains how various leadership features impacted the success of the integration projects. A notable finding from the case dynamics matrix which pertains to team dynamics and relationships is worth highlighting here. Several study participants expressly mentioned that the success of these projects came solely down to "relationships" and "team dynamics". While not expressly identified at the study's outset, these findings stood out as relevant and new. Some quotations from the case dynamics matrix help illustrate these findings, such as "[the team members'] ability to really work together and with other partners to make it the best system that it could be." One participant simply stated that, "team dynamics achieve the outcomes." The functions of relationships and team dynamics were subsumed into the leadership factor for this analysis but bear further exploration.

Next, the researcher examined co-occurring codes (Appendix U) and their underlying quotations to further identify relationships among variables. The most substantive code co-occurrence emerged among the *Informatics Leader* and *Leadership* codes, substantiating earlier findings of the relationship between informatics personnel and other agency leaders. In particular, the co-occurrence analysis highlights the considerable role program directors play in these initiatives. Regardless of where the Informatics Office is located in the agency, the informatics personnel find themselves working closely with program directors on a regular basis.

Finally, the researcher created the case summary table (Appendix S) drawn from case summary memos (Appendix T). The table lists each case and a summary of the case for additional cross-case comparison. Together, the case summary memos and the case summary table facilitate cross-case analysis.

<u>Study Validity and Reliability</u>

The study validity is impacted by many factors, and those factors are addressed here, along with those concerning reliability. Construct validity has been met through the following: ensuring clear definitions and operational measures; ensuring a chain of evidence; and including multiple sources of evidence – triangulation. The study requires clear methods for defining variables using specific constructs and the means by which the constructs are measured. This study addresses the variables, their constructs, and operational measures for those constructs within the literature review, the conceptual framework, Table 3 of the dissertation report, and the study protocol, which includes a table that maps study questions to interview items. The chain of evidence (and audit log) established for this study allows one to logically link between the study questions, the study protocol, the study database, and this report (with associated manuscripts). Lastly, multiple sources of evidence have been utilized for this study to establish converging lines of inquiry, corroborating findings. This plurality of sources effectively triangulates the study data, ensuring multiple measures of the same phenomenon. Multiple parties from each state were interviewed as previously specified. Those interview transcripts (primary data source) and related notes or summaries were compared with the survey data and document content analysis (supplementary data sources) to ensure a plurality of data sources from which richer conclusions may be drawn with more confidence.

Internal validity is addressed through specific data analysis techniques, such as pattern matching and explanation building. In order to test or confirm findings and address internal validity, the researcher utilized several tactics. Triangulation (described earlier) is one such method. Weighting the evidence was employed. Additionally, the researcher checked for representativeness by: increasing the number of cases, looking purposively for contrasting cases, and ordering cases in various ways to ensure nothing was missing. Finally, the researcher searched for researcher effects: avoiding biases stemming from the site on the researcher through the following approaches: avoiding the elite bias (including a plurality of participant types); including dissidents; avoiding pleas for confirmation; and sticking to research questions.

External validity (analytic generalization) is addressed through the literal replication logic for case selection. Described more thoroughly earlier, the results for the study are generalized to the broader study theory. As findings are replicated among additional cases, the results provide strong support for the theory.

Four reliability aspects are addressed here: the study protocol, the study database, the audit trail, and qualitative data analysis documentation forms. The role of the study protocol is to set a standard agenda for the line of inquiry (Appendix V). It prescribes the process for selecting cases and collecting data, and also specifies detail about the study database and audit trail. The study database contains all evidentiary data such as interview transcripts and audio recordings, as well as investigator reports, such as interview summaries and notes. All documents for the content analysis are maintained in their respective state-specific folders. ATLAS.ti was used for analysis of study data maintained in the study database, as well as for creating and storing all study memos. A legend describes how each artifact is related to one another for auditing purposes. The database is available for inspection upon request, as is the analytical database project within ATLAS.ti. The qualitative data analysis documentation forms specify analytical procedures, decision rules, and analytical operations employed throughout the analyses. Collectively, these improve the study reliability.

IV. MANUSCRIPTS

Paper #1

An Assessment of State Public Health Information System Database Integration Project Success Factors

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Conflicts of Interest and Source of Funding:
The author certifies that he has no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript. There is no funding source for this study.

A manuscript similar to this has been submitted for review with the Journal of the American Medical Informatics Association. That manuscript focuses on findings that relate to project management.

This material is based upon a dissertation in partial fulfillment of the requirements for the doctoral degree at the School of Public Health of the University of Illinois at Chicago.

Abstract

Context:

Public Health Information Systems (PHIS) are critical components of public health infrastructure, providing for how health departments collect and maintain data for practice. Databases are a central component of PHIS, and advancements have allowed for database integration, permitting the creation of more complete records to be used across the public health enterprise. Several factors impact a database integration project's success.

Objectives:

The purpose of this cross-case study is to identify factors that most contribute to successful intra-state public health database integration projects. These factors were studied by examining aspects of these projects and explaining why certain factors prevail over others in their importance.

Design, Setting, and Participants:

The state health department is the unit of observation and the database integration projects themselves are the unit of study. Case selection followed literal replication logic, screening cases through a survey followed with literature review characterization of documented, successful PHIS database integration projects. The author reviewed survey responses, conducted semistructured interviews with key informants, and analyzed departmental documents. Data were transcribed when required, thematically coded, and analyzed.

Results and Conclusion:

Findings suggested that organizational leadership factors predominate in project success importance. When the leadership dimension is partitioned, distinctions emerge among the roles of executive leadership, program directors, and the informatics director. Informatics-savvy executive sponsors establish the required vision for the initiative. Engaged program directors remove project obstacles. Informatics directors foster relationships and teamwork while applying expertise at the intersection of technical design and programmatic business needs. State health department personnel interested in pursuing PHIS database integration projects must evaluate the agency's executive leadership support and project championship by program directors and informatics staff.

Key words: informatics, information systems, leadership, project management

Introduction

The United States public health infrastructure includes those components that comprise the public health system, including health departments, community partnerships, and the workforce. Public Health Information Systems (PHIS) are critical components of public health infrastructure, providing the means by which health departments collect and maintain data for public health practice.[1] These data support services such as applying communicable disease control measures or creating health promotion programs targeting high infant mortality rates. States possess the legal authority for establishing many PHIS,[2] and those administered at the state level directly impact public health programs and service delivery at the local level.[3]

An essential component of PHIS is information technology, the application of computing to manipulate data. A critical piece of information technology includes databases that store and maintain data.[4] Advances in information technology have allowed for cheaper and easier database development to suit tailored, individualized program needs.[5] Specialized program-specific state public health databases have proliferated because of both this database development ease and due to increased categorical funding that has incentivized the development of program-specific databases. Information technology advancements not only enabled development of these databases, but also facilitated database integration[6] often achieved by information system semantic interoperability, the unambiguous sharing of data according to prescribed vocabulary and messaging definitions.[7]

While definitions vary, database integration can be considered to include the development of a central data repository that consolidates operational data from multiple sources.[8] When databases are integrated with one another, they create more complete or comprehensive records by piecing together different data elements from multiple sources.[9]

Access to complete records can lead to improved coordination of program activities, better performing public health operations, and reduced costs.[10] Pursuing database integration benefits the health department by improving the value of the agency's information, one of the department's most strategic assets.[11] To be a truly effective public health system, intra-state databases must integrate across the public health department.[12] The Joint Council of Governmental Public Health Agencies has agreed that 1) public health agencies at all levels must work to establish integrated databases, and 2) these databases must meet information needs at the client service level.[13]

Efforts to integrate intra-state child health information systems (CHIS) across different public health programs serve as a practical example of a PHIS database integration business case, the methods used to execute a database integration initiative, and how these initiatives have been studied previously.[14] In response to a large measles outbreak, experts from public health and healthcare fields began efforts to integrate CHIS databases in the early 1990s. Many child health databases—such as birth registries, immunizations registries, and childhood lead surveillance systems—were adversely siloed, and over the course of a decade state health department staff sought to connect these individualized intra-state databases. Findings from CHIS integration studies inform research in related areas.[15]

Program-specific public health databases have proliferated but are often not integrated together. Siloed databases contain data elements that support individual program goals but fail to address broader enterprise data needs across the organization.[16] Many public health program managers have developed their databases without considering broader integration, resulting in duplicate data management and narrow program perspectives that fail to address holistic client needs. Siloed public health data systems are inefficient, and result in missed opportunities to detect and manage outbreaks; coordinate service delivery; and protect communities during public health emergencies.[17] Some CHIS database integration has occurred,[18] but beyond these known instances, few PHIS database integration initiatives have been successfully executed and documented. It is not known which database integration project factors are most important and how they impact the success of public health database integration projects.

The purpose of this study is to identify factors that most contribute to the success of intra-state public health database integration projects and explain how. Organizational factors, such as agency leadership, impact whether the agency is sufficiently prepared to embark on these projects. Project-specific factors impact aspects such as whether the project has effective project management techniques. Other factors somewhat outside the agency's direct control can influence the project's success, such as state privacy laws, or the actions of external stakeholders. And technological factors, such as the quality of the data sourced from contributing databases, directly impact how smoothly the databases will operate once developed. In 2003, the Health Resources & Services Administration (HRSA) published the *Tool for Assessment and Planning* and the *Sourcebook*, a guide that describes nine integration project non-technical elements.[19] Table 1 summarizes these elements and includes technical factors to consider; they are organized into logical Domain groupings designed for this study: Organizational, Project-oriented, External, and Technical.

Table 1 – Database Integration Elements, Grouped

ORGANIZATIONAL DOMAIN
Leadership The project has an executive sponsor, a high level official who advocates for the project, and a champion, someone who is willing to devote a significant effort to see the project succeed.
Organizational and Technical Strategy The project has a strategy that takes into consideration local issues such as funding, the political environment, organizational structure, the strengths of the organization, and stakeholder beliefs and values. The selected technical integration approach accounts for internal data governance and data sharing needs, which must conform to state and federal laws and agreements made with stakeholders.

PROJECT ORIENTED DOMAIN

Project Governance
The project is guided by a steering committee representing all key stakeholders. The steering committee develops the integration strategy, based on clearly defined business processes.

Project Management
The project has formalized management strategies and project management methodologies designed to assure consistent communications, accountability, and resource constraints.

Technical Support and Coordination
Technical information systems support and coordination is organized centrally to assure consistent support and a robust infrastructure capable of maintaining and complying with standards. A business analyst supports implementation.

Financial Support and Management
The project is adequately funded and has multiple funding sources.

Evaluation
The project has some form of qualitative and/or quantitative monitoring or evaluation that is performed regularly.

EXTERNAL DOMAIN

Stakeholder Involvement
Frequent communication with stakeholders and involvement of stakeholders in the integration project throughout the life cycle of the project contributes to its success and credibility.

Policy Support
Rules, regulations, legislation, and policy advisory or policymaking bodies are supportive or at least neutral to the integration of health information systems. Executive sponsors educate policymakers about sensitive issues to garner their support.

TECHNICAL DOMAIN

Source Systems
Databases contain quality program-specific data to be contributed to the database integration project.

Development Technology
Project managers select a particular technology to be utilized for the integration project including architecture, hardware, database software, data integration engines, user interface, etc.

Methods

A cross-case study design was used for this research. The state health department is the unit of observation, and the database integration projects are the unit of study.

Case Selection

Criteria for inclusion in the study as a case are summarized here: cases with successful PHIS database integration projects are evidenced by 1) long-standing, functional projects actively operational for three or more years; and 2) projects that have demonstrated a high number of integrated databases (minimally two). A three-phase screening procedure was utilized to identify cases through literal replication logic,[20] entailing the use of a survey, followed with literature review characterization of documented, successful PHIS database integration projects, and finally reputational case selection.

First, the survey was deployed in March of 2016, targeting state health department informatics staff identified through involvement in the Association of State and Territorial Health Officials (ASTHO) Informatics Directors Peer Network (IDPN). All IDPN members received the questionnaire and their responses were compared. This initial screening stage reduced the candidate list to cases with successful PHIS database integration projects. Seven participants responded to the survey, and three met the criteria for inclusion in the study.

Next, for the second screening phase, the researcher identified cases based on criteria specified through the literature of frequently documented, successfully completed PHIS database integration projects. This Journal had previously reported on CHIS database integration activities culminating in the development of the HRSA Sourcebook[21] and the Environmental Public Health Tracking initiative.[22] This research presented successful state efforts and best practices for integrating PHIS databases, and the researcher contacted staff from the state health departments to solicit inclusion in this study. Three cases were identified through this process.

One additional case was included in the study through reputational case selection as referred by the Public Health Informatics Institute (PHII). Through these processes, the researcher retained seven distinct state health departments to serve as cases, with individuals willing to serve as study participants and provide materials for the document review analysis.

Data collection

Survey responses, focused interviews, and documents constitute this study's data. The survey was launched to select cases; it also addressed questions that pertain to the Technical and Project-oriented Domains. After the survey concluded, the researcher conducted and recorded hour-long semi-structured focused interviews with state health department informatics directors along with referral follow-up interviews with program directors, bureau chiefs, system administrators, and information technology staff. The researcher based the interview guide design from a previous CHIS study[23] and piloted it with four state informatics directors. The researcher interviewed twenty-five participants through nineteen interviews (some interviews included two participants) from April to September of 2016. The interview recordings were transcribed, and the survey data were then paired with their associated interview transcripts. Finally, the researcher obtained copies of relevant project documentation for review: strategic information technology plans and operational plans for the database integration projects, agency budgets, project meeting minutes, project charters, progress reports, policy documents, and protocols. The study protocol was reviewed and approved by the University of Illinois – Chicago Institutional Review Board.

Analyses

The analyses included within-case analysis followed by cross-case analysis. The within-case analysis entailed comparing survey and interview responses, then contrasting these summaries with document content analyses. Once these analyses were completed for each case, the cases themselves were compared.

Data were analyzed using a priori theory-based codes, entailing primarily deductive coding: assigning labels to data to summarize the basic topic of a qualitative data passage. The deductive coding began with an initial list of codes from pre-existing theory, largely from the CHIS database integration studies.[24] Additional codes emerged inductively through the analytical process. The document content analysis included categorically classifying text to further describe integration project objectives, activities, and estimate project results.[25] A common codebook was established which served as the basis for the analyses. All preliminary data analysis occurred through ATLAS.ti to code and compare thematic survey responses, interview transcripts, and the document contents.[26] The researcher utilized data display matrices to illustrate systemic relationships and the within-case and cross-case synthesis.

Results

<u>Leadership is the most important integration project success factor</u>

Study participants discussed state PHIS database integration projects and the factors that contributed to the projects' success. Supporting documentation substantiated participants' claims. Participants seem to discuss the technological aspects of the project most frequently, with 9019 (18%) of all coded words associated with the technology. The second-most frequently discussed topic was any cross-cutting projects underway at the agency (11%). Informatician leadership (11%) and Project Management (10%) were the third and fourth most frequently discussed PHIS database integration project topics.

Even though participants discussed technology most frequently, the participants report leadership aspects as the single-most important factors impacting integration project success. Table 2 plots all participants' mentions of the most important integration project success factors. The mentions are grouped by Domain and a variable called project scope: small-scale or large-scale projects. This table illustrated the prominence of the Organizational Domain relative to the other Domains, with Leadership aspects contributing the largest proportion of mentions by far

(27 of 47 total mentions). The mentions seemed evenly distributed between the project scope assignment, except for the role of program director championship. For those participants involved in larger-scale projects, there were six mentions of the role of program directors compared to just one such mention by participants involved in smaller-scale projects. Four Project Management mentions and four Financial Support and Management mentions constitute the next most-frequently reported primary contributors to project success.

Table 2 - Content-Analytic Summary Table: Interviewee Mentions of Most Important Integration Project Success Factors (grouped by domain and project scope)

	Greatest Contribution - any mentions for most important factor	
DOMAIN	**Large-scale project**	**Small-scale project**
Organizational Domain [30] Leadership [27]	Informatician Leader (2) Receptive executive sponsors (3) **Program director champions (6)** Senior leadership vision Team dynamics (2)	Informatician Leader (3) Receptive executive sponsors (3) **Program director champions** Senior leadership vision Team dynamics Overcoming turf Changing culture Effective champions (2)
Organizational and Technical Strategy [3]	Strategic Plan	Strategic Plan Organizational realignment
Project-oriented Domain [10] Project Governance [0]		
Project Management [4]	Shift to Agile (2)	Setting clear project scope Delivering value
Technical Support and Coordination [2]	Business analysis	Business analysis
Financial Support and Management [4]	Long-term stable funding	Long-term stable funding (2) Multiple funding sources
Evaluation [0]		
External Domain [3] Stakeholder Involvement [2]	Stakeholder participation	Stakeholder participation
Policy Support [1]		Data suppression issues
Technical Domain [4] Source Systems [1]		High quality source data
Development Technology [3]	Effective standards (2)	Data warehouse expertise
TOTALS [47]	**22 mentions**	**25 mentions**

Given the prominence of the leadership dimension, another matrix (Table 3) was then created to understand this further. Organized by case, Table 3 excludes those participants who did not substantively contribute to the leadership factor discussion, and lists the remaining participants' report of the most important factors along with the participant's report of the role of leadership in general; the role of the informatician; and his or her stance on the contributions of the executive-level or program-level leadership. The reported role of leadership in general and that of the informatician specifically appears to be similar across the participants. Participants describe how leaders obtain buy-in from stakeholders and provide vision and support. They also describe how informaticians serve as business analysts, collecting system requirements aided through their prior program-specific experience. Informaticians also serve as project champions, promoting the initiative to stakeholders while fostering teamwork among project participants.

