The Impact of Care Coordination Strategies in Health Information Systems on Healthcare Outcomes

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THESIS

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LIST OF ABBREVIATIONS

AACC	Assuming Accountability for Care Coordination
ACA	Affordable Care Act
ACO	Accountable Care Organization
AHCA	American Health Care Act
AHRQ	Agency for Healthcare Research and Quality
ARRA	American Recovery and Reinvestment Act
BCRA	Better Care Reconciliation Act
CAHPS	Consumer Assessment of Healthcare Providers and Systems
CMS	Centers for Medicare and Medicaid
CPP	Communicating with Participating Provider
DHS	Department of Human Services
EAIT	Ensuring Appropriate Information Transfer
EHR	Electronic Health Record
EM	Expectation Maximization
EMR	Electronic Medical Record
FITT	Fit between Individual, Task, and Technology
HCH	Health Care Home
HIE	Health Information Exchange
HIT	Health Information Technology
HITECH	Health Information Technology for Electronic and Clinical Health Act
ICHOM	Consortium of Health Outcomes Measurement
IOM	Institute of Medicine
ISTA	Interactive Sociotechnical Analysis
MAR	Missing at Random
MCCD	Medicare Coordinated Care Demonstration
MDH	Minnesota Department of Health
MU	Meaningful Use

LIST OF ABBREVIATIONS (continued)

OECD	Organization for Economic Cooperation and Development
PCHMH	Patient-Centered Medical Home
PHI	Patient Health Information
PPS	Providing Patient Support
VIF	Variance Inflation Factor
WHO	World Health Organization

SUMMARY

The immense impact of modern technology in the field of healthcare services has caused all facets of healthcare delivery to rapidly transform. In recent years, there has been a growing emphasis on the need for more-comprehensive and more-reliable communication, as well as the need to better coordinate the services provided. Failure in the efficient delivery of comprehensive care promotes shortcomings in healthcare services and wasteful consumption of resources, which drives up the cost of care and lowers its value.

The adoption of electronic health record (EHR) systems is considered a cornerstone of modern health care reform. These systems have evolved from their initial function of storing patient records, to a more robust role in coordinating care, enhancing efficiency and controlling cost. Increasingly, they have elements of care coordination embedded into their functionality. Care coordination is a process that focuses on the deliberate organization of all patient care-related activities by sharing care plans with the stakeholders and encouraging active participation of involved parties. The lack of coordinated care in many cases could be the cause of duplicated medical services and wasteful expenditure; it could also lessen the quality of care provided and patients' satisfaction with the care they received.

Although current EHR systems can provide a range of care coordination elements, it is essential to identify their impact on care outcomes. This will form an understanding about the prioritization of investment within healthcare organizations, and can potentially inform standardization efforts for the most effective care coordination strategies. This study assessed care coordination functionalities embedded in health information systems and their impact on

care outcomes related to patient experience, such as patient-provider communication and accessibility to health.

We used data gathered from the 2015 Minnesota Health Information Technology clinic survey (see Appendix A) to discuss care coordination implementation in Health Care Homes. The MDH conducts an annual cross-sectional study to compare between clinics that are implementing EHR systems and are certified as HCH entities to clinics that utilize EHR systems but are not HCH certified. The subjects comprised 80% of the ambulatory clinics in Minnesota that are operated by one or more physicians. Of the 662 primary care clinics responding to the survey, 311 were HCH certified and 351 were not certified. The survey explored two main areas of: Care Management and Care Coordination; it examined clinical decision support systems, patient care summary reports, patient portals, and electronic health data exchange that were reviewed and assessed in all participating clinics. We used regression analysis to establish the relationship between care coordination measures embedded within EHR systems and patient experiences displayed as care outcomes, the FITT framework ("Fit between Individuals, Tasks, and Technology") was included to assess the interaction between these elements in order to better identify issues related to health information technology adoption and information system implementation.