While the roles of leadership in general and informaticians appear uniform, this matrix illustrated some interesting patterns regarding the participants' reports of the contributions of executive- versus program-level leadership in impacting the project's success. Some cases included mixed responses among case participants as to the relatively more important role of the executive leader compared to that of program directors (State E and State C), whereas other cases appeared to uniformly report either executive or program director contributions as being primarily responsible for the project's success. This appears to suggest that while opinions about specific leadership contributions to the project's success may vary, in some instances participants fully agree that either executive leaders or program directors contribute most substantively to project success.

Table 3 - Conceptually-clustered Matrix - Examining the Leadership Factor

		Most important factors	Role of Leadership	Role of Informatician	Executive vs. Program Director Leadership
State B	Part.4	Financial Support; Organizational Strategy; Tech Support & Coordination	DK1	Business analysts collect system requirements, a critical function	**Executive:** "But right now we have a very receptive executive level and we are making great progress."
	Part.8	Leadership, executive; Financial Support	Executive champions secure funding and provide support; reduce silos and turf	DK1	**Executive:** "That really has pushed this along because [the Director] really has an interest in it."
	Part.9+	Leadership, executive; Financial Support	Executive support and persistent enthusiasm	DK1	**Executive:** "We've been lucky at [our agency] that our upper leadership are very supportive of data."
	Part.6	Financial Support; Tech Support & Coordination	Insightful and supportive executive sponsors	DK1	**Executive:** "We have a really good director…we have pretty good, solid sponsorship."
State E	Part.18	Leadership, program; Financial Support	Program managers obtain executive buy-in while engaging stakeholders	Provide conviction and vision. Work well together, and with partners propel the project and get buy-in.	**Program:** "I think it was kind of a mixture. It definitely--in terms of leadership--definitely [was our program director]."
	Part.17	Project Management; Leadership, program	Longevity among program leaders and capable project manager	DK1	**Program:** "But it definitely helped to have [our program director] come on and stick."
	Part.16+	Leadership, executive; Informatician Leader	Executive vision, practical support, and cultural change	Establish informatics capacity and develop business cases	**Executive:** "[Executive leaders] saw the value, and they were able to help us move forward."
State C	Part.13	Technology; Leadership, program	Program managers provide the use case and buy-in	DK1	**Program:** "Program directors."
	Part.10+	Financial Support; Informatics leader; Leadership, executive	Executive interest and ongoing resolve	Serve as the overall project champion	**Executive:** obtained secretary approval early on with sustained engagement
State F	Part.22	Leadership, program; Informatician Leader; Technology; Tech Support & Coordination	Foster relationships between tech lead and informatician and among team members	Ensure teamwork and communication while pursuing project vision	**Program:** informatician fostered functional relationships
	Part.19+	Leadership, program; Informatician leader	Longevity, persistence, vision, and fearless support	DK1	**Program:** quickly obtained Program Director support for the initiative
State G	Part.24	Leadership, program; Informatician leader	Program director and informatician provide expertise, support, and collaborative environment	Utilize prior epidemiological experience to pursue use case and tech vision	**Program:** "We have the same medical director, and we work on a lot of projects together."
	Part.23+	Leadership, program	Ongoing commitment	Persistence and relationship development	**Program:** share a common medical director between both programs, "...so it's a pretty easy sell."
State A	Part.1+	Organizational Strategy; Informatician Leader; Policy Development	Project ownership and executive vision	Possess enterprise view for technology	**Executive:** "So I would say at the executive level though, our chief of staff...was very supportive of it."
State D	Part.14+	Financial Support; Leadership, executive and program	Executives directly involved initially, with program managers leading implementation	Build informatics capacity through assessments, etc.	**Program,** although acknowledgement of critical **executive** support in the initial project phases

+Informatics Director
This matrix includes key participants, excluding those with little input on the leadership factor
DK1 = Question Not Asked of Participant

Table 4 contrasts summaries of eight identified leadership contributions that promote project success as reported by participants and evaluated by the researcher, and it explains how various leadership actions impacted the success of the database integration projects. Common examples include strategic alignment of agency resources and meaningful project sponsorship by senior executives; long-term substantive involvement by program directors; and project team/relationship development by skilled informaticians. Each case possesses varying degrees of these leadership contributions in their respective integration projects. No case included each leadership contribution, but some combination thereof seems to facilitate project success.

Table 4 – Case Dynamics Matrix – Leadership Dimension

Leadership Contribution	Activity	Primary effect	Summary of Value
Executive sponsorship	Practical senior-level interest and support	Tangible informatics capacity development	**Informatics-savvy senior leadership pays dividends.** *"Of course I've had great support from the secretary's office and the administrator [of the Division of Public Health]. Right from the start when I told them that this was a good thing to do and I thought that, they have just been 100% supportive of all we tried to do, and without that it's difficult to get anything done."*
Executive vision	Strategically positioning information management	Realignment of agency goals with data at the center	**Recognition of the strategic nature of data and committing resources to develop its value.** *"...and our current director has been here for three years, and he is very interested in data, so he has been a wonderful champion."*
Project championship	Substantial personal effort among influential project members	Devoted commitment to project success	**Considerable personal investment among the right people can help ensure project success.** *"It's something that everybody wanted, and people were willing to kind of make sacrifices to make it happen."*
Program director engagement	Develop use case and collaborative environment	Motivation and momentum	**Visionary program directors identify pain points and harness technology to overcome them.** *"A director needs to have a vision for informatics--that really helps. If they're afraid of technology, systems don't get built. The program directors need to have vision. If they're afraid you never see these systems get built, and the information doesn't go any further up the chain."*
Steadfast commitment	Ongoing project support	Persistent and durable project activities	**The projects take years to complete, requiring long-term resolve.** *"The other piece is the staff that work on [the integrated database]--they've been with us a long time. Our IT guys have been there 20 years, we have trainers who have been with us for over 15 years, and it's because they believe in what they're doing, and they love informatics. It's challenging and changing. I'm amazed how long people have stayed with this project."*
Relationship development	Engage project stakeholders	Buy-in, vested interest	**Foster collaboration with stakeholders, senior leadership, and project team members.** *"Their conviction and vision of what the system needed to be, and how the system needed to work. Their ability to really work together and with other partners to make it the best system that it could be. Their ability to sell the system to others and get buy-in from others."*
Fostering teamwork	Develop cohesive team	High-performing teammate interaction	**Effective team dynamics among sometimes divergent members.** *"The team dynamics achieve the outcomes."* *"I hope it doesn't sound too hokey but it's relationships."* *"It's important to have the right team combination and the right vision. Sometimes that's hard to do. You just need one bad egg to stop your progress. If you can weed that out before you take it to get buy-in you're much better off. All the projects I've worked on really come down to personality."*
Applying expertise	Domain experts contribute critical knowledge	Information gaps are reduced	**Prior experience and expertise of informaticians leads to shared understanding and unifying of team goals.** *"The way we work together was a success. [Our informaticist] also. She has great knowledge of both the [IIS] and [NEDSS] systems and she comes at it from an epi perspective and works on the project by programming also."*

Consistent findings across each case

The case summary table (Table 5) lists each case and a summary of the case for cross-case comparison. Many commonalities emerge. Funding is mentioned as a critical catalyst for these initiatives, although not necessarily as the single most important factor that contributes to project success. Leadership at multiple levels of the organization facilitate project success through many ways, whether through providing project vision and support, developing the business case, ensuring teams function well, or removing obstacles. Each case highlighted these

Table 5 – Case Summary Table

State	Summary
State A	Informatician plays a critical role, and the engagement of the team members (team dynamics) including subject matter experts, ensures success. Technology, especially the quality of the source data and systems, plays a central role. Strategic planning and policy development supports the effort.
State B	Executive leadership champions and dedicated funding contribute the most to the project success. Informatician leadership and sound business requirement collection supports these efforts. The strategic planning that included information management principles seems to have had a lasting positive effect.
State C	Leadership among the program staff and the informatician makes a big difference; team dynamics are important. Technological protocols and standards facilitate integration of other programs' databases. Executive support and interest bolsters project activities. Funding once again is critical.
State D	Executive leadership commitment from the beginning plays a critical role, with strong program and bureau leaders required to push the initiative to successful resolution. Federal funding was essential.
State E	Program and executive-level leadership plays a critical role. A change in approach to project management from waterfall to agile made a big difference. Informatics staff lead these initiatives. Timing and a shift toward a more business-like model (strategic planning and leadership) make a difference. Funding was crucial.
State F	Program-level leadership and informatics staff as leaders are crucial to project success. This translates to healthy relationships and team dynamics. Information Technology team member continuity makes a difference.
State G	Team dynamics and relationships are the most important factors impacting project success. Program directors and informaticians make sure the project succeeds.

leadership contributions, further defining the prominent role of leadership in successful project resolution. Other factors such as the quality of the data and sound project management support successful project resolution.

Discussion

This study has four principal limitations. The cases recruited for the study are a purposeful sample of exemplary instances and they represent a narrow subsection of all state public health departments. The study results should not be interpreted as a representative sample that applies to all state health departments. Secondly, the data collected are restricted to what was reported by participants and discovered through document review; responses may have been affected by participants' subjectivity. Ideally, the data could have been triangulated with onsite visits and additional observations to corroborate findings. Moreover, a single researcher performed the data collection, coding, and analysis. Further triangulation with another researcher(s) could confirm findings. Finally, the size and scope of the state health departments' projects were not explicitly defined at the outset of the study. During the course of research, size of projects was considered and categorized to evaluate impact on other variables; conclusions based upon project size should be carefully interpreted.

Despite these limitations, the study's findings provide useful insight into factors associated with PHIS database integration project success. As leaders further their informatics understanding, they may effectively translate growing public health data into meaningful information.[27] State health department leaders can apply these findings to their own PHIS database integration projects and potentially improve the likelihood of project success by adopting lessons learned from other organizations' projects and invest in leadership capacity among project participants.

Leadership, an Organizational Domain factor, is the most important PHIS database integration success factor. Leadership is a complex dimension that for this study can be partitioned into the roles played by executives, program directors, and informaticians. Executive leaders champion the project vision, program directors invest substantial energy in the initiative, and informaticians foster relationships and improve project goal development and communication. Collectively they develop the business case for the initiative.[28]

Many participants reported the role of team dynamics or relationship development as a primary contributor to project success. A sample quote helps illustrate this distinction:

> *"Our two programs work really well together. We have the same medical director, and we work on a lot of projects together. Teamwork makes it a success."*

The aspects of team dynamics or relationship development are not explicitly described as one of the nine non-technical integration project success factors from the HRSA Sourcebook, but these functions seem to support project progress. These aspects might relate to the involvement of leaders and their contributions, in how leaders foster cohesive teamwork and regularly engage with stakeholders to build project support and buy-in. These findings warrant further study.

Project Governance and Evaluation never surfaced as most important. Participants only cited the following factors as most important once or twice: Policy Support, Stakeholder Involvement, and Technical Support and Coordination. While these factors were not explicitly described by participants as the most important project success factors, they likely should not be overlooked when conducting these projects.

Improving data quality for public health use will remain an important public health informatics goal, perhaps indefinitely. Since leadership appears to play such a central role to the success of these initiatives, it is recommended that senior executives, program directors, and informatics staff receive informatics and leadership training to facilitate informatics project management and possibly improve the likelihood of project success. The PHII Informatics Academy is an example of one such source of training.[29] Similarly, the Informatics Training in Place (I-TIPP) program is designed to expand internal health department informatics capacity, and programs like I-TIPP might improve the informatics savviness of in-house local and state health department staff.[30]

Project Management training might also promote the success of these initiatives. Agile methodology is emerging as a nimble approach to software development.[31] Many of this study's participants stated that their projects' day-to-day activities were managed utilizing the Agile approach. Agile methodology training is readily available, and an affordable alternative given the relative cost of project failure. Health departments could invest in the project management skills for staff involved in these projects, and evaluate whether the Agile methodology is worth pursuing.

Since financial support and management was also identified as an important project success facilitator, health departments should establish a concerted national plan to fund sustainable projects that address enterprise-wide information management needs across the health department. The HRSA-funded State Systems Development Initiative grants are an example of a successful long-term funding mechanism designed to improve intra-state CHIS database integration. Similar grant programs should be explored for related projects.

Implications for Policy & Practice

A common assumption is that to succeed in technology-oriented public health projects requires developing substantial technological expertise and surmounting formidable privacy barriers. Additionally, much attention has been given to the role executive leaders play in ensuring a project's success. While this study confirms their importance, it also illustrates the lesser known but substantive contributions of the informatician and program director. Importantly, this study shows that leadership qualities take precedence over other aspects such as technology and privacy requirements.

Opportunities to integrate PHIS databases persist. State health department staff interested in pursuing PHIS database integration projects must evaluate the agency's executive leadership support and project championship by program directors and informatics staff. Future advancements in PHIS database integration projects and related informatics activities will rely on engaged leaders from across the agency to ensure timely access to and proper management of public health data.[32] Skilled and actively engaged leaders from across the organization help ensure success.

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Paper #2

Successful Public Health Information System Database Integration Projects: A Qualitative Study

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Abstract

Objective

To explore the most important public health information system database integration project success factors, whether technological, organizational, project-specific, or external in nature.

Materials and Methods

This study involved a cross-case design. Cases were identified through literal replication logic and screened through a survey and literature review. Study participants were interviewed through hour-long sessions with a semi-structured guide. Survey responses, interview transcripts and available documents were coded and analyzed deductively, with matrices developed to illustrate relationships.

Results

Leadership among the project's participants is the most important integration project success factor. Executive sponsors champion the initiative. Informaticians facilitate communication and system requirement collection. Program directors contribute substantive energy to the project and remove obstacles. Other factors substantially contribute to project success. Strong Financial Management and Support promotes project initiation. Technological aspects impact the functionality of the final product. Utilizing formal project management techniques, particularly the Agile software development methodology, contributes to successful project resolution by ensuring daily operational effectiveness.

Discussion

The principal finding illustrates project leadership transcending the role of the executive sponsor. Other participants, notably informaticians and program directors, substantially contribute to the

project's success. Additionally, the Agile software development methodology is emerging as a successful approach to project management for these and related projects.

Conclusion

Investing in the leadership and project management skills of database integration project participants could improve the success of future projects. State health department staff considering these projects should carefully select project participants and train them accordingly.

BACKGROUND AND SIGNIFICANCE

Public Health Information Systems (PHIS) are foundational components of public health infrastructure, providing how health departments collect and maintain data for public health practice.[1] These data support population health services such as controlling outbreaks or designing health promotion programs targeting teen smokers. State governments often establish PHIS through the state health department, and the system functionality primarily serves state and local health department data needs.[2]

The use of information technology to develop databases is a critical aspect of PHIS. These databases store public health data, and advances in information technology have improved the ability to develop databases that suit specific program requirements.[3] Specialized state public health databases have propagated because of this technical development ease and because of categorical funding incentives. Computing advancements have also readily allowed for the integration of siloed databases.[4]

Database integration often entails the development of a common database for the organization that consolidates operational data from multiple sources.[5] When individual databases are integrated, they collectively create more complete records by piecing together different data elements from different sources.[6] Access to complete records can improve coordination of public health activities and reduce costs.[7] The Joint Council of Governmental Public Health Agencies suggested that 1) health departments must integrate databases, and 2) these integrated databases must meet information needs at the service delivery level.[8]

Previous child health information system (CHIS) database integration activities illustrate the development of a PHIS database integration business case, actions required to successfully execute the project, and prior evaluation efforts.[9] A large measles outbreak in the late 1980s prompted public health and healthcare leaders to evaluate data collection and usage techniques, which led to the initiation of CHIS database integration efforts. A workgroup identified programs such as immunizations and vital registration as a suitable starting point for the integration projects.[10] Evaluation activities included documenting and studying the critical success factors for these integration projects. Findings from CHIS integration studies inform research in related areas.[11]

Customized program-specific databases have proliferated but they are often not integrated other databases throughout the health department. Many public health program managers have established databases without considering broader database integration. These databases meet the individual program's data needs, but do not address enterprise information management needs across the organization.[12] Siloed public health databases result in inefficiencies, such as poor disease control and outbreak response coordination; incomplete service delivery at the local level; and underperforming population health protection measures during public health emergencies.[13] While leaders integrated and evaluated some CHIS databases, few other successful PHIS database integration initiatives have been studied. It is not known which PHIS database integration project factors are most important and how they impact successful public health database integration projects.

OBJECTIVE

This study explored factors that most contribute to successful intra-state public health information system database integration projects. Organizational factors, such as meaningfully engaged executive leadership and strategic plans, impact the agency's readiness and commitment to the initiative. Project-specific factors, such as effective governance and formal project management techniques, impact the day-to-day administration of the initiative. Other factors outside the agency's direct control, such as data privacy laws or the actions of external stakeholders, can also influence the project's success. And technological factors, such as the quality and structured of the data from the source data systems, impact record linkage feasibility in the integrated database. The Health Resources & Services Administration's *Sourcebook* lists the nine non- technical integration project elements (factors).[14] Table 1 includes this list in addition to the technical factors. All factors have been grouped into logical Domains for this study based upon prior research.[15,16,17,18,19,20,21,22]

Table 1. Integration Project Success Factors, Grouped
ORGANIZATIONAL DOMAIN **Leadership** The project has an executive sponsor, a high level official who advocates for the project, and a champion, someone who is willing to devote a significant effort to see the project succeed. **Organizational and Technical Strategy** The project has a strategy that takes into consideration local issues such as funding, the political environment, organizational structure, the strengths of the organization, and stakeholder beliefs and values. The selected technical integration approach accounts for internal data governance and data sharing needs, which must conform to state and federal laws and agreements made with stakeholders.
PROJECT ORIENTED DOMAIN **Project Governance** The project is guided by a steering committee representing all key stakeholders. The steering committee develops the integration strategy, based on clearly defined business processes. **Project Management** The project has formalized management strategies and project management methodologies designed to assure consistent communications, accountability, and resource constraints. **Technical Support and Coordination** Technical information systems support and coordination is organized centrally to assure consistent support and a robust infrastructure capable of maintaining and complying with standards. A business analyst supports implementation. **Financial Support and Management** The project is adequately funded and has multiple funding sources. **Evaluation** The project has some form of qualitative and/or quantitative monitoring or evaluation that is performed regularly.
EXTERNAL DOMAIN **Stakeholder Involvement** Frequent communication with stakeholders and involvement of stakeholders in the integration project throughout the life cycle of the project contributes to its success and credibility. **Policy Support**

Rules, regulations, legislation, and policy advisory or policymaking bodies are supportive or at least neutral to the integration of health information systems. Executive sponsors educate policymakers about sensitive issues to garner their support.
TECHNICAL DOMAIN **Source Systems** Databases contain quality program-specific data to be contributed to the database integration project. **Development Technology** Project managers select a particular technology to be utilized for the integration project including architecture, hardware, database software, data integration engines, user interface, etc.

This manuscript will also describe how Agile software development facilitated the daily project management for many of the PHIS database integration initiatives illustrated in this study. The use of the Agile software development methodology in public health practice is poorly understood. Agile software development, or simply "Agile", is emerging as a popular software development project management alternative to more traditional approaches such as the widely-used waterfall methodology. The Waterfall model entails a prescriptive stage-oriented software development process characterized by exhaustive initial requirement collection and design phases.[23] Agile is considered a "lightweight" method for developing software, with principles that focus on intensive collaboration and rapid software iteration versus extensive up-front system requirement documentation and highly-regimented planning.[24]

Many technology companies utilize Agile to rapidly iterate software products and gain a competitive advantage. Organizations have utilized Agile to create software for healthcare applications,[25] and others have modified aspects of the organizational culture by adopting Agile practices for managing other types of projects.[26] Researchers have studied their experiences in utilizing Agile to create and maintain biomedical software, and found the Agile approach to be a good fit for these projects.[27] Following the failed rollout of HealthCare.gov, some departments of the United States federal government immersed themselves in Agile methodology with some success.[28] Implementing the Agile methodology does not come without its risks for failure, but its success factors have been studied.[29] The role of Agile in the PHIS database integration projects identified in this study will be illustrated further.

MATERIALS AND METHODS

A cross-case study design was used for this research. The state health department is the unit of observation, and the database integration projects are the unit of study.

Case Selection

The researcher identified cases through literal replication logic, seeking successful state health department intra-state public health information system database integration projects.[30] A three-phase screening procedure was utilized, entailing deploying a survey; reviewing literature of documented, successful PHIS database integration projects; and reputational case selection. The survey targeted state health department informatics staff as members of the Association of State and Territorial Health Officials (ASTHO) Informatics Directors Peer Network (IDPN). The survey was administered to IDPN members, and the first phase of screening reduced the candidate list to cases that most closely fit the literal replication design. Seven participants responded to the survey, and three met the criteria for additional follow-up.

Next, the researcher identified and screened cases based on criteria specified through a literature review of frequently documented, successfully completed PHIS database integration projects. Peer reviewed literature, books, and federal agencies have documented these projects, and this literature illustrates best practices and exemplars. In particular, CHIS database integration research and studies evaluating the Environmental Public Health Tracking activities provide substantive insight into successful PHIS database integration initiatives.[31] The researcher contacted representatives from state health departments presented in these research bodies for inclusion as participants in this study. Three cases were selected through this literature review process. Finally, one case was identified through reputational case selection referral by the Public Health Informatics Institute. Through these processes, the researcher retained seven cases that best fit the literal replication design of successful PHIS database integration projects. The study protocol was reviewed and approved by the University of Illinois – Chicago Institutional Review Board.

Survey and interview questions

The researcher adapted questions from a previous CHIS database integration study.[32] The survey questionnaire addressed case demographics and questions that pertain to the technical and project planning domains. The interview guide was piloted with four informaticians from state health departments, and the final version was organized into the Domain groupings from Table 1. The interview guide asked participants about the agency's informatics projects and the impact of each Domain's factors on the integration project's success.

Procedure

The researcher conducted and recorded approximately one-hour semi-structured interviews with state health department informatics directors along with referral follow-up interviews of program directors, bureau chiefs, system administrators, and technical staff. The researcher interviewed twenty-five participants through nineteen interviews (some interviews included two participants) from April to September of 2016. The survey responses were then paired with associated interview transcripts. Finally, the researcher obtained from participants and websites copies of pertinent project documentation for review: strategic information technology plans and operational plans for the database integration projects; agency budgets; project meeting minutes; project charters; progress reports; policy documents; and protocols.

Analyses

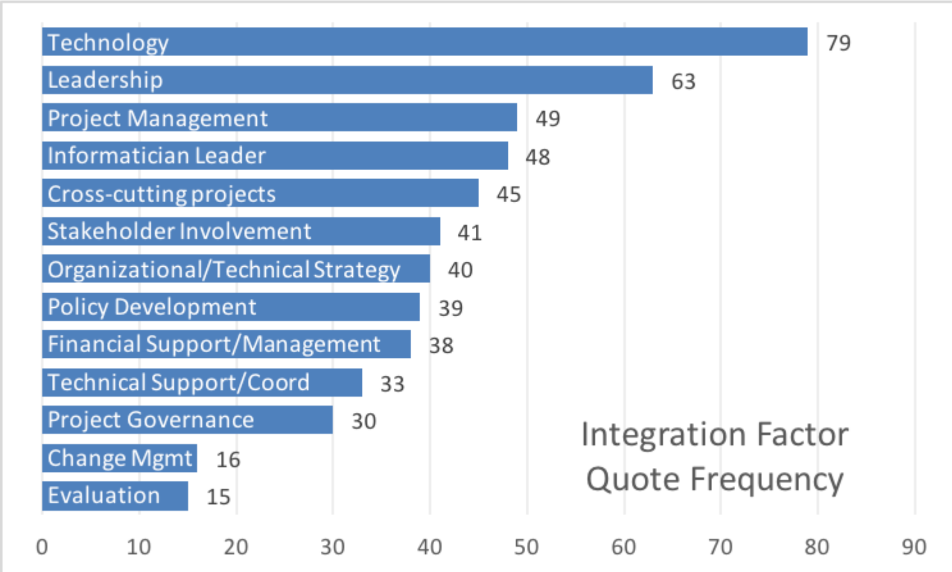
The analysis included within-case analysis followed by cross-case analysis. The within-case analysis entailed comparing and summarizing survey and interview responses, then contrasting these summaries with the document content analyses. Once this was performed for each case, the cases were compared.

Data were analyzed using a priori theory-based codes with deductive coding: assigning labels to data to summarize the basic topic of a qualitative data passage. The coding began with an initial list of codes based upon pre-existing theory, largely from the CHIS database integration studies.[33] Additional codes emerged inductively. All data analyses were performed using ATLAS.ti to code and compare thematic survey responses, interview transcripts and the document contents.[34] A common codebook was established serving as the base for all analyses. Data display matrices were created to illustrate systemic relationships and the within-case and cross-case synthesis.

RESULTS

Study participants discussed state PHIS database integration projects and the factors that contributed to the projects' success. Supporting documentation substantiated participants' claims. Chart 1 illustrates quote frequencies from the survey responses, interview transcripts, and codes from the document review, and it provides a basis for drawing initial conclusions. These counts principally illustrate how much the participants spoke about any of the integration project factors, as specified through the coding process. The technological aspects of the integration projects are discussed most frequently, followed by leadership aspects or cross-cutting departmental projects more generally.

Chart 1 – Integration Factor Quote Frequency



Leadership emerges as the most important factor

After obtaining information about how the factors contribute to the project's success, participants were asked which factors were the most important and why. These factors are illustrated in Table 2, which organizes each interview grouped by case, with columns illustrating the most important project integration factors as reported by the interview participants and an overall conclusion from the researcher's perspective. Leadership aspects of the projects predominate in importance. In particular, participants highlighted the leadership roles of executive sponsors, program directors, and informaticians. Financial Support and Management; Project Management; and the project's Technology are three other factors that regularly surfaced as important project success factors.

Table 2. Reported most important project success factor and explanation		
Participant by State	**Most important reported factor(s)**	**Researcher's explanation**
State B Participant 4	-Financial Support -Organizational Strategy -Technical Support & Coordination	Organizational alignment and accreditation set the stage. Executive staff serve as project champions. Informatics business analysts make a difference. Demonstrating value secures flexible funding.
Participant 5	-Financial Support -Informatics Leader	Dedicated funding is crucial. Informaticists bridge communication gaps.
Participants 6 & 7	-Financial Support -Technical Support & Coordination	Project completely stalled when the funding temporarily vanished. Well-defined system requirements propel the project.
Participant 8	-Leadership, executive* -Financial Support	Executive champions play a critical role. Funding is crucial, and can be frustrating.
Participant 9	-Leadership, executive* -Financial Support	Executive champions and project funding are crucial.
State F Participants 19 & 20	-Leadership, program* -Informatician leader	Team dynamics and personalities make or break the project. Program-level leadership, not executive support, makes the most difference.
Participants 21 & 22	-Leadership, program* -Informatician Leader -Technology -Technical Support & Coordination	Interaction between the tech team and business analyst/informatician is critical. Division-level (not executive) leadership facilitates success. A competent and capable information technology team is key.
State A Participant 1	-Organizational Strategy -Informatician Leader -Policy Development	Organizational changes linked to strategic planning can have a big impact. Informatician leaders have an enterprise approach. Effective policy facilitates technical decisions.
Participants 2 & 3	-Technology -Project Management	Source data matters. Dedicate a tech person to the project. Strong project management includes subject matter experts.
State E Participant 16	-Leadership, executive* -Informatician Leader	Engaged executive leadership provide vision and support, and can facilitate practical changes, such as the shift to Agile project management. Informatics staff lead the projects.
Participant 17	-Project Management -Leadership, program*	Moving to Agile from Waterfall profoundly impacted the project's success and augmented team synergy. Program directors provide substantive leadership.
Participant 18	-Leadership, program* -Financial Support	Sustained program director leadership was crucial. Agency timing was right--the will emerged. Federal grants were critical.
State G Participant 23	-Leadership, program*	Relationships are important. Program director leadership remove obstacles and ensure team synergy.
Participant 24	-Leadership, program* -Informatician leader	Teamwork is most critical. The involved programs have the same program director and they frequently collaborate. Lead informatician is instrumental in making it a success.
State D Participants 14 & 15	-Financial Support -Leadership, executive and program*	Federal funding has been critical. The first phase of the projects directly involves senior leadership, whereas latter phases require program leaders to step up.
State C Participant 10	-Financial Support -Informatics leader -Leadership, executive*	Federal funding for a related initiative was leveraged for this project. Informatician and IT tenacity are critical. Senior-level support and interest are required.
Participant 11	-Informatics leader	Team dynamics achieve the outcomes. Informatics capacity must be carefully maintained or it can erode.
Participants 12 & 13	-Technology -Leadership, program*	Standards makes much of the work possible. Program directors facilitate project success. Funding plays an important prioritization role. Data sharing agreements are necessary.

*Illustrates the distinction between executive-level and program-level leadership.

Further exploration into the leadership dimension illustrated important nuances. Participants agreed upon the contributions of the informatics staff involved in the initiatives.

Informaticians seemed to facilitate the collection of system requirements, translated and communicated needs across project participants and to project sponsors, and developed collaborative team dynamics. However, the contributions of executive leadership and that of program directors were less universally-acknowledged. Some participants attributed project success to the involvement of meaningfully-engaged executive sponsors, whereas others suggested success was due to the regular involvement of program directors directly impacted by the project.

Agile emerges as a promising project management technique

Project management was indicated by many participants as an important success factor for these initiatives. Table 3 illustrates the project management technique used for each case's project and a summary of the technique's impact on the project's success. All but one case referenced Agile project management in some way, and the participants appeared to express favorable opinions about the role the Agile project management methodology played in the project's success.

The participants described that by utilizing Agile, the program staff, informatics personnel, technological developers, and others involved in the project closely collaborated in the development of the integrated database, producing a better product and overall experience than that through traditional software development techniques. One case's participants in particular, State E, stated that the shift to Agile from the Waterfall methodology introduced a profound cultural shift within the agency that transcended PHIS database integration and general information technology project management. Other areas of the agency began applying Agile methodology to other projects based upon the success identified in its use with the PHIS database integration projects. Participant 16 described this profound shift:

> *"Since that time we don't do anything but Agile. What's really cool is some of our business side—our service areas—want to start using Agile with their staff, because it*

holds people accountable. You have to stand up and say 'This is what I did yesterday, and this is what I'm going to do today.' Everybody gets to hear it; everybody has to be accountable. It builds that team that you just don't always see with things like that. It was a profound difference, I'll tell ya."

Table 3. Project management techniques by case

Case	Project Management Methodology	Project Management impact on project's success
State A	Agile with SCRUM specifically	SCRUM techniques facilitate project management. Agency recently moved to Agile model. *"In terms of the meetings and stuff go, we are using the SCRUM process here, an Agile SCRUM process for development, which was also a big change. We used to use Waterfall… But it's proven that it's working pretty well, since we switched a couple of years ago."*
State B	None, although vendor possibly utilized Agile	Minimal impact from participants' perspective. *"I think they used the Agile method with short sprints."*
State C	Agile	Agile methodology referenced by one participant but not by others. *"We do Agile development. So pretty standardized as far as project management, planning and the reporting is concerned."*
State D	Agile	Regular, sustained activities move the project forward. *"[The NEDSS] uses the agile development approach. All the local users' representatives really committed a lot of time to do it."*
State E	Agile	Moved to Agile from Waterfall methodology and this change has had a substantive impact, including leading other areas of the agency to adopt the methodology. *"We also have moved from a Waterfall method for project management to an Agile methodology. It has made all of the difference in the world; I cannot tell you what a difference it has made. It's been incredible."* *"I think that if we hadn't had Agile, we still wouldn't have a system up. We would have trashed the build and still wouldn't have something."*
State F	Waterfall for most projects but Agile for one	Consider Agile to be the better method but not used consistently across the organization. *"And Agile to me was superior and definitely what we should implement here."*
State G	None	Minimal impact from participants' perspective.

This shift to Agile methodology had substantively changed the project management experience for some of the study's participants. Participant 17 from State E suggested that the utilization of the Agile methodology was the most important success factor for the project:

"I definitely think it's the Agile process in and of itself. It helped the project move forward. Even when we had a roadblock it's not like everything just stopped…It created this wonderful team atmosphere where everybody knows we're working for this same end goal."

"Switching to Agile made a huge difference, and I would recommend it for any process." "So it's a very interactive, engaged process. It's incredible, I'll tell ya. I've been amazed at the differences—-the speed at which a project gets done. All of that front-end time is lost."

Agile clearly changed the way the health department conducted business, and positively impacted many of the integration projects described in this study.

Consistency across cases

The case summary table (Table 4) illustrates cross-case comparisons and distinct features of each. The participants' remarks from each case seem to consistently reflect across the spectrum

Table 4. Case Summary Table

State	Summary
State A	Strategic planning and policy development set the project context. The Informatician plays a critical role by fully engaging team members. The quality of the source data impacts development progress.
State B	Executive leaders align resources and seed funding. Informaticians collect thorough business requirements. Prior strategic planning that addressed information management principles seems to have had a lasting positive effect.
State C	Leadership by the program staff and informatician ensure functional team dynamics. Technological standards facilitate other programs' integration efforts. Executive support and interest bolster project activities. Funding is critical.
State D	Executive leadership set the project vision and initial activities, and strong program and bureau leaders are required for project sustainment. Funding is essential.
State E	Program and executive-level leadership both impact the project. An agency-wide shift to Agile project management changed the organizational culture and facilitated success. Informatics staff lead these initiatives. Funding was crucial.
State F	Program-level leadership and informatics leaders promote healthy relationships and team dynamics. Information Technology team member permanence ensures continuity.
State G	Program directors and informaticians ensure success by fostering functional team dynamics and relationships.

of cases. Funding is cited as a project catalyst, and Leadership involvement across multiple levels of the organization ensures project success in various ways. Technological factors such as the quality and structure of source data, ensuring standards are employed, and maintaining data warehousing expertise impact the development of the integrated database. Effective project management facilitates project success, and Agile is regularly referenced as a useful method.

However, important differences surface when participants describe the contributions of the executive leaders compared with those of program directors. As alluded to in Table 2, some cases evenly highlight the contributions of both groups, whereas other cases are characterized by substantive involvement of either executive leaders or program directors, but not both.

DISCUSSION AND CONCLUSION

Principal Findings

The study's principal findings illustrate the complex depth in PHIS database integration project leadership beyond the role of the executive. Much is known about how executive leader sponsorship and support foster project success. This study suggests that other project participants, notably informaticians and program directors, substantially contribute to the project's success. While executive involvement might be critical for initiating the project, program directors ensure project staff remain engaged, and informaticians provide a crucial role in facilitating project conversations across diverse participants.

Additionally, the Agile software development methodology is emerging as a successful approach to project management for these and related projects. Some participants claim adopting this approach introduced a dramatic shift in how the integration projects progressed, and one suggested this was the main reason that site's project succeeded. Agile improves project accountability and team member involvement and interaction, while speeding the deployment of useful software.

Implications

This study has three primary implications. First, developing the leadership skills of informaticians, program directors involved in PHIS database integration projects, and executive leadership may promote the success of these and related initiatives. Since these projects require informatics savviness, these individuals may benefit from informatics training more generally, and PHIS database integration training specifically. Secondly, project financing challenges are not new to public health departments, and this aspect seems to impact PHIS database integration project success, especially the launching of these initiatives. Federal programs have funded these efforts in the past, and future funding could facilitate their initiation. Finally, employing formal project management techniques might ensure the project runs smoothly. Investing in Agile methodology training and enabling its use could be an effective approach to ensuring the project is properly managed.