Our analysis identified five variables that displayed significant impact on the outcome variables in their corresponding coordinating categories: EHR-supported patient summary reports, clinical guidelines for chronic patients, EHR-supported patient preventive care reminder,

EHR-supported patient demographic information, and viewing patient information online displayed relatively higher significance on the outcome variables. However, when external variables (FITT model attributes) were considered as part of the multiple linear regression model to assess the impact of the predictive variables, only one variable remained as significant: EHR-supported electronic summary report provided for patients.

Few studies until now have attempted to build a direct link between widely used EHR system functionalities and patient experiences. Despite its limitations, this study facilitates the formation of an evidence-based relationship between clinical tasks that emphasize coordinated care and care outcomes.

1. INTRODUCTION

Health information technology has been a powerful driving force in all aspects of care delivery systems (diagnosis, treatment, patient-physician interaction, and clinical communication) and a rapidly transforming element in the adopting systems. This transformation has led to the formation of newly recommended standards of care delivery. Innovative technologies, such as patient monitoring wristbands that report and track patient activity and sensors that are periodically registering cardiac patient's heart rate, are tools that provide clinicians with a large breadth and volume of data/information. Utilizing this large amount of information produced in healthcare facilities requires adequate planning to properly apply and exchange patient health information. Furthermore, highly complex transplant surgeries and the utilization of robotic technologies in many health care treatment plans are continuously increasing what patients (and their caregivers) expect from clinical care. Finally, new forms of communication and the abundance of resources providing medical knowledge are evolving both patient-physician and clinician-clinician communication standards, which results in new models that promote transparency and group evaluations. These new developments are accompanied by the need for reliable communication.

1-1. Electronic Health Records

Most clinical encounters that utilize EHR/EMR systems provide sufficient resources to improve patient care outcomes; however, the efficient utilization of these systems and the adoption of care coordination measures are major challenges in the continuous treatment process. Failure in the efficient delivery of comprehensive care promotes shortcomings in the healthcare services and wasteful consumption of available resources, which in-turn drives the cost of health care to unmanageable rates. Clinical communication and collaboration that lack appropriate health information technology will increase the potential for error and hence increase medical flaws. EHR systems are introduced as a reliable approach for reducing and eventually eliminating human errors. The impact of EHR systems on patient health care outcomes can be grouped into three distinct categories: 1) Enhancing the quality of care, 2) Reducing health care cost, and 3) Resolving medical errors (Linder, J., Bates, Middleton, & Stafford, 2007).

1-1. Coordination in Care

Integrated care, which is becoming an essential component of the US healthcare system, is an approach to the provisions of care that focuses on collaboration, communication and information sharing among care providers and creation of comprehensive treatment plans to address a patient's medical, behavioral and social needs based on the coordination measures. A closely related concept, care coordination, seeks to optimize the efficiency and value of care by stressing the connectedness of all contributions of all those involved, including the patient. Traditional care delivery methods largely rely on provider-specific, rather than patient-centric, approaches. This causes misalignment of participating provider approaches, which ultimately results in fragmentation of care delivery. Gaps created by these methods lead to duplication of services and inefficiency of care, which adversely impacts patients who are in-need of multi-disciplinary care, especially chronic care patients (Elhauge, 2010). Care that is not integrated also forces patients to become care managers, and plan for themselves the coordination of services they receive. These patients are required to establish channels of communication between medical care providers (specialists, radiologists, primary care practitioners, et a.) and community resources to receive comprehensive healthcare (Elhauge, 2010).

The adoption of EHRs is considered a cornerstone of modern health care reform. EHR systems have evolved from their initial role of storing patient records into a more robust role in coordinating care, enhancing efficiency and controlling cost in the care process. From preventing medical errors to collecting and analyzing health-related data, EHRs have introduced information technology to assist providers in meeting federal requirements (for example, stages of Meaningful Use) while allowing efficient tracking, identification, and monitoring of patient care procedures with the goal of improving care. Utilization of a team approach in care delivery models empowers care coordination strategies that are supported by EHR systems. Key aspects of an EHR that could support coordination are: integrating, organizing, and facilitating the proper distribution of patient health information among all care stakeholders involved in the delivery of care.