Limitations

This study has three principal limitations. First, cases purposefully recruited represent an exemplary and small subset of all state public health departments. Therefore, the study's results should not be interpreted as representative of all state health departments. Secondly, the data is based on survey responses, interviews, and a document review. Participant responses may be affected by subjectivity, and undiscovered documentation may suggest alternative conclusions. The data had not been triangulated with onsite visits and additional observations to corroborate findings. Thirdly, a single researcher performed the data collection, coding, and analysis. Inclusion of another researcher could confirm codes and findings. Despite these limitations, the study's findings provide useful insight into integration project success. More research in this area is needed to further understand this topic.

CONCLUSION

This study improves the understanding of the most important public health information system database integration projects. Public health data integration needs persist, and stakeholders may use these findings to improve the likelihood of future project success.

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V. CONCLUSION

To understand success factors associated with public health information system database integration projects, the researcher surveyed and interviewed participants from seven state health departments, and reviewed available supporting documentation. Study participants largely included public health informaticians, and they reported the importance of certain factors in bringing about successful resolution to these projects.

This study finds that the Organizational Domain factor, Leadership, in the form of executive support, program director commitment, and skilled informaticians, most contributes to the project success. Executive leaders sponsor the project, program directors champion the initiative, and informaticians foster relationships and improve project goal development and communication. The researcher has encountered two common misconceptions when discussing successful technology-oriented public health projects: they require developing substantial technological expertise and surmounting formidable privacy barriers. Additionally, much attention has been given to the role executive leaders play in ensuring a project's success. While this study confirms executive leaders' importance, it also illustrates the lesser known but substantive contributions of the informatician and program director. Importantly, this study shows that leadership qualities take precedence over other aspects such as technology and privacy requirements.

There may be a relationship between the scope/size of the integration project and whether executive or program-level leadership plays a greater role. While a relationship seems to exist, it is difficult to identify any causal factors that might explain the relationship. The conceptually-clustered matrix and content-analytic summary table illustrate these distinctions well, introducing some potential rival explanations. State B, for instance, universally featured reports of the role of executive leadership in supporting the integration project. This case's project is smaller in scope (integrating data from multiple sources to establish a business intelligence dashboard). The document review for this case supports the assertion that the agency has enjoyed long-standing executive support and a robust vision for the development of the agency's data. This could explain the universal conclusion by those informants of the relative importance of executive sponsorship. Conversely, State F is characterized with nationally-renowned informaticists and program directors. Their contributions overshadowed those of the agency's executives (although those contributions were highlighted as well). State F's project was larger in scope, and involved a close-knit team that worked on the initiative for many years. These dynamics should be explored through future research.

While participants overwhelmingly reported an Organizational Domain factor, leadership, as most important, other Domains' integration project factors were also recognized for their importance. Financial support and management is critical, especially for initiating and sustaining these projects, and sound project management ensures the projects operate smoothly. Participants noted the importance of organizational and technical strategies—also from the Organizational Domain. Lastly, they described the importance of using development technology standards. The following integration project factors rarely or never surfaced as most important: policy support, stakeholder involvement, project governance, technical support and coordination, and evaluation.

Limitations

This study has four principal limitations. First, cases purposefully recruited represent an exemplary and small subset of all state public health departments. Therefore, the study's results should not be interpreted as representative of all state health departments. Secondly, the project scope variable was not explicitly defined at the outset of the study. Since some effect of this variable appeared to impact relationships among variables, it felt natural to include this concept, although conclusions based upon this variable should be carefully interpreted. Thirdly, data collection solely included survey data, interview transcripts, and document review. Ideally, additional sources of data such as observations could have been collected to further triangulate the data set. Finally, a single researcher performed the data collection, coding, and analysis. Inclusion of another researcher could confirm codes and findings.

Future Areas of Study

Future exploration could examine whether the integration project factor Domain groupings are necessary or relevant. This grouping seemed important based upon the smaller pilot study (2014), but did not seem to substantively contribute to this study's design (although this was not explicitly analyzed for this study). It was initially designed as the construct of interest for that pilot, but for this study individual factors' importance was the target of consideration—the groupings assumed a diminished role.

Another avenue of future research would be to apply this study's methods to the relatively large cohort of state health department Environmental Public Health Tracking programs. The "Tracking" initiative includes a broad representation of health departments from across the country that have established data warehouses and business intelligence data visualization tools for the purposes of tracking environmental health hazards, exposures to those hazards, and health outcomes that result. These projects possess many of the characteristics of the projects of interest for this study (including the foundational use case and funding for one of the cases in this study), and could be explored to identify additional insights or replicate this study's findings.

Another area of future study should contrast successful and unsuccessful database integration projects. As described in the Design section of this report, this study utilized literal replication logic—solely comparing states with successful PHIS database integration projects. It did not contrast states with successful projects and states with failed projects—a process that would entail a theoretical replication logic design. Another study employing a theoretical replication logic—predicting contrasting results for anticipatable reasons—would have merit, and is a logical next step for this line of inquiry. Cases with successful database integration projects, such as those identified and examined in this study, should be contrasted with cases with failed integration projects. Such a study could validate this study's findings, and illustrate important difference between the two types of projects. Ideally, the study would be conducted prospectively, as retrospective analysis is more prone to bias, and a prospective study could potentially overcome case selection logistical issues, particularly for identifying "failed" projects to serve as contrasting cases to successful projects.

Lastly, many participants reported the role of "team dynamics" or "relationship" development as a primary contributor to project success. Team dynamics refer to the interactions among integration project team members, and relationship development refers to the engagement of relevant stakeholders. While these aspects are not directly discussed in the conceptual framework as one of the nine non-technical integration project success factors, these functions seem to have an important role in ensuring the projects progress forward. They were subsumed into the Leadership factor for this study, although they could possibly possess unique qualities that transcend leadership. These findings warrant further study.

Recommendations

Improving data quality for public health use will remain an important public health informatics goal perhaps indefinitely. The factors associated with PHIS database integration project success likely apply to related complex projects. Since leadership plays such a central role to the success of these initiatives, a recommendation would be to ensure executive-level, program director, and informatics staff receive informatics and leadership training to facilitate informatics project management and possibly improve the likelihood of successful project completion. The Informatics Training in Place Program (I-TIPP), established through a partnership between the National Association of County and City Health Officials (NACCHO), Centers for Disease Control and Prevention (CDC), and the Council for State and Territorial Health Officials (CSTE), is an example of a program designed to expand health department informatics capacity (86). The PHII Informatics Academy is another source of relevant informatics training (87). Programs like I-TIPP and courses through the PHII Informatics Academy may improve the informatics savviness of local and state health department staff.

Project Management training might also promote the success of these initiatives. The Agile software development methodology (Agile) is emerging as a nimble approach to software or application development. Agile training is readily available, and an affordable alternative given the relative cost of project failure. Health departments could invest in the project management skills for staff involved in these projects. Future study of these investments could provide insight into their benefits.

Since financial support and management was also referenced as an important project success facilitator, health departments should establish a concerted national plan to fund and address enterprise-wide information management needs. The Digital Bridge initiative is an example of a potential nation-wide technical platform facilitating public health data exchange (88), and the HRSA-funded State Systems Development Initiative grants are an example of a successful long-term funding mechanism.

Implications for Future Practice

This study has three primary implications. First, developing the leadership skills of informaticians, program directors involved in PHIS database integration projects, and executive leadership may promote the success of these and related initiatives. Since these projects require informatics savviness, these individuals may benefit from informatics training more generally, and PHIS database integration training specifically. Secondly, project financing challenges are not new to public health departments, and this aspect seems to impact PHIS database integration project success, especially the launching of these initiatives. Federal programs have funded these efforts in the past, and future funding could facilitate their initiation. Finally, employing formal project management techniques might ensure the project runs smoothly. Investing in Agile methodology training and enabling its use could be an effective approach to ensuring the project is properly managed.

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APPENDICES

Appendix A – Questionnaire (survey instrument)

Appendix B – Semi-structured interview guide

Appendix C – Interviewee Legend

Appendix D – Data Accounting Log

Appendix E – Codebook

Appendix F – Qualitative Analysis Documentation Form 1

Appendix G – Qualitative Analysis Documentation Form 2

Appendix H – Qualitative Analysis Documentation Form 3

Appendix I – Qualitative Analysis Documentation Form 4

Appendix J – Integration Factor Quote and Word Frequency Charts

Appendix K – Table: Case Participant Reports for Level-specific Leadership Contributions

Appendix L – Partially-ordered Meta Matrix

Appendix M – Explanatory Effects Matrix

Appendix N – Content-Analytic Summary Table

Appendix O – Role-ordered Matrix

Appendix P – Conceptually-clustered Matrix

Appendix Q – Variable-by-variable Matrix

Appendix R – Case Dynamics Matrix

Appendix S – Case Summary Table

Appendix T – Case Summary Memos, deidentified

Appendix U – Co-occurrence explorer table

Appendix V – Study Protocol

Appendix A – Questionnaire[1]

For the purposes of this study, the following definition is being used for database integration: *the development of a central repository that consolidates operational data from multiple sources.*

An Office of Information Technology is defined as an organizational office housed within the public health agency that is responsible for handling computing needs such as maintaining the network, storage space, application development, hardware and software needs. An Informatics Office is responsible for strategic information and computer science goal setting.

Demographic (5)

1. Name
2. Email
3. Are you the Chief Information Officer, Informatics Director, Program Manager, Other (Drop Down)
4. State (Drop down)
5. Agency (Drop down (ASTHO))

Public Health Informatics Structure and Workforce (9)

1. Is there a separate and distinct position of Informatics Officer with duties that differ of the CIO? Y/N
2. Does your state have an agency that has centralized the bulk of the information technology services for the state government? Y/N If yes, name the agency
3. How many professional IT staff are employed by your agency? NUM
4. What is your agency's yearly IT Budget and IT Spend? (NUM fields x 2)
5. * Does your agency have an IT Strategic Plan? Y/N If so, how far along in its implementation is your agency? (not started, 25%, 75%, completed)
6. Has the agency conducted an organizational readiness assessment with the purpose of gauging interest and commitment to informatics change? Y/N
7. * Does your agency have an IT Governance process (entails checks and balances and established procedures for launching initiatives e.g. IT Project Charter)? Y/N
8. Does your State IT Office host regular meetings? Y/N How regularly? (weekly, semi-monthly, monthly, quarterly, annually, OTHER) Do you or your designee regularly attend? (Y/N/NA/UNK)
9. Is there a quality improvement program in place that focuses on examining business processes and redesigning workflows? (Y/N)

DATABASE INTEGRATION (7)

1. * Does your DOH have an established centralized enterprise data warehouse? Y/N
A data warehouse is a central repository created by integrating data from multiple sources for the purposes of data reporting and visualization.
2. * Does your DOH utilize a Master Person Index to organize records originating from multiple databases?

It is recommended to reach out to the specific database points of contact for each of these databases in order to obtain proper responses.

3. Describe how easy it was to identify registry points of contact: (Easy/medium/difficult)
4. How many databases has your agency integrated? NUM
5. Which of the following databases have been integrated:

[1] Questionnaire is, by permission, based on that which was used by Bara et al. (2009)

a. Immunization registry
b. Newborn metabolic screening program
c. Newborn hearing program
d. Blood lead screening program
e. Vital records (e.g. birth certificates/records)
f. WIC program
g. Early intervention program
h. Other maternal and child health databases (please specify)
i. Other databases beside those related to maternal and child health (please specify)
j. N/A - No integration activities are underway or planned within the next three years (skip out of survey; go to thank you page)

6. Are each of the three databases listed on the left integrated either internally as specified or among other databases (externally) as specified?

Database	**Integration (internal and external)**	Y/N/U
Vital Registration System (VRS): these include the birth and death registries	Birth database integrated with death database	
	Birth database integrated with immunization information system	
	Death database integrated with electronic disease surveillance system	
Immunization Information System (IIS): vaccine registry	Client vaccination records database integrated with provider vaccine ordering database, integrated with vaccine quality control	
	Child vaccine records integrated with adult vaccine records database	
	Immunization information system integrated with electronic disease surveillance system	
Electronic Disease Surveillance System (EDSS): infectious disease reporting and surveillance	Integrated surveillance for sexually transmitted infections (STIs): gonorrhea and chlamydia, syphilis, and HIV/AIDS	
	Integrated surveillance for STIs, tuberculosis, vaccine preventable diseases (VPDs) and other communicable diseases	
	Electronic disease surveillance system integrated with laboratory test results (lab information management system, LIMS)	

7. Which technologies have been used to integrate these databases (list all)?

BARRIERS (2)

1. What are the three most important barriers to database integration in your jurisdiction? Please rank the three options from the available list below from 1 (most important) to 3 (least important).

Compliance with IT Standards
Health Department incentives
Mandated electronic reporting
Electronic Message Variation

Health Department Funding
Partner incentivization/assistance
Health department staffing levels
Health department staff knowledge/training
Vendor costs
Internal competing priorities
Lack of authority
Interoperability
Other (please specify)

2. As Informatics director how do you spend the majority of your time (rank the following from most to least)?

Troubleshooting hardware problems;
Network and desktop software support;
Procurement;
Standards Development;
Project Management;
Staff Management (hiring, firing, etc.);
Responding to mandates;
Responding to political needs within the agency.

DATABASE INTEGRATION PLANNING (10):

1. * When did your organization begin formal planning activities related to the integration of public health information system databases? (*Note: formal planning typically starts when staff and/or other resources are allocated to a particular effort*)

Within the past year
1 to 2 years ago
2 to 3 years ago
3 to 4 years ago
4 to 5 years ago
6 to 10 years ago
More than 10 years ago
N/A – enable skip pattern

2. * Does your organization have a strategic plan for the integration of public health databases?
3. * If yes, which of the following best describes your organization's strategic plan for the integration of public health databases: (select one: Organization-wide, Department-specific, Program-specific, Other (please specify)).
If no, are there efforts underway to develop such a strategic plan? (Y/N)
4. * Which of the following internal factors influenced the decision made within your organization to pursue public health database integration activities? (check all that apply)

Funding became available
Previous integration project(s) was successful
Leadership provided support for integration (e.g., executive sponsor or champion)
Organizational change(s) (e.g., reorganization, merged programs, new programs)
Desire to improve public health program effectiveness
Desire to improve assessment/monitoring
Desire to support policy development
Desire for improved follow-up
Desire to support technical improvements (i.e., bi-lateral, real-time data exchange)
Desire to enhance data quality
Desire to reduce or eliminate duplicate data systems / redundancy of separate, specialized data systems
Desire to comply with state integration or IT plan
Other (please specify)
Do not know / Not sure

5. * Which of the following external factors influenced the decision made within your organization to pursue public health database integration activities? (check all that apply)

Health information exchange (HIE) established
Stakeholder desire for integrated public health data
Budget appropriations created funding for integration
Emergency preparedness initiatives developed
Grant received (federal, state or local)
Regulations were developed (federal, state or local)
Political influence exerted at the state level (e.g., governor's initiative, political will/influence)
Clinician desire for individual patient health information
Other (please specify)
Do not know / Not sure

6. * Is a public health database integration project currently underway at your agency? Y/N/U

7. * Please rate the importance of the following database integration project's non-technical elements (Likert, Scale of 1 to 3: 1=not important, 2=neutral importance, 3=very important)

1. Leadership—project has an executive sponsor and a champion.
2. Project governance—project is guided by a steering committee representing all key stakeholders and uses outside facilitators.
3. Project management—Formalized management strategies and methodologies are used. Project has adequate and appropriate staffing.
4. Stakeholder involvement—there is frequent interaction and high quality communication with stakeholders
5. Organizational and technical strategy—strategy is based on local issues, aligned with national efforts, customer-focused, developed through a legitimate process, and based on business processes.
6. Technical support and coordination—centralized within the health department with technical staff working closely with program staff. Uses business analysts to coordinate between technical and program staff.
7. Financial support and management—funding is adequate, derived from multiple sources and managed by an oversight committee.
8. Policy support—Legislation, regulation and policy foster, or are neutral, to the integration of information systems.
9. Evaluation—regularly performs qualitative and/or quantitative monitoring or evaluation.

8. Who has emerged as a major leader in the development of informatics projects and how has he or she demonstrated leadership characteristics?

9. Which leadership strategies have been used to address database integration project challenges?

10. Are you willing to be interviewed (~60 minutes) as a follow-up phase to this study?

Items with an asterisk * are those included for stage 2 case selection and retention

[33 Total]

Appendix B – Semi-structured interview guide

Good morning/afternoon. My name is Matt Roberts and I am a student with the University of Illinois at Chicago and I am also the informatics program manager at the Chicago Department of Public Health. I want to thank you for your time today and participating in this research regarding the integration of public health information systems. This interview will take approximately one hour to conduct. I would like to record the interview. Your name and health department will not be included in anything that comes from this research. Is it ok for me to record our conversation? Are there any basic logistical questions you have prior to beginning?

Name:
Agency:
Position/Role:
Date/Time:

Note: the following prompts differ depending on whether the informatics director or program-specific database manager is being interviewed.

<u>Informatics Director:</u>

1. What informatics or IT projects are you currently working on?

2. What sort of IT planning activities has your agency conducted in the past year or two?
    a. What future IT planning activities do you plan to conduct?

For the purposes of this study, database integration is defined as: the development of a central repository that consolidates operational data from multiple sources.

3. If any prior database integration attempts have been made, what is your opinion about these efforts to integrate these systems? [If no attempts have ever been made, excuse yourself and exit the interview].

[While presenting the following item, if interviewee also responded to the survey, reference the survey item about the nontechnical elements of database integration].

In the context of integration initiatives, the following four domains group various factors associated with integration projects together. They include organizational (leadership and organizational/technical strategy), project-specific (project governance, project management, coordinating tech support, financial/budget support and evaluation), external factors (stakeholder involvement and policy support), and technical (architecture, source systems, etc.).

4. Regarding the organizational domain, has your agency developed a strategy that involved integrating information systems? How did your agency think through the implications of

integration such as staffing, data ownership and data sharing, and how were these reflected in an organizational strategy? Who was involved in this process? Which positions?

In what ways did the technical strategy reflect business goals and objectives of each program? How was the technical strategy reflected in writing? How does the strategy reflect national and local standards, and the technologies to be implemented?

5. The following questions pertain to the project champion or sponsor. How long has the project champion/sponsor been in place? Have there been smooth transitions when one leaves? How did these individuals receive project updates? Please describe the sponsor's and the champion's contributions to the project.
    a. Did they secure funding? Other resources? Did they promote policy changes and build support for the project among stakeholders?

6. Regarding the project-specific domain, does the project have a steering committee with representation from all stakeholders? How did these committee members contribute to the project's goals, content and policies? Are the members afforded decision-making power and encouraged to communicate status to their constituencies?

    Were formal project management processes used? How does the project plan describe what value aspects the project must achieve, or return on investment? Does the plan articulate key goals, objectives, milestones, deadlines, and persons responsible? Did the project planners actively engage end-users throughout the process? What change management practices were implemented? How did communication occur?

    How was technical support/development handled (in-house or contractor)? Who approved? Was it adequate? Describe the process through which the tech team interacted with program staff. Does the project have a dedicated business analyst? Describe service level agreements, hours of support desk, etc. Describe the training plan. How was the tech team prepared for the rollout or technological solution?

    Was the budget diversely funded and realistically developed? How did it account for sustainability or any unanticipated budget shortages?

    How was the project evaluated? What sorts of process and outcome measures were developed? How were periodic evaluation findings reported back?

7. Regarding the external domain, how have stakeholders and/or advocacy groups impacted or influenced the integration project? How were they identified, and how did they provide input into the project? How did stakeholder communication and feedback occur?

    What sorts of policy changes needed to occur in order for the project to proceed? Who identified and reviewed existing policies and regulations? How was HIPAA compliance determined? Does a written security plan exist that covers safeguarding data? Please describe data sharing agreements between programs that support the integration project.

8. Regarding the technical domain, I have already received your description of which systems were integrated. Let's delve deeper into those integrated databases. Which technologies were used for the integration project?

9. Of the four domains previously described, which has the most importance and why?

10. Have any people emerged as leaders that drove the project forward or otherwise meaningfully contributed to the project's success? Please elaborate.
    a. Which leadership styles have emerged
    b. From which parts of the organization have leaders emerged that embraced the project's goals, potentially contributing to its success?

11. What database integration initiative lessons have you learned?
    a. What are some barriers to system integration that you have faced?
    b. What has been the single most frustrating part of these integration initiatives?
    c. What is the single most important factor that contributed to the integration project success?

Appendix C – Interviewee Legend

State A = Ohio [Survey Respondent]
1. Participant 1, Informatics Director
2. Participant 2, Data Warehouse Architect; Participant 3, IT Project Manager

State B = Iowa [Literature Review]
1. Participant 4, Community Health Consultant
2. Participant 5, Informatician
3. Participant 6, Project Coordinator for data integration; Participant 7, Business Analyst
4. Participant 8, Bureau Chief of Planning Services
5. Participant 9, Data Management Program Manager

State C = Wisconsin [Literature Review and Reputational]
1. Participant 10, Director, Office of Health Informatics
2. Participant 11, Milwaukee Environmental Health Director
3. Participant 12, WIR Unit Manager; Participant 13, Immunization Program Manager

State D = Utah [Survey Respondent]
1. Participant 14, Director of the Center for Health Data and Informatics; and Participant 15, Health Informaticist

State E = Oklahoma [Survey Respondent]
1. Participant 16, HIE Director
2. Participant 17, Immunization Information System Manager, Acting
3. Participant 18, Program Manager, Division of Surveillance and Informatics

State F = Michigan [Literature Review]
1. Participant 19, PHII consultant; Participant 20, Query By Parameter Implementer
2. Participant 21, Lead Programmer; and Participant 22, Programmer, Crystal Lightning

State G = Oregon [Reputational]
1. Participant 23, Interoperability Director
2. Participant 24, Immunization Program Epidemiologist

State TengoOne = Minnesota [Excluded]
Participant 25, Director of Informatics Sciences, Public Health Informatics Institute

Appendix D – Data Accounting Log

Interview		Unique Interviewees	State	Date ↑	Minutes	Length
Participant 1		1	Ohio	4/15/16	90	13
Participants 2 and 3		2	Ohio	5/3/16	45	5
Participant 10		1	Wisconsin	5/25/16	45	9
Participant 4		1	Iowa	5/25/16	45	5
Participant 5		1	Iowa	5/26/16	60	9
Participants 14 and 15		2	Utah	5/27/16	30	7
Participant 16		1	Oklahoma	6/3/16	60	11
Participants 19 and 20		2	Michigan	6/6/16	55	10
Participant 6 and 7		2	Iowa	6/10/16	35	6
Participant 8		1	Iowa	6/10/16	40	7
Participant 23		1	Oregon	6/17/16	60	11
Participant 17		1	Oklahoma	6/23/16	50	9
Participant 24		1	Oregon	6/28/16	30	4
Participants 21 and 22		2	Michigan	7/21/16	30	6
Participant 25		1	Minnesota	7/28/16	60	10
Participant 11		1	Wisconsin	8/17/16	40	1
Participant 9		1	Iowa	9/2/16	60	10
Participants 13 and 12		2	Wisconsin	9/2/16	60	10
Participant 18		1	Oklahoma	9/8/16	40	6
Totals	**19**	**25**	**8**		**935**	**149**

Participants		**State**
6 and 7	2	Iowa
9	1	Iowa
5	1	Iowa
8	1	Iowa
4	1	Iowa
21 and 22	2	Michigan
19 and 20	2	Michigan
25	1	Minnesota
1	1	Ohio
2 and 3	2	Ohio
18	1	Oklahoma
16	1	Oklahoma
17	1	Oklahoma
24	1	Oregon
23	1	Oregon
14 and 15	2	Utah
10	1	Wisconsin
11	1	Wisconsin
13 and 12	2	Wisconsin

State	Participants	Scope*	Type
Iowa	6	small	BI Dashboard
Wisconsin	4	big	deep integration
Michigan	4	big	full integration
Ohio	3	small	BI Dashboard
Oklahoma	3	big	deep integration
Oregon	2	small	middleware link
Utah	2	big	full integration
Minnesota	1	NA	

58 documents (436 pages) and 28 memos
13 codes with 735 quotations

Appendix E – Codebook

ATLAS.ti Report

Integration Project Study

Codes grouped by Code groups

Report created by Matthew Roberts on Sep 25, 2016

External

2 Codes:

- ### Policy Development

Created: 4/24/16 by Matthew Roberts, **Modified:** 4/24/16 by Matthew Roberts

Comment:

> Rules, regulations, legislation, and policy advisory or policymaking bodies are supportive or at least neutral to the integration of health information systems. Executive sponsors educate policymakers about sensitive issues to garner their support.

- ### Stakeholder Involvement

Created: 4/24/16 by Matthew Roberts, **Modified:** 4/24/16 by Matthew Roberts

Comment:

> Frequent communication with stakeholders and involvement of stakeholders in the integration project throughout the life cycle of the project contributes to its success and credibility.

Organizational

3 Codes:

- ### Informatician Leader

Created: 4/24/16 by Matthew Roberts, **Modified:** 4/24/16 by Matthew Roberts

Comment:

> Instance wherein the informatics director exhibited specific leadership traits.

- ### Leadership

Created: 4/24/16 by Matthew Roberts, **Modified:** 4/24/16 by Matthew Roberts

Comment:

> The project has an executive sponsor, a high level official who advocates for the project, and a champion, someone who is willing to devote a significant effort to see the project succeed.

- **Organizational and Technical Strategy**

  Created: 4/24/16 by Matthew Roberts, **Modified:** 4/24/16 by Matthew Roberts

  Comment:

  > The project has a strategy that takes into consideration local issues such as funding, the political environment, organizational structure, the strengths of the organization, and stakeholder beliefs and values. The selected technical integration approach accounts for internal data governance and data sharing needs, which must conform to state and federal laws and agreements made with stakeholders.

Project-Specific

5 Codes:

- **Evaluation**

  Created: 4/24/16 by Matthew Roberts, **Modified:** 4/24/16 by Matthew Roberts

  Comment:

  > The project has some form of qualitative and/or quantitative monitoring or evaluation that is performed regularly.

- **Financial Support and Management**

  Created: 4/24/16 by Matthew Roberts, **Modified:** 4/24/16 by Matthew Roberts

  Comment:

  > The project is adequately funded and has multiple funding sources.

- **Project Governance**

  Created: 4/24/16 by Matthew Roberts, **Modified:** 4/24/16 by Matthew Roberts

  Comment:

  > The project is guided by a steering committee representing all key stakeholders. The steering committee develops the integration strategy, based on clearly defined business processes.

- **Project Management**

  Created: 4/24/16 by Matthew Roberts, **Modified:** 4/24/16 by Matthew Roberts

  Comment:

  > The project has formalized management strategies and project management methodologies designed to assure consistent communications, accountability, and resource constraints.

- **Technical Support and Coordination**

Created: 4/24/16 by Matthew Roberts, **Modified:** 4/24/16 by Matthew Roberts

Comment:

> Technical information systems support and coordination is organized centrally to assure consistent support and a robust infrastructure capable of maintaining and complying with standards. A business analyst supports implementation.

Technology

1 Codes:

- **Technology**

  Created: 4/24/16 by Matthew Roberts, **Modified:** 4/24/16 by Matthew Roberts

  Comment:

  > Databases contain quality program-specific data to be contributed to the database integration project.
  >
  > Project managers select a particular technology to be utilized for the integration project including architecture, hardware, database software, data integration engines, user interface, etc. This can also include the development technique, whether agile, waterfall, etc.

No code group

2 Codes:

- **Change Management**

  Created: 4/30/16 by Matthew Roberts, **Modified:** 4/30/16 by Matthew Roberts

- **Cross-cutting projects**

  Created: 4/24/16 by Matthew Roberts, **Modified:** 4/24/16 by Matthew Roberts

  Comment:

Project transcends multiple programs

Appendix F – Qualitative Analysis Documentation Form 1

Procedures for Frequencies (10/23/16)

1. Research issue being explored: most commonly-discussed factors and most important factors as reported by participants

2. What was I aiming to do with this analysis task? descriptively characterize frequencies of participant data

3. Description of procedures:

specific datasets in use	**procedural steps**	**decision rules**	Analysis Operations*			**conclusions drawn**	**research comments**
			readying data for analysis	**drawing conclusions**	**confirming conclusions**		
Interview transcripts	-creation of the Data Accounting Log led to a need to understand and characterize the study's participant responses -created a basic series of tables presenting participant and case demographics -ran frequency reports for coded quotes and words	-thematically coded phrases, sentences or paragraphs -most frequently-coded factor is defined by quotation frequency, with ties broken by word counts -sorted cases by participant count, in order to potentially weight participants in the future	-classifying -categorizing -summarizing -subsuming	-clustering -counting -noting relations between variables	-representativeness -researcher--bias prevention: broad range of participants; included dissenting opinions -triangulation: data source -rival explanations -weighting evidence	-Participants clearly wanted to discuss the technology the most. -Leadership was the second-most frequently coded factor.	These frequencies are useful. They confirm some basic assumptions and seem to partially support the study hypothesis.
survey responses	-incorporated responses into the coding work	-thematically coded phrases -excluded cases based upon criteria specified in methods; worth mentioning that some respondents reported no current or planned integration and were immediately excluded	-classifying -categorizing -summarizing	-clustering -counting	-bias prevention: broad range of participants	Few responded to the survey. Some respondents suggest many databases are integrated	Some responses warrant follow-up whereas others are non-starters
documents	-identified relevant publicly available documents -participants provided documents	-thematically coded phrases, sentences or paragraphs	-classifying -categorizing -summarizing	-clustering -counting	-triangulation: data type	Agile project managers have the best documentation	Many documents simply support other data

*Based on Display 11.8 from Miles and Huberman

Appendix G – Qualitative Analysis Documentation Form 2

Procedures for Exploratory Displays: Partially-Ordered Meta Matrix, Explanatory Effects Matrix, and Content-Analytic Summary Table (11/11/16)

1. Research issue being explored: what are the cases' themes and how do they compare

2. What was I aiming to do with this analysis task? exploratively compare interview themes

3. Description of procedures:

specific datasets in use	**procedural steps**	**decision rules**	Analysis Operations			**conclusions drawn**	**research comments**
			readying data for analysis	**drawing conclusions**	**confirming conclusions**		
Interview transcripts	-the partially-ordered meta matrix (P-O MM) was the first matrix created -referred to documents to substantiate -for explanatory effects matrix, copied-and-pasted most important factor from prior matrix and built on that -prior to doing the content-analytic table, typed and scoped each case's integration project in the Interview Log	-the P-O MM column for 'most important factor' included initial response(s) to the 'most important factor' question; 'most frequently-coded factor' entails quotation frequencies w/word count breaking ties -the content-analytic table included any mentions for the most important factors in the conclusion of the interviews -scope defined as small or big based upon how much integration was involved (and whether the integration was as granular as record-level data)	-partitioning -filling in matrix	-pattern finding -plausibility -comparisons -inferences	-bias prevention: including dissenting opinions	Most all is pointing to Leadership. The content-analytic table revealed a substantial concentration in the organizational domain (Leadership) and no major difference by project scope. See other comments below.	The partially-ordered meta matrix is an obvious first choice. Perspective seems to matter, and there may also be differences by case. Explanatory effects provided a layer of depth as well as some usable quotes. It led to the content-analytic table, which provided illustrative frequencies. The partitioning of the leadership variable seems to have paid off.

Survey responses and documents played little role in the development of these matrices

Taken from my journal: The following themes continue to resonate the most: Leadership across three dimensions: executive (champions), program/division, informatician; and funding. Team dynamics matter, and are impacted by the leadership skills of team members. Leadership variable partitioning is the most interesting finding from the PO MM. This led to exploring whether project scope or type impacts case participants' position on the role of executive vs. program leadership.

*Note on the above table: the matrices I developed build upon prior analyses, and borrow the same procedural steps, decisions rules and analysis operations unless otherwise specified.

Appendix H – Qualitative Analysis Documentation Form 3

Procedures for Descriptive Matrices: Role-Ordered Matrix and Conceptually-Clustered Matrix (11/11/16)

1. Research issue being explored: which participants were involved and how do variables differ

2. What was I aiming to do with this analysis task? descriptively characterize participant data and variability

3. Description of procedures:

specific datasets in use	**procedural steps**	**decision rules**	Analysis Operations			**conclusions drawn**	**research comments**
			readying data for analysis	**drawing conclusions**	**confirming conclusions**		
Interview transcripts	-participants had provided their titles and I created general categories for grouping and sorted on Project Scope -I created a degree of involvement in the integration project based upon centrality to the project -I summarized the participant's reports on the role of leadership	-"Informaticist" is anyone performing informatics work; directors are in charge of that work -"IT Staff" perform or oversee the development of associated databases -"Registry Managers" are in charge of any database being studied -"Epidemiologists" are self-explanatory -"Program Managers" run an office -"Bureau Chiefs" are high-level executive staff -Degree of involvement is determined by how much personal activity went into the project -C-C Matrix excludes those participants who spoke little about the role of leadership	-filling in matrix	-pattern finding -plausibility -comparisons -inferences	-bias prevention: including dissenting opinions -weighting the evidence	-When stratifying by staff member role, there doesn't seem to be much difference in the reported role of leadership, excepting that collectively the IT staff had few relevant comments -In the C-C Matrix, the column contrasting executive vs. programmatic leadership provokes the most thought. Some cases nicely align in one perspective or another, whereas others are more mixed. Difficult to conclude why this is the case.	Completing the Content-Analytic Summary Table reinforced the need to do a Role-Ordered Matrix, to see if there were important differences by participant type. The Conceptually-Clustered Matrix nicely lays out most of the relevant leadership aspects.

Survey responses and documents played little role in the development of these matrices

*Note on the above table: the matrices I developed build upon prior analyses, and utilize the same procedural steps, decisions rules and analysis operations unless otherwise specified.