The Institute of Medicine (IOM) defines care coordination as a strategy that could improve effectiveness, safety, and efficiency of the health care system (Institute of Medicine, 2015). Care coordination is a process that focuses on the deliberate organization of all patient care-related activities by sharing care plans with the stakeholders and encouraging active participation of involved parties (Stanford University–UCSF Evidence-based Practice Center, 2007). This process promotes patient-centeredness, with an emphasis on care value and efficiency. By identifying the care requirements for patients, care coordination tools work to prevent medication errors, decrease frequent ER visits, reduce redundancy in health care services and eliminate needless hospitalizations (McDonald et al., 2010). Care coordination is emphasized on the point of transition, where the care responsibilities are shared or transferred from one entity to another or when patient care requires the collaboration of several entities over time. A team-based approach will provide patients and their caregivers with an efficient and effective methods of navigation through the services provided while responding to the specific medical/physical needs. This approach has been shown to positively impact care outcomes

(Hupke, 2014). However, failures can occur through miscommunication or an improper hand-off between the entities providing care.

1-2. The Evolution of Care Coordination

Attempts to better coordinate the provision of healthcare services, in order to both improve patient outcomes and reduce costs, go back at least to the 1980s and 90s, with projects such as the Social Health Maintenance Organizations and the National Long-Term Care Demonstration Project. Most of these early projects focused on patients with chronic and/or complex conditions, which are both costly and tend to involve multiple providers (Shojania, McDonald, Wachter, & Owens, 2007).

The American Reinvestment and Recovery Act of 2009 (ARRA), enacted to stimulate the economy following the Great Recession, included $787 billion for health information technology (Amadeo, 2017). One component of the ARRA, the “Health Information Technology for Economic and Clinical Health (HITECH) Act,” was intended to support the adoption of electronic medical records by providing incentive for “meaningful use.” This concept was promoted by Centers for Medicare and Medicaid Services and the Office of the National Coordinator for Health IT (Center for Surveillance, Epidemiology, and Laboratory Services, 2017). Meaningful Use is defined as the incorporation of electronic medical records in the care facilities in a substantial way that will enhance the electronic exchange of health information and will improve health outcomes. Incentive payments are considered for providers and facilities that adopt the meaningful use protocols in its three main stages:

- **Stage 1** focused on storing, sharing, and accessing standardized health information electronically. This stage also emphasized care coordination by tracking clinical conditions using EHR (How to Attain Meaningful Use, 2013).

- **Stage 2** included the addition of e-prescribing and lab results in the electronic health record systems and provides health care summary reports. During this stage, patients were to have more control over their health data (How to Attain Meaningful Use, 2013).
- **Stage 3** is designed to improve quality, safety, and efficiency of care by providing decision support systems to complex cases. Patients were to be able to manage their conditions as more comprehensive patient data became available through the adoption of EHR systems. The main goals for this stage are to improve population health and healthcare outcomes (How to Attain Meaningful Use, 2013).

Although meaningful use provisions will help patient health record expansion and standardize care accessibility, which in turn will positively impact clinical health information exchange, more provisions are required to ensure the transformative capabilities of these measures (Ashish, 2010). Tracking meaningful use adoption results via accurate healthcare outcome measures could assist in the introduction of financial incentives for healthcare facilities that integrate and coordinate care. To enhance the effect of meaningful use provisions, clinicians and healthcare facilities must be evaluated based on their outcome measures.