Appendix I – Qualitative Analysis Documentation Form 4

Procedures for Explanatory Analyses: Variable-by-Variable Matrix and Case Dynamics Matrix (11/11/16)

1. Research issue being explored: why selected factors are the most important

2. What was I aiming to do with this analysis task? explain inter-relationship and change

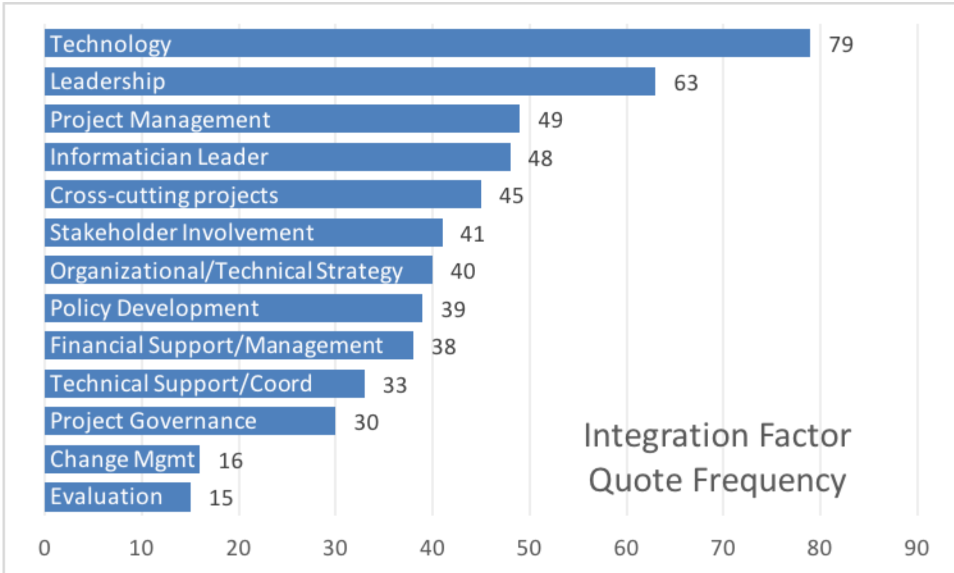
3. Description of procedures:

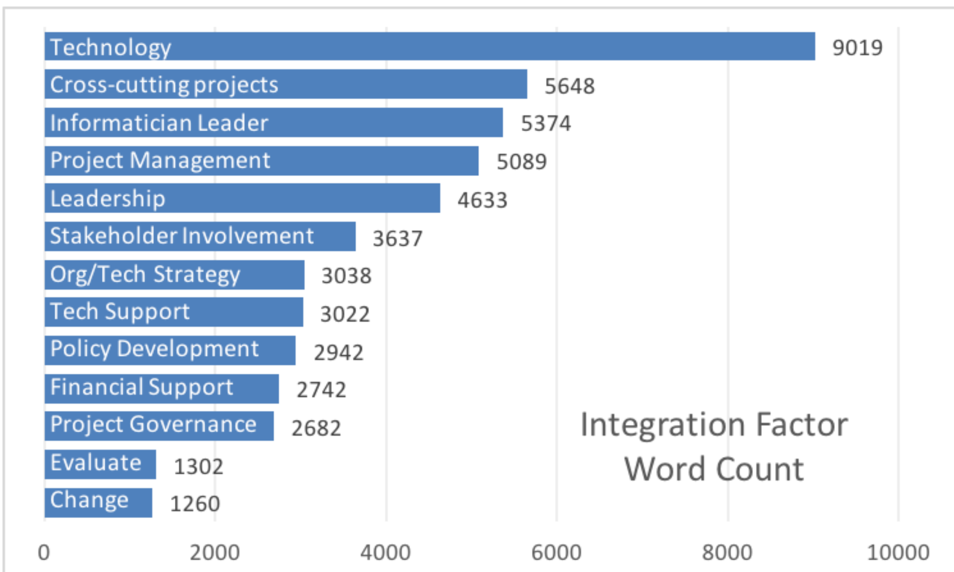
specific datasets in use	procedural steps	decision rules	conclusions drawn	research comments
Interview transcripts	-As a follow-up matrix to the Content-Analytic Table, I wanted to see which cases interact or inter-relate among the leadership dimension -contrast leadership features along with other salient integration factors. In the Variable-by-Variable matrix, I compared across and down the matrix for patterns. -The Case Dynamics Matrix included a summary of the V-b-V Matrix Leadership features and compared summaries of these features -Co-occurrence Table run May '17	-included as columns the most frequently-mentioned factors from the Content-Analytic Table and leadership traits as rows; definitions follow: Sponsorship = high level involvement; Support = indirect but substantive involvement in some way; Remove Obstacles = identify and eliminate project barriers; Obtain buy-in = securing support from others; Stability = providing longevity and project consistency; Engagement = coordinating/communicating with stakeholders; Commitment = ongoing substantive project involvement; Build relationships = work with internal and external stakeholders to obtain buy-in, support, and overall cohesiveness; Teamwork = foster project participant collaboration; Provide expertise = utilize experience and knowledge to personally propel initiative; Champion = commit energy to directly propel project; Capacity building = expand organizational informatics capabilities. -Inputted case names across the matrix in variable pairs -each "most important factor" mention has been included in the matrix, with specific pairings for the planning/strategy; financial; project; and tech factors -other mentions outside those specific factors of interest are assigned by project scope to a prominent leadership trait -for Case Dynamics Matrix, grouped leadership traits to create unique categories by leadership role	-when comparing exec vs. program vs. informatician leadership, one can quickly observe whether responses are fairly dispersed (exec) or sparse (informatician) -If one excludes the first two catch-all scope-oriented columns, one observes broad inter-case dispersion for planning and financial support (both mostly at the exec level), and single case mentions for project management -while not each case enjoyed each leadership contribution, some combination thereof seems to facilitate project success -Co-occurrence table and underlying quotes show strong informatician & program director interaction	-the Variable-by-Variable Matrix has the most subjective decision rules of all analyses I have created. Some assignment is straightforward whereas others are less-so. -the Case Dynamics Matrix provides a clean summary of the leadership dimension as it relates to participants' reports on leadership's role and impact. -Co-occurrence reinforces interaction among key staff. They work together often, and build relationships that ensure team's success.

Survey responses and documents played little role in the development of these matrices

*Note on the above table: the matrices I developed build upon prior analyses, and utilize the same procedural steps, decisions rules and analysis operations (these two matrices replicated the exact same analysis operations so this column has been removed from this table)

Appendix J – Integration Factor Quote and Word Frequency Charts





Appendix K – Table: Case Participant Reports for Level-specific Leadership Contributions

Case	Executive- versus Program-Level Leadership
State A	Executive*
State B	Executive
State C	Mixed (One for Program and one for Executive)
State D	Mixed* (one respondent reported that both levels mattered)
State E	Mixed (Two for Program and one for Executive)
State F	Program
State G	Program

*Unable to triangulate participant's response with that of another participant for that case

Appendix L – Partially-ordered Meta Matrix: Comparing Interview Themes

Participant by State	Most frequently-coded factor*	Interview Themes	Most important factor(s)	Researcher Explanation
State B 1. Participant 4	Organizational and Technical Strategy	Interview not recorded Highlight business analyst role	Financial Support Organizational Strategy Tech Support & Coordination	Organizational alignment and PHAB set the stage. Executive staff serve as project champions. Informatics business analysts make a difference. Demonstrating value secures flexible funding.
2. Participant 5	Technology	Infectious disease perspective Role of informaticist	Financial Support Informatics Leader	Dedicated funding is crucial. Informaticists bridge communication gaps.
3. Participant 6 & Participant 7	Technical Support & Coordination	Not as familiar with project Tech perspective Highlight business analyst role	Financial Support Tech Support & Coordination	Project completely stalled when the funding temporarily vanished. RFP process is frustrating. Solid system requirements help.
4. Participant 8	Cross-cutting projects	High-level executive Short in project detail	Leadership, executive** Financial Support	Executive champions play a critical role. Funding is crucial, and can be frustrating.
5. Participant 9	Financial Support & Management	Great reputation within the agency Knowledgeable	Leadership, executive** Financial Support	Executive champions play a critical role. Funding is crucial.
State F 1. Participant 19 & Participant 20	Leadership	Nationally-renowned informatician Perspective beyond Michigan	Leadership, program** Informatician leader	Team dynamics and personalities make or break the project. Program-level leadership, not executive support, makes the most difference.
2. Participant 21 and Participant 22	Project Management	Contractual tech staff Decades of experience with the initiative Nationally-renowned expertise	Leadership, program** Informatician Leader Technology Tech Support & Coordination	Interaction between the tech team and business analyst/informatician is critical. Division-level (not executive) leadership facilitates success. A competent and capable information technology team is key.
State A 1. Participant 1	Policy Development	Long interview Informatician leader Emphasis on strategy	Organizational Strategy Informatician Leader Policy Development	Organizational changes linked to strategic planning have a big impact. The informatician leader has an enterprise outlook for the agency. Policy facilitates technical decisions.
2. Participant 2 & Participant 3	Technology	Tech team members; not recorded Data warehouse approach	Technology Project Management	Source data matters, as does having a tech person dedicated to the project. Also important is project management and inclusion of subject matter experts.
State E 1. Participant 16	Stakeholder Involvement	Agency-wide informatician Small but mighty team	Leadership, executive** Informatician Leader	Engaged executive leadership help people think outside the box and provide crucial support. Business-like management style sets the tone, and can facilitate practical changes, such as the shift to Agile project management. Informatics staff lead the projects.

2. Participant 17	Technology	Seasoned and diverse background Appreciates the informatician	Project Management Leadership, program**	Moving to Agile from Waterfall profoundly impacted the project's success and augmented team synergy. Program director leadership matters.
3. Participant 18	Organizational and Technical Strategy	Received questions in advance Role of organizational timing	Leadership, program** Financial Support	Program director leadership was crucial (3+ years involvement). Agency timing was right--the will emerged. Federal grants were critical.
State G 1. Participant 23	Informatician Leader	Regionally-respected informatician Project was smaller in scope	Leadership, program**	Relationships are important. Program director leadership matters the most, by removing obstacles and ensuring team synergy.
2. Participant 24	Informatician Leader	Immunization epidemiologist Interview not recorded	Leadership, program** Informatician leader	Teamwork is most critical. The involved programs have the same program director and they frequently collaborate. Lead informatician is instrumental in making it a success.
State D 1. Participant 14 & Participant 15	Financial Support & Management	One of the most nationally-renowned informaticians	Financial Support Leadership, executive and program**	Federal funding has been critical. The first phase of the projects directly involve senior leadership. Latter phases required program leaders to step up to successful resolution.
State C 1. Participant 10	Cross-cutting projects	High-level IT leader	Financial Support Informatics leader Leadership, executive**	Federal funding for a related initiative was leveraged for this project. Informatician and IT tenacity are critical. Senior-level support and interest are required.
2. Participant 11	Leadership	Not directly involved in the project Deep Environmental Health experience	Informatics leader	Team dynamics achieve the outcomes. Informatics capacity must be carefully maintained or it can erode.
3. Participant 12 & Participant 13	Technology	IT guy and Immunization registry manager Tech focus	Technology Leadership, program**	Standards to which others conform makes much of the work possible. Program directors facilitate project success. Funding plays an important role, including project prioritization (a function of leadership and project management). Legal agreements for data sharing (policy development) are necessary.

*Defined by quotation frequency. A tie is broken by using word counts

**Note the delineation between executive-level and program-level leadership.

Appendix M – Explanatory Effects Matrix: Most Important Integration Success Factor by Interviewee by State

Participant by State	Most important factor	Participant explanation	Researcher Explanation
State B 1. Participant 4	Financial Support Organizational Strategy Tech Support & Coordination	Five years of consistent EH Tracking funding and receptive leadership	Years of stable funding and supportive leadership provided traction
2. Participant 5	Financial Support Informatics Leader	"I would say communication is the absolute most important factor." "When I first got here, program areas and IT spoke past each other thinking they were talking about the same thing."	Informatics staff bridge communication gaps
3. Participant 6 & Participant 7	Financial Support Tech Support & Coordination	"The biggest thing is always money, making sure that you secure the funds to make it happen."	A funding gap stalled the project for a long time
4. Participant 8	Leadership, executive Financial Support	"That leadership buy-in and that understanding why information is so important."	Leaders work to break down silos and overcome turf issues.
5. Participant 9	Leadership, executive Financial Support	"The leadership champions--without that it wouldn't have happened."	Sustained executive enthusiasm and support kept the project alive.
State F 1. Participant 19 & Participant 20	Leadership, program Informatician leader	"To me, having the right people at the table that are willing to work together and eliminating the barriers." "It's getting that right mix of people to work on a project, and then use their strengths to get stakeholder involvement and leadership buy-in." "All the projects I've worked on really come down to personality."	Important to have the right team combination and vision. Effective team dynamics overcome project obstacles. Team leaders drive towards success.
2. Participant 21 and Participant 22	Leadership, program Informatician Leader Technology Tech Support & Coordination	"It was the extraordinary communication between the technical side and the program side and the leadership side of the program that had vision. [The informatics director] drove all of that."	The informatician and division director in IT collaborated closely and understood both the business and technological factors.
State A 1. Participant 1	Organizational Strategy Informatician Leader Policy Development	"It's the organizational changes, we wouldn't have gotten far without that. Single most important would be organizational challenges, followed by policy stuff, and consensus around which direction to go. Which also relates to strategic plan as well."	Strategic decisions about the data warehouse and aligning staff and financial resources bolstered the initiative.

2. Participant 2 & Participant 3	Technology Project Management	"You need someone who understands a data warehouse and the underlying technology." "You also need much cleaner data, or to get a sense of how well they understand their source data."	Tech staff need to meet with the respective data owners to obtain an understanding of source data nuance, which universally persists.
State E 1. Participant 16	Leadership, executive Informatician Leader	"Having the leadership was probably one of the most critical pieces because it gave us the ability to think outside the box." "They saw the value, and they were able to help us move forward."	Senior leadership staff recognized the role of data and information, and supported the informatician's efforts to expand informatics capacity.
2. Participant 17	Project ManagementLeadership, program	"I definitely think it's the Agile process in and of itself. It helped the project move forward. Even when we had a roadblock it's not like everything just stopped."	A shift from Waterfall to Agile project management improved the day-to-day implementation of the integrated database.
3. Participant 18	Leadership, program Financial Support	"[The previous division director] was just able to really spearhead the contracts, getting the right partners involved, and just continuing to keep things moving along." "There were times when funding was in question, and it was hard to continue support for the contractors and development. And [she] was able to speak to leadership and find funding from other areas to help support the project when needed."	The division director at the program level contributed greatly to moving the project forward and elevating issues like funding to senior leadership.
State G 1. Participant 23	Leadership, program	"The most important thing--and I think that Oregon in particular struggles with this--is informatics capacity." "I hope it doesn't sound too hokey but it's relationships."	The informatics staff and program staff work closely together and are vested in the project's success.
2. Participant 24	Leadership, program Informatician leader	"The way we work together was a success. [The head of informatics] also--she has great knowledge of both...systems and she comes at it from an epi perspective and works on the project by programming also. Our two programs work really well together. We have the same medical director, and we work on a lot of projects together. Teamwork makes it a success."	Program directors serve as champions and ensure project success. Positive team dynamics and efforts by the informatician facilitate collaboration and progress towards a common goal.
State D 1. Participant 14 & Participant 15	Financial Support Leadership, executive and program	"The leadership came out to lead. I don't think the Executive Director came out and told us how to run it; it really requires the programs and bureaus to come up with the ideas to try on their own." "From a federal perspective, they need to change the way they fund these systems, they need to fund integrated systems."	Executive support can get the project off the ground, but success is predicated on program-level leadership. Program-specific funding leads to siloed database development.

State C 1. Participant 10	Financial Support Informatics leader Leadership, executive	"Persistence. When you're dealing with a lot of different actors, lot of different system policies, it's easy to wring your hands and stop pushing, I guess...Of course I've had great support from the secretary's office and the administrator [of the Division of Public Health]. Right from the start...they have just been 100% supportive of all we tried to do, and without that it's difficult to get anything done."	Informaticians can play a critical role in steadfastly driving the initiative forward. Executive support makes a big difference in achieving success.
2. Participant 11	Informatics leader Leadership, program	"The Team Dynamics achieve the outcomes."	Informatics capacity is critical for the sustainability of these initiatives. Positive team dynamics facilitate project success.
3. Participant 12 & Participant 13	Technology Leadership, program	"It's the technical aspect that contributed to the success--being able to have one standard that anybody could use to pass us data." "If this was a heavy lift for us to do on the registry's part each time this was brought up, it would not happen or it would take much longer because we would have to find the funds to do it." "And I think the buy-in from leadership on both sides, that this is important and that this is going to help improve immunizations going forward."	The program staff had developed comprehensive standards which facilitated project implementation. Vision and buy-in at the program-level leadership led to project success.

Appendix N – Content-Analytic Summary Table: Interviewee Mentions of Most Important Integration Success Factors (grouped by domain and project scope)

	Greatest Contribution - any mentions for most important factor	
DOMAIN	**Large-scale project**	**Small-scale project**
Organizational Domain [30] Leadership [27]	Informatician Leader (2) Receptive executive sponsors (3) **Program director champions (6)** Senior leadership vision Team dynamics (2)	Informatician Leader (3) Receptive executive sponsors (3) **Program director champions** Senior leadership vision Team dynamics Overcoming turf Changing culture Effective champions (2)
Organizational and Technical Strategy [3]	Strategic Plan	Strategic Plan Organizational realignment
Project-oriented Domain [10] Project Governance [0]		
Project Management [4]	Shift to Agile (2)	Setting clear project scope Delivering value
Technical Support and Coordination [2]	Business analysis	Business analysis
Financial Support and Management [4]	Long-term stable funding	Long-term stable funding (2) Multiple funding sources
Evaluation [0]		
External Domain [3] Stakeholder Involvement [2]	Stakeholder participation	Stakeholder participation
Policy Support [1]		Data suppression issues
Technical Domain [4] Source Systems [1]		High quality source data
Development Technology [3]	Effective standards (2)	Data warehouse expertise
TOTALS [47]	**22 mentions**	**25 mentions**

Appendix O – Role-ordered Matrix: Stratifying by Staff Role the Most Important Integration Factor and Reported Role of Leadership

		Most important factors	Project Scope	Degree of Involvement	Role of Leadership
Informaticist	Part.5	Financial Support; Informatics Leader	small	low	DK1
	Part.23+	Leadership, program	small	high	Ongoing commitment
	Part.9+	Leadership, executive; Financial Support	small	high	Executive support and persistent enthusiasm
	Part.1+	Organizational Strategy; Informatician Leader; Policy Development	small	high	Project ownership and executive vision
	Part.6	Financial Support; Tech Support & Coordination	small	low	Insightful and supportive executive sponsors
	Part.7	DK2	small	low	DK2
	Part.10+	Financial Support; Informatics leader; Leadership, executive	big	medium	Executive interest and ongoing resolve
	Part.19+	Leadership, program; Informatician leader	big	high	Longevity, persistence, vision, and fearless support
	Part.20	DK2	big	high	DK2
	Part.16+	Leadership, executive; Informatician Leader	big	high	Executive vision, practical support, and cultural change
	Part.14+	Financial Support; Leadership, executive and program	big	medium	Executives directly involved initially, with program managers leading implementation
	Part.15	DK2	big	low	DK2
IT Staff	Part.2	Technology	small	high	DK3
	Part.3	Technology	small	high	DK2
	Part.21	DK2	big	high	DK1
	Part.22	Leadership, program; Informatician Leader; Technology; Tech Support & Coordination	big	high	Foster relationships between tech lead and informatician and among team members
Registry Manager	Part.17	Project Management; Leadership, program	big	high	Longevity among program leaders and capable project manager
	Part.12	Technology	big	high	DK2
Epidemiologist	Part.4	Financial Support; Organizational Strategy; Tech Support & Coordination	small	high	DK1
	Part.24	Leadership, program; Informatician leader	small	high	Program director and informatician provide expertise, support, and collaborative environment
Program Manager	Part.18	Leadership, program; Financial Support	big	medium	Program managers obtain executive buy-in while engaging stakeholders
	Part.13	Technology; Leadership, program	big	medium	Program managers provide the use case and buy-in
Bureau Chief	Part.8	Leadership, executive; Financial Support	small	low	Executive champions secure funding and provide support while reducing silos and turf
	Part.11	Informatics leader; Leadership, program	big	low	DK1

+Informatics Director

DK1 = Question not asked of participant

DK2 = Question asked, but not answered

DK3 = ambiguous response

Appendix P – Conceptually-clustered Matrix: Examining the Leadership Factor

		Most important factors	Role of Leadership	Role of Informatician	Executive vs. Program Director Leadership
State B	Part.4	Financial Support; Organizational Strategy; Tech Support & Coordination	DK1	Business analysts collect system requirements, a critical function	**Executive:** "But right now we have a very receptive executive level and we are making great progress."
	Part.8	Leadership, executive; Financial Support	Executive champions secure funding and provide support; reduce silos and turf	DK1	**Executive:** "That really has pushed this along because [the Director] really has an interest in it."
	Part.9+	Leadership, executive; Financial Support	Executive support and persistent enthusiasm	DK1	**Executive:** "We've been lucky at [our agency] that our upper leadership are very supportive of data."
	Part.6	Financial Support; Tech Support & Coordination	Insightful and supportive executive sponsors	DK1	**Executive:** "We have a really good director…we have pretty good, solid sponsorship."
State E	Part.18	Leadership, program; Financial Support	Program managers obtain executive buy-in while engaging stakeholders	Provide conviction and vision. Work well together, and with partners propel the project and get buy-in.	**Program:** "I think it was kind of a mixture. It definitely--in terms of leadership--definitely [was our program director]."
	Part.17	Project Management; Leadership, program	Longevity among program leaders and capable project manager	DK1	**Program:** "But it definitely helped to have [our program director] come on and stick."
	Part.16+	Leadership, executive; Informatician Leader	Executive vision, practical support, and cultural change	Establish informatics capacity and develop business cases	**Executive:** "[Executive leaders] saw the value, and they were able to help us move forward."
State C	Part.13	Technology; Leadership, program	Program managers provide the use case and buy-in	DK1	**Program:** "Program directors."
	Part.10+	Financial Support; Informatics leader; Leadership, executive	Executive interest and ongoing resolve	Serve as the overall project champion	**Executive:** obtained secretary approval early on with sustained engagement
State F	Part.22	Leadership, program; Informatician Leader; Technology; Tech Support & Coordination	Foster relationships between tech lead and informatician and among team members	Ensure teamwork and communication while pursuing project vision	**Program:** informatician fostered functional relationships
	Part.19+	Leadership, program; Informatician leader	Longevity, persistence, vision, and fearless support	DK1	**Program:** quickly obtained Program Director support for the initiative
State G	Part.24	Leadership, program; Informatician leader	Program director and informatician provide expertise, support, and collaborative environment	Utilize prior epidemiological experience to pursue use case and tech vision	**Program:** "We have the same medical director, and we work on a lot of projects together."
	Part.23+	Leadership, program	Ongoing commitment	Persistence and relationship development	**Program:** share a common medical director between both programs, "...so it's a pretty easy sell."
State A	Part.1+	Organizational Strategy; Informatician Leader; Policy Development	Project ownership and executive vision	Possess enterprise view for technology	**Executive:** "So I would say at the executive level though, our chief of staff...was very supportive of it."
State D	Part.14+	Financial Support; Leadership, executive and program	Executives directly involved initially, with program managers leading implementation	Build informatics capacity through assessments, etc.	**Program,** although acknowledgement of critical **executive** support in the initial project phases

+Informatics Director

DK1 = Question Not Asked of Participant

Appendix Q – Variable-by-variable Matrix: Comparing the role of leadership with other case factors

	Big Project	Small Project	Strategic Plans	Technical Strategy	Financial Support	Project Management	Technology
Executive Leadership							
Sponsorship	STATE C	STATE B		STATE D			
Support	STATE E	STATE B STATE A	STATE B	STATE A STATE B STATE E	STATE B STATE C STATE D	STATE E	
Remove obstacles		STATE B					
Vision			STATE A STATE E		STATE B		
Program Leadership							
Obtain buy-in	STATE C STATE F				STATE E		
Stability	STATE E STATE F	STATE G					
Engagement	STATE F					STATE E	STATE C
Commitment	STATE F STATE D	STATE G					STATE F
Informatician Leader							
Build relationships	STATE F	STATE G					
Communicate requirements	STATE E	STATE B					
Teamwork	STATE E	STATE G					
Provide expertise		STATE G					
Champion	STATE E STATE C STATE F			STATE A			
Capacity building	STATE E STATE D						

Appendix R – Case Dynamics Matrix: Leadership Dimension

Leadership Contribution	**Activity**	**Primary effect**	**Summary of Value**
Executive sponsorship	Practical senior-level interest and support	Tangible informatics capacity development	**Informatics-savvy senior leadership pays dividends.** *"Of course I've had great support from the secretary's office and the administrator [of the Division of Public Health]. Right from the start when I told them that this was a good thing to do and I thought that, they have just been 100% supportive of all we tried to do, and without that it's difficult to get anything done."*
Executive vision	Strategically positioning information management	Realignment of agency goals with data at the center	**Recognition of the strategic nature of data and committing resources to develop its value.** *"...and our current director has been here for three years, and he is very interested in data, so he has been a wonderful champion."*
Project championship	Substantial personal effort among influential project members	Devoted commitment to project success	**Considerable personal investment among the right people can help ensure project success.** *"It's something that everybody wanted, and people were willing to kind of make sacrifices to make it happen."*
Program director engagement	Develop use case and collaborative environment	Motivation and momentum	**Visionary program directors identify pain points and harness technology to overcome them.** *"A director needs to have a vision for informatics--that really helps. If they're afraid of technology, systems don't get built. The program directors need to have vision. If they're afraid you never see these systems get built, and the information doesn't go any further up the chain."*
Steadfast commitment	Ongoing project support	Persistent and durable project activities	**The projects take years to complete, requiring long-term resolve.** *"The other piece is the staff that work on [the integrated database]--they've been with us a long time. Our IT guys have been there 20 years, we have trainers who have been with us for over 15 years, and it's because they believe in what they're doing, and they love informatics. It's challenging and changing. I'm amazed how long people have stayed with this project."*
Relationship development	Engage project stakeholders	Buy-in, vested interest	**Foster collaboration with stakeholders, senior leadership, and project team members.** *"Their conviction and vision of what the system needed to be, and how the system needed to work. Their ability to really work together and with other partners to make it the best system that it could be. Their ability to sell the system to others and get buy-in from others."*

Fostering teamwork	Develop cohesive team	High-performing teammate interaction	**Effective team dynamics among sometimes divergent members.** *"The team dynamics achieve the outcomes."* *"I hope it doesn't sound too hokey but it's relationships."* *"It's important to have the right team combination and the right vision. Sometimes that's hard to do. You just need one bad egg to stop your progress. If you can weed that out before you take it to get buy-in you're much better off. All the projects I've worked on really come down to personality."*
Applying expertise	Domain experts contribute critical knowledge	Information gaps are reduced	**Prior experience and expertise of informaticians leads to shared understanding and unifying of team goals.** *"The way we work together was a success. [Our informaticsist] also. She has great knowledge of both the [IIS] and [NEDSS] systems and she comes at it from an epi perspective and works on the project by programming also. Our two programs work really well together. We have the same medical director, and we work on a lot of projects together. Teamwork makes it a success."*

Appendix S – Case Summary Table

State	Summary
State A	Informatician plays a critical role, and the engagement of the team members (team dynamics) including subject matter experts, ensures success. Technology, in particular the quality of the source data and systems, plays a central role. Strategic planning and policy development supports the effort.
State B	Executive leadership champions and dedicated funding contribute the most to the project success. Informatician leadership and sound business requirement collection supports these efforts. The strategic planning that included information management principles seems to have had a lasting positive effect.
State C	Leadership among the program staff and the informatician makes a big difference; team dynamics are important. Technological protocols and standards facilitate integration of other programs' databases. Executive support and interest bolsters project activities. Funding once again is critical.
State D	Executive leadership commitment from the beginning plays a critical role, with strong program and bureau leaders required to push the initiative to successful resolution. Federal funding was essential.
State E	Program and executive-level leadership plays a critical role. A change in approach to project management from waterfall to agile made a big difference. Informatics staff lead these initiatives. Timing and a shift toward a more business-like model (strategic planning and leadership) make a difference. Funding was crucial.
State F	Program-level leadership and informatics staff as leaders are crucial to project success. This translates to healthy relationships and team dynamics. Information Technology team member continuity makes a difference.
State G	Team dynamics and relationships are the most important factors impacting project success. Program directors and informaticians make sure the project succeeds.

Appendix T – Case Summary Memos, deidentified

State B case synopsis memo

Created: 5/30/16 by Matthew Roberts, **Modified:** 10/30/16 by Matthew Roberts

Content:

Overall takeaways:

Leadership champions and dedicated funding contribute the most to the project success. Informatician leadership and sound business requirement collection supports these efforts. The strategic planning seems to have had a lasting positive effect regarding information management.

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The following items have been reinforced within the documentation obtained by State B:

-ELC grant funding contributed to developing an integrated database for infectious disease surveillance systems; $500,000 in state budget for database integration review, along with $500,000 for MCH database integration.

-Strategic plans do exist, and they outline goals, objectives and strategies to achieving a data management blueprint. Exec team members will be tasked with weekly IT project updates.

Two of the three objectives reflect performance measurement, whereas the third speaks to developing a department-wide data blueprint. Each of the strategies provide solid detail in the steps to how the objectives will be achieved.

-Exec Team is responsible for providing data management oversight and priority setting while identifying resources

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The State B interviews suggested the following:

Leadership champions and dedicated funding contribute the most to the project success. Informatician leadership and sound business requirement collection supports these efforts.

Details from each interview follow:

Participant 8 covered in great detail the roles of leadership, executive support and champions, and data governance. She was short of detail in the technical support and project management aspects.

-leadership, champions.

-financial resources dedicated to the project. This was mentioned as a key piece of the success and also a source of frustration.

Participant 5:

-ELC grant funding was critical in bringing about the integrated surveillance system.

-Informaticist to bridge communication between the program staff and IT.

Participant 4:

-hiring of more business process analysts who have an informatics role

-demonstrating project value to help secure additional flexible state-level funding

-PHAB Accreditation and other organizational alignment efforts

Leadership was mentioned at the very executive level but seems to be more from a support/champion perspective rather than regular engagement.

Participants 6 and 7:

-funding. They suggest the whole project had collapsed when there was a lapse in funding, and the reinstatement of fiscal resources got the project going again. This is still pretty fresh, so there might be some bias, but this does correspond with one of the priorities identified by Participant 14 from State D.

-in the frustration questioning she explains how the RFP process was frustrating, and how important it is to ensure quality business requirement collection.

Participant 9:

Recipes for success:
-leadership champions
-Funding

State F case synopsis memo

Created: 10/30/16 by Matthew Roberts, **Modified:** 10/30/16 by Matthew Roberts

Content:

Overall takeaways:

Program-level leadership and informatics staff as leaders are critical to project success. This translates to healthy relationships and team dynamics. Tech team continuity makes a difference.

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Document Review:

State F immunization registry documentation is thorough, and much attention is paid to policy, data use agreements, etc. All documents were obtained online and illustrate the policies and procedures for accessing the integrated registry. They are thorough and suggest substantive program development (many health departments do not have the resources to provide such detailed documentation online).

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Interview findings:

All interview participants are stating the importance of program-level leadership and informatics staff interaction. Team dynamics are mentioned in this case as well. Technical team depth and experience is important.

Participants 19 and 20:

-leadership buy-in. It seems that the most important level here is not executive support, rather program-level support. If the program directors responsible for the technology are supportive, then they will see that it happens. Executive support is less critical.

-personality, team dynamics. Therese is getting at the critical role of having a functional team. To me this speaks less to the importance of executive buy-in and support, rather the informatics-savviness of the team that is putting the system into production. If they are all on-board, things will go smoothly. This speaks to multiple aspects: Project Management, Project Governance, Leadership, and the role of Informatics.

Participants 21 and 22:

-interaction between the technical side and the business analyst [informatician] from the program
-Division-level leadership.
-sound technical team with many years of experience with the application.

State A case synopsis memo

Created: 10/30/16 by Matthew Roberts, **Modified:** 10/30/16 by Matthew Roberts

Content:

Overall takeaways:

Informatician plays a critical role, and the engagement of the team members (team dynamics) including subject matter experts, ensures success. Technology, in particular the quality of the source data and systems, plays a central role. Strategic planning and policy development supports the effort.

— —

Document overview:

Good project overview document. They have samples of their project management and project governance activities.

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Interview findings:

Strategic planning and the role of the informatician is the most important. Policy plays a critical supportive role. The technical staff thought that technology in general, and the source data in particular, plays a pivotal role. They also thought that project management and ensuring the involvement of project participants (such as SMEs) plays a key role. This hints at the role of the team dynamics.

Participant 1:

The respondent thinks that organizational changes, linked back to strategic planning and organizational strategy have had a big impact. The informatician as a leader is also key—he is positioned to have an enterprise outlook for the agency, and that has greatly improved the project success.

Policy about which direction to take with respect to legal aspects is the second-most important aspect. He reiterates that the policy piece is also related to the strategic plan.

Participants 2 and 3:

Both decided that the most important points to the project success pertained to technological aspects, in particular the quality of source data. But important project management aspects emerged, including having a dedicated resource to maintain the data warehouse (Participant 2) and ensuring the involvement of project participants, such as source system subject matter experts.

State E case synopsis memo

Created: 7/16/16 by Matthew Roberts, **Modified:** 10/30/16 by Matthew Roberts

Content:

Overall takeaways:

Program and executive-level leadership plays a critical role. A change in approach to project management from waterfall to agile made a big difference. Informatics staff lead these initiatives. Timing and a shift toward a more business-like model (strategic planning and leadership) make a difference. Funding was critical.

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Document review:

Participant 16 provided a series of useful documents. The PITS document serves as an overall blueprint and charter for their governance process, providing nice definitions, expectations, and guidance on navigating the process.

The Attachment B is the charter itself that is submitted for each project. Attachment C is a guide for committee members and the person submitting the charter. Attachment D is a workflow that illustrates the process in its entirety.

Attachment E is the scoring rubric for charters and project proposal submissions.

The DISCUSS Data Governance Manual is the first document I have received that illustrates the Technical Strategy. It shows how multiple state agencies are outlining their data governance principles and strategies.

The Strategic Map illustrates how program and system integration are part of an agency priority.

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Interview findings:

Leadership at executive and program level; business-like mentality; funding.

Participant 16:

-leadership, especially executive level support, getting people to think outside the box

-helping the department function more like a business (also on the leadership thread)

-informatics staff help lead these initiatives

It should be noted that Becki's peer, Participant 17 (immunizations system Manager in State E) thought that moving to the Agile development process (away from Waterfall) considerably helped the project success. Participant 16 also mentioned it as important in her interview.

Participant 17:

-Project Management: going to the Agile methodology accelerated the project when it was off track. This was the most important piece. It also promoted synergy of effort among project participants. Participant 16 also mentioned that as an important aspect during her interview.

-Having a stable constant program director (immunizations chief) who has been there consistently for three years.

Participant 18:

-Leadership in their Program Director

-Timing was right to implement a new system.

-Funding; couldn't have done it without the federal grant support.

State G case synopsis memo

Created: 10/30/16 by Matthew Roberts, **Modified:** 10/30/16 by Matthew Roberts

Content:

Overall takeaways:

Team dynamics and relationships are the most important factors impacting project success. Program directors and informaticians make sure the project succeeds.

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Document review:

Their project evaluation efforts were presented at the CSTE conference.

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Interview findings:

Informatician; program leaders; team dynamics and relationships.

Participant 23:

-she mentioned that informatics capacity is an issue.

-she thinks relationships are the most important aspect. This tends to push back towards the concept that leadership is critical, but at the program director level instead of executive support. They help ensure that teams function well and overcome obstacles.

Participant 24:

She thinks the following are critical:
-teamwork. The two programs have the same medical director as a program leader, and they frequently collaborate on projects.

-the head informatician was also instrumental in making it a success.

State D case synopsis memo

Created: 5/30/16 by Matthew Roberts, **Modified:** 10/30/16 by Matthew Roberts

Content:

Overall takeaways:

Executive leadership commitment from the beginning plays a critical role, with strong program and bureau leaders required to push the initiative to successful resolution. Federal funding was critical.