A year after the ARRA went into effect, the Patient Protection and Affordable Care Act (ACA) was signed into law by then President Barack Obama; its main goals were to increase access to health insurance coverage and to better control costs (Taylor, 2014); it also sought to offer better care integration, better-designed services, and better measurement tools (Emmer). The ACA set standards to expand healthcare coverage, improve quality of services delivered and control cost. Planners of the law sought to do this in part by incentivizing care coordination across healthcare silos. Innovative approaches of care delivery were introduced that impacted all facets of healthcare system. It introduced new privacy laws and payment innovations to transform the episodic-care approach to one that rewards preventive measures and improvements in patient outcomes (Taylor, 2014). These measures played a significant role in introducing pilot programs into healthcare facilities that highlighted the value of efficiency and quality of care.

Care coordination continues to play a key role in the promotion of policies for primary care. In the later stages of MU, providers are asked to exchange patient health information electronically across multiple settings to facilitate care coordination (Cohen & Adler-Milstein, 2015). Preparing up-to-date patient summary records and standardized patient information exchange documentation for referral can become challenging for practitioners. Lack of Health Information Exchange standards/protocols that are seamlessly integrated into EHR systems could be a major shortcoming that forces providers to introduce cumbersome new steps into their workflow. The three MU stages were originally planned to identify methods of collaboration between clinical teams that are involved in patient care.

The new administration that was elected in November 2016 brought a clear intent for repealing and replacing the ACA. Although there is low probability that many of the major ACA provisions, such as the pre-existing condition clause, will be completely removed, it is likely that many significant changes will be introduced. Several attempts such as the Better Care Reconciliation Act (BCRA), the American Health Care Act (AHCA), and the "skinny repeal" bill were made to replace the ACA or establish legislation that can lead to further repeal negotiations, but none of these attempts secured the required majority for passing in the houses (Oberlander, 2017). According to the Congressional Budget Office (CBO) the plans introduced by the House and Senate would impact the coverage for low-income persons as coverage will become less affordable (Congressional Budget Office, 2017). To repeal the ACA without an adequate replacement could lead to adverse effects which will significantly impact the coverage of many Americans (Malina et al., 2017). Regardless of the changes that might impact accessibility to healthcare, however, the fact remains that with current resources and a high demand on clinical services, there is a fundamental need for effective care collaboration and communication.

1-4. Health Information Technology

Health information systems originated in the economic management segment of the health care discipline (Payne et al., 2013). Over the years, these systems have evolved into a sophisticated, yet fragmented groups of technologies with the goal of delivering safe, appropriate, patient-centered care, including care coordination. Effective care coordination relies on the accuracy of the information exchanged among all participants in the care system to lead to a robust evidence-based decision-making process. Health Information Technology (HIT) plays an essential role in providing coordinated care, because the accurate information required can be gathered primarily from health care information systems, which are currently utilized by EMR/EHR adopting providers. Also, the coordination strategies that utilize patient information and set care delivery benchmarks are implemented via tools that either currently exist within the HIT systems or could be augmented to serve as care coordination mechanisms. This implementation requires two main phases: the implementation phase and the outcome assessment phase.

1-5. Study Significance

This study focuses on the link between healthcare issues that arise due to lack of standardization in quality measurement and existing health information technology systems that could be utilized to resolve such issues. This study is significant because it analyzes care coordination factors that are indicated by the Meaningful Use measures. These factors are used to enhance collaboration between all stakeholders and align all care efforts to deliver appropriate care based on patient needs. The lack of coordinated care in many cases could be the cause of duplicated medical services and wasteful expenditure. Lack of standardized measures could contribute to wasteful spending workflows that are rarely monitored or addressed efficiently. Healthcare facilities are undergoing a series of transformations in the care delivery system that in turn have motivated the U.S. government to develop different coordinating models that could serve in different settings. Most of the newly developed models are emphasizing the need for coordination by tying health outcomes with payment methods and encouraging all stakeholders involved in the care delivery to participate effectively and efficiently. However, these models mostly target a portion of the providers or patient populations that are selectively or voluntarily participating in these programs. Lack of comprehensiveness in developing quality measurement models could cause insufficiencies in the future model requirement gathering process. Traditional payment systems of fee-for-service have been increasingly replaced by alternative payment models such as: Accountable Care Organizations (ACOs), Primary Care Medical Homes (PCMH), and bundled payments. These models will help in forming measurable goals when implemented in different settings and will move payment systems to become quality-based rather than quantity-based. However, a measuring framework or tool is required to provide an assessment of current care quality status for the majority of practitioners.