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Documentation:

CHARM documentation (Needs Assessment and Data Integration Plan):

-Organizational strategic/technical planning present. Participant 14 had not thought that this was deeply present for the CHARM initiative, but these documents were the richly-developed products of 2 years' worth of organizational strategic planning around this initiative.

-Leadership commitment from the beginning

-Funding from multiple sources—even funding for the actual plan development from a HRSA MCHB Genetic Services Data Integration Planning grant (# 5 H46 MC 00171-02)

-Stakeholders are listed and spelled out, plus shows who was engaged for focus groups

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Interviews:

Funding; leadership at the executive and program level.

Participants 14 and 15:

-the federal funding has been critical

-first phase of the projects directly involved agency leadership

-the latter phases required program and bureau leaders to step up and move these projects into a successful resolution

State C case synopsis memo

Created: 10/30/16 by Matthew Roberts, **Modified:** 10/30/16 by Matthew Roberts

Content:

Overall takeaways:

Leadership among the program staff and the informatician makes a big difference; team dynamics are important. The technological protocols and standards facilitate integration by other programs' databases. Exec support and interest provides important support. Funding once again is critical.

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Document Review findings:

Not many documents available to review. The annual budget speaks to realigning staff resources to support database integration and an enterprise approach to technology.

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Interview findings:

Funding, whether directly or by leveraging other resources, seems to be prominent for this case. Leadership among the program staff and informatician also impacts the project success; executive support and interest provides a supportive secondary role. The technology is an important aspect—developing standards lowers the barrier to integration project entry. Team dynamics are important.

Participant 10:

-federal funding for a major initiative was leveraged to build out this data management project

-tenacity in the informatician, leading a multi-agency effort

-Division Administrator and Departmental Secretary support and interest

Participants 12 and 13:

-the technology. They had established a solid standard to which others conformed, and as a result they were able to ensure adherence which enabled success through a lighter lift on their end.

-program level leaders on both sides of the interface project—those contributing data and the WIR/Immunizations staff.

Biggest barrier is funding. This has come up many times as the main success factor, which implies its relevance to success. Other barriers cited include prioritization of projects (possibly a function of leadership and project management), as well as the development of legal agreements for data sharing (policy development).

Participant 11:

-Team dynamics achieve the outcomes.

-Informatics capacity must be carefully maintained or it can quickly erode.

Appendix U – Co-occurrence explorer table

	Change Management	Cross-cutting projects	Evaluation	Financial Support and Management	Informatician Leader	Leadership	Organizational and Technical Strategy	Policy Development	Project Governance	Project Management	Stakeholder Involvement	Technical Support and Coordination	Technolog
Change Management	0	0	0	0	0	2	4	0	1	2	0	1	0
Cross-cutting projects	0	0	1	1	4	0	0	0	0	1	0	0	8
Evaluation	0	1	0	0	0	0	0	0	0	0	1	0	0
Financial Support and Management	0	1	0	0	1	1	1	0	0	0	0	0	0
Informatician Leader	0	4	0	1	0	12	2	1	1	1	0	1	1
Leadership	2	0	0	1	12	0	1	0	3	3	2	0	1
Organizational and Technical Strategy	4	0	0	1	2	1	0	0	1	0	0	1	0
Policy Development	0	0	0	0	1	0	0	0	1	0	0	0	0
Project Governance	1	0	0	0	1	3	1	1	0	3	4	0	0
Project Management	2	1	0	0	1	3	0	0	3	0	3	4	1
Stakeholder Involvement	0	0	1	0	0	2	0	0	4	3	0	0	0
Technical Support and Coordination	1	0	0	0	1	0	1	0	0	4	0	0	4
Technology	0	8	0	0	1	1	0	0	0	1	0	4	0

Appendix V – Study Protocol

A. <u>Introduction to the case study and the purpose of the protocol</u>
   a. **Case study questions, hypotheses and propositions:** This case study serves as the doctoral dissertation for Matthew Roberts, UIC DrPH student. It builds on prior research conducted concerning the integration of child health information system databases. The study seeks to identify barriers and facilitators of intrastate public health database integration projects as described by state health department staff with successful integration projects.
   b. **Theoretical framework** for the case study (see conceptual framework diagram)
   c. **Role of protocol in guiding the case study investigator:** This protocol is designed to set a standardized agenda for the line of inquiry. It prescribes the order for selecting cases and also process for collecting data.

B. <u>Data collection procedures</u>
   a. **Name and phone numbers of individuals to be interviewed:** [insert once cases have been selected]
   b. **Data collection plan:** This covers the type of evidence to be expected, including the roles of interviewees and documents to be collected and reviewed. Informatics staff will be prioritized, and the additional database administrators will be identified through inquiry of the informatics director. See *minimum document review set* regarding the documents to be collected.
   c. **Expected preparation prior to conducting interviews**. Review study protocol, review survey responses and The Sourcebook's descriptions of database integration project success factors.

C. <u>Study database</u>
   a. The interview transcripts, audio recordings, and my interview notes will be retained in a secure Google docs location with a folder for each of the states (the study's unit of observation).
   b. All requested items associated with the document review will be retained in their respective Google docs folders.
   c. The Google docs site will be made available for inspection upon request. Paths:

School >> Dissertation Study >> Study Evidence >> Survey Results OR State A >> Case Study Documents OR Interview Recordings OR Interview Transcripts

School >> Dissertation Study >> Study Investigator Documents >> State A >> Case study notes

D. <u>Case selection procedures</u>

Components from the top state successful integration projects that will be used to reduce the list to about 5:

- Mature projects. If the project has been actively operational for **three** or more years, then that will represent an example of a mature integration project.
- Number of integrated databases. If a survey respondent says that at least two databases are integrated, then that will represent an example of successful integration. Exemplary integration projects are those where **ten** or more databases are integrated.

In order to reduce pool to 3-5 cases, the following items from the literature will be used:

- Any states from the prior literature, excluding the pilot states (New York, Oregon, Nebraska, Michigan): Utah, Rhode Island, Missouri, Colorado, Iowa.
- Favorable responses from the asterisked items from the survey
- Exemplary responses to items pertaining to the nine non-technical integration factors

Minnesota Department of Public Health was identified by reputation (PHII) as a state with successful public health database integration projects. Iowa contributed to the development of The Sourcebook. These two health departments can serve as potential backup candidates.

E. Document content analysis. The **minimum document review set** required to be obtained in order for a case to be retained for study: IT Strategic Plan, Agency Strategic Plan, PHIS DB Integration Project Charter, Budget and Plan. If the documentation submitted by any department is too large in its entirety for analysis then a purposive sampling of those documents will be used and chronicled for audit purposes. Sampling of a document's segments may be employed if relevant material is confined to a specific section of a document. Any documents to be retained for analysis that are not yet computer readable will be converted to that format in advance of the analysis.

   Once the textual material has been obtained and defined, the recording units will likely follow the following: word, sentence, and theme. If analyzing words, the content analysis will entail a word count [by category]. If sentence is analyzed, I will code the sentence according to its category. If theme (a single assertion about some subject) is the unit, then I will code the theme according to its category; themes can include sentence fragments or multiple sentences.

   When calculating frequencies or percentages, tables will be used to illustrate findings as such for drawing inferences. The final report will "reveal the evaluation question addressed; the nature of material analyzed; the variables coded and coding categories; whether documents were sampled and if so, how; the recording units; the coding procedures and copies of coding instruments; the statistical analysis techniques; and limitations that would prevent another from using the information correctly" (GAO Content Analysis Methodology, 1996).

F. Institutional Review Board

This study involves human subjects and therefore warrants obtaining study clearance through UIC's Institutional Review Board (IRB). Language requested by the IRB when engaging the study subjects follows:

a. That the activity involves research
b. name, affiliation and contact information for investigator,
c. the purpose of the research,
d. a description of the procedures,
e. measures to protect the privacy of subjects and the confidentiality of the research information,
f. description of any reasonable foreseeable risks, as well as anticipated benefits,
g. statement that participation is voluntary,
h. statement that the researcher is available to answer any questions.

G. Questions to answer prior to data collection (Yin, 1993: Applications of case study research)

- *Define the case*: the PHIS DB integration projects themselves are the cases for the study, and successful cases will be studied.

- *Single- or multiple-case study. If multiple, should they be done sequentially or in parallel, and if sequentially, what order*: MULTIPLE, in parallel.
- *How should the case be bounded with regard to time, participants, and relevant evidence?* Only current employees will be interviewed as participants. Staff must have reasonably substantive understanding of prior project activities, either directly involved or through current experience with the existing database/EDW.
- *Seeking to prove, conclude, or observe*: that the agency's organizational domain is most important for project success, and leadership is most critical.
- *Whom to interview and how long should the interview be? What type of interview instrument?* Staff familiar with the projects (informaticians and DB administrators). Survey filled out by informaticians and semi-structured survey tool.
- *How deal with other sources of evidence, and what happens if events change drastically during the case? Do you need to start over again?* Documents will be collected for the document review. If case participants (interviewees) drop out of the study then the case will be eliminated and another suitable case will be pursued.
- *How manage notes and other materials once ready to "write up" the case?* Maintain all documents and transcripts in personal Google Drive location. Google Drive maintains an addition and deletion history and a document legend which are used for audit purposes.

DESIGN

- See the proposal for a description of the objectives and questions to be answered, as well as the rationale for the case study approach.
- See table below detailing the linkage between objectives and questions.
- See proposal for an understanding of how interviews and documentation will contribute to the source of evidence for the study.
- See proposal's analytical framework section for an understanding of the techniques to be used.

For the **survey**, see *Informatics Director Survey 100115*
For the **structured interview guide**, see document: *interview questionnaire version nov 2015*

TABLE MAPPING THE STUDY QUESTIONS TO THE SURVEY AND INTERVIEW ITEMS

Objective	Question
1. Assess integration project organizational domain elements. a. Describe leadership features as expressed through presence and involvement of an executive leader and project champion. b. Describe organizational strategy. c. Describe technical strategy.	Who has emerged as a major leader in the development…characteristics? Have people emerged as leaders…Please elaborate. Which leadership strategies have been used to address challenges? How long has the project champion/sponsor been in place? Describe champion's contributions.

	Is there a separate and distinct…CIO? Does your state have an agency that has centralized…government? Has the agency conducted an organizational readiness assessment…informatics change? Which of the following internal factors influenced…activities? Is there a quality improvement…redesigning workflows What are the three most important barriers…jurisdiction? As informatics director…time? What sort of IT planning activities has your agency conducted…two? Future Does your agency have an IT Strategic Plan? If so, how far along in its implementation? Does the technical strategy address business goals and identify technologies to address deficiencies? How many professional…agency? What is your agency's…spend? Does your agency have an IT Governance…Charter? Does your State IT Office…attend? Describe how easy it was to identify registry points of contact.
2. **Assess integration project-specific domain elements.** a. Describe project governance features as evidenced by a regularly convened steering	Does the project have a steering committee with representation from all stakeholders? How did members contribute?

committee with a charter and strategic plan. b. Describe project management principles as evidenced through staffing and project plans. c. Describe technical support arrangement as specified through the business unit involved in supporting the project. d. Describe project financing as evidenced through budgets and listing of funding sources, complete with oversight measures. e. Describe project evaluation components as evidenced through evaluation plan and reports.	Were formal project management steps used? How was change management addressed? Was tech support in-house or contracted and was it adequate? Did the project have a business analyst? Training plan? When did your organization begin formal planning…databases? Does your organization have a strategic plan…databases? Which of the following best describes your organization's…databases? Is a public health database integration project currently underway? Was the project funded through multiple diverse sources? Was it realistic? How was the project evaluated? Reports?
3. Assess integration project external domain elements. a. Describe stakeholder involvement as expressed through stakeholder assessments, engagement methods. b. Describe laws and policies that impact (at least are neutral) the project through departmental counsel involvement and legislative changes made.	Which of the following external factors influenced…activities? How were stakeholders identified and communicated with? How did they influence the process? Which policy changes needed to occur to facilitate the project? Who identified them? How was HIPAA addressed? How is data safeguarded? How were data sharing agreements among programs modified?
4. Assess integration project technical domain elements. a. Describe source systems used. b. Describe technical architecture and development technology.	Does your DOH have an established centralized enterprise DWH? Does your DOH utilize a MPI…? How many databases…integrated? Which ones (expressed as a list)?

	Which databases have been integrated internally and externally as specified? Which technologies have been used to integrate these databases?
5. Assess relative importance of integration project non-technical elements.	If any database integration attempts…integrate these systems? Please rate the importance of the following DB integration project's non-technical elements. Which of the four domains has the most importance and why? What database integration lessons have you learned?

The following business cases illustrate a walkthrough of the expected integration connections between the PHIS databases of interest for the study: infectious disease surveillance systems, immunization registries, and vital statistics registries (birth and death). The profiling of these connections will be pursued through the survey instrument and confirmed in the program-specific database manager interviews.

- NEDSS should have all infectious diseases in one database, including tuberculosis, vaccine preventable diseases, STIs, other infectious diseases; additionally distinguish between STIs and HIV (gonorrhea and chlamydia vs. syphilis vs. HIV/AIDS)
- NEDSS should be connected to the Death Registry. This will allow for the surveillance of cases not detected through the traditional notifiable condition reporting system.
- NEDSS should be connected to the LIMS. The LIMS captures data through the state laboratory services and automated message transmission into the NEDSS facilitates timely response to infectious disease issues.
- NEDSS should be connected to Immunization Registry. Facilitates research and understanding of vaccination status among cases and contacts of vaccine preventable diseases.
- Immunization Registry should be connected to the Birth Registry. Birth record registries can be used to populate and deduplicate immunization records.
- Immunization Registry should have clients' vaccination history, vaccine ordering, and vaccine maintenance / Quality Assurance in one consolidated system.
- Birth and death registries should be integrated with one another.

University of Illinois – Chicago, Research Protocol #2016-0087

Dear INTERVIEWEE NAME:

This is to introduce myself, a doctoral student at the University of Illinois – Chicago and the Informatics Project Manager at the Chicago Department of Public Health. I am familiar with public health information management needs and as a student am researching intra-state public health database integration initiatives.

Ultimately, by means of a case study approach, I hope to identify and document the factors that serve as barriers or facilitators to successful database integration projects. This will attempt to answer the question: of states integrating certain essential internal public health information system databases, are the prevailing barriers and enablers technical, organizational, project-specific, or external in nature and why?

This letter is directed to state public health informatics staff and those state health department personnel directly involved in managing public health information systems and their associated databases. In particular, I will target those staff managing infectious disease surveillance systems, immunization registries, laboratory testing, and vital records registries. Your cooperation is essential to this study, and I thank you in advance for time that you can commit to participating in interviews, organizing pertinent documents, and responding to survey items.

All interview recordings and transcripts, along with survey responses and documents supplied will be maintained in a secure folder with access only by myself and my dissertation committee members. I will anonymize transcripts by replacing interviewee identifiers with codes available only to myself. Once the study has concluded I will erase the interview audio recordings.

While participation in the study is low risk, a minimal chance of identification persists as this study includes a small subset of state health departments. However, the perceived benefits of conducting the study likely outweigh the risks. This study will help further define relevant integration project success factors and draw attention to data integration leadership needs.

Participation is voluntary. I am available to answer any questions you might have about the research study. Again, thank you very much.

Sincerely,

/signed/

Matthew Roberts, MPH
mrobe03s@uic.edu
217.415.7931

Survey distribution email:

University of Illinois – Chicago, Research Protocol #2016-0087

Dear Potential Survey Participant:

This message is to introduce myself, a doctoral student at the University of Illinois – Chicago and the Informatics Project Manager at the Chicago Department of Public Health. I am familiar with public health informatics topics and as a student am researching intra-state public health database integration initiatives.

Ultimately, by means of a case study approach, I hope to identify and document the factors that serve as barriers or facilitators to successful database integration projects. This will attempt to answer the question: of states integrating certain essential internal public health information system databases, are the prevailing barriers and enablers technical, organizational, project-specific, or external in nature and why?

The aim of this initial survey phase of the study is to collect data from state health department informaticians about basic informatics program setup and any efforts to integrate databases. All responses will be maintained in a secure folder, and shared only with ASTHO staff.

This study will help further define relevant integration project success factors and draw attention to data integration leadership needs. Participation is voluntary, and your involvement is much appreciated. I am available to answer any questions you might have about the research study.

Sincerely,

Matthew Roberts, MPH
mrobe03s@uic.edu
217.415.7931
Follow this link to the Survey:
Take the survey
Or copy and paste the URL below into your internet browser:
https://uic.qualtrics.com/SE?SID=SV_aXatNU66Z5hM097&Q_CHL=email&Preview=Survey
Follow the link to opt out of future emails: Click here to unsubscribe

VITA

NAME: Matthew Wesley Coates Roberts

EDUCATION:

B.A., Psychology, Illinois Wesleyan University, Bloomington, Illinois, 2001
M.P.H., University of Illinois at Springfield, Springfield, Illinois, 2003

PROFESSIONAL EXPERIENCE:

Informatics and Health IT Director, Chicago Department of Public Health, Chicago, Illinois, 2013-present

Quality Assurance Division Chief, Bureau of Long Term Care, Illinois Department of Public Health, Springfield, Illinois, 2013

Communicable Diseases Section Chief, Illinois Department of Public Health, Springfield, Illinois, 2010-2013

Emergency Response Coordinator, Illinois Department of Public Health, Springfield, Illinois, 2006-2010

Supervisor of Health Services, Springfield Department of Public Health, Springfield, Illinois, 2003-2006

Preparedness Contractor, Menard County Health Department, Petersburg, Illinois, 2003

Prevention Specialist, Triangle Center, Springfield, Illinois, 2002-2003

PUBLICATIONS:

Roberts, M.: Volunteerism. In: Disaster nursing: a handbook for practice, eds. D.S. Adelman, and T.J. Legg. Jones and Bartlett Publishers, Sudbury, Massachusetts, 2009.