1-6. Problem Statement

Increasing healthcare cost is a challenge faced by most developed countries. Aging populations and advances in care that enhance the quality of clinical processes are some of the contributing factors (Appleby, 2012). Reimbursement systems that focus on the volume of performed procedures rather than outcome quality also contribute to the rising costs. Health care expenditures currently account for more than 17% of the entire US GDP. Economists predict that this share will rise to 20% by 2025 (Centers for Medicare and Medicaid, 2015). Care outcomes are not displaying a similar rise in improvement to match this expenditure growth. Policy makers and health care organizations are turning their attention towards initiatives that can improve quality of care and control expenses in an effort to find a balance between cost and outcome. To succeed in improving care quality, it is essential to utilize measuring systems that track and coordinate the contributions of all stakeholders and evaluate their impact on the care outcomes. Coordination and communication between all participants in the care process becomes a fundamental step towards stakeholder accountability.

Although initial estimates were highly optimistic about the role of health IT in controlling cost and enhancing the efficiency of care delivery, data has shown that after several years of technology adoption the cost of providing services has increased remarkably (Kellermann & Jones, 2013). One of the reasons that health IT was not able to reach its full potential could be associated with the failure of facilities to adopt all the capabilities that the new IT systems offered. There could be many factors that potentially impact the optimum utilization of health IT. The IT transformation in industries such as telecommunication, banking, and manufacturing highlights the value of coupling information technology with organizational support that includes planning and incentivizing adoption. To incentivize the adoption of IT systems in the healthcare field, it is critical to develop measuring tools that can provide comprehensive quality assessment. In this study, we provide methods to quantify coordinated EHR functionalities and measure the link between them and care outcomes. This connection will enable providers and policymakers to plan for and invest in information systems that can directly influence coordinated care measures and potentially ultimately improve care outcomes.

1-7. Purpose of the Study

In this study, we explore the relationship between care coordination functionalities that are embedded within the EMR/EHR systems and patient experiences measured in health quality outcomes (patient-provider communication and patient accessibility to care). To ensure care coordination, clinicians are required to provide care continuity during transitions between different care settings (referrals, clinical decision support systems, and patient summary reports), to access and interact with interoperable patient records (standardized EMR/EHR systems, patient summary reports), to share responsibility and accountability with all stakeholders including patients (standardized EMR/EHR systems, patient portals, care-related benchmarks), and to report complex/chronic conditions to regional and federal health authorities (using interoperable EMR/EHR systems, patient summary records, patient registries). Although current EHR systems can provide a range of care coordination measures, it is essential to identify their impact on care outcomes. Many of the current clinical tasks that are classified as coordinating efforts only track a given point-of-time of the care process measures while care coordination requires continuous connectivity between actions performed and future events planned based on current care status (O'Malley, Grossman, Cohen, Kemper, & Pham, 2009).

In this study, we view care coordination as an integral and fundamental part of health information technology. Many of the current health IT applications include the potential for coordinating care and tracking stakeholder contributions; however, determining the appropriate value of each set of functionalities as a coordinating strategy requires a detailed study of their impact on healthcare outcomes. The impact of coordinated care on healthcare outcomes was assessed after considering the social determinants in the community studied. We identified the most significant health IT measures that could be categorized as coordinating processes, and hence which had the greatest potential to improve care efficiency.

1-8. Research Questions

The following research questions were identified to measure the impact of care coordination on healthcare outcomes. Care coordination measures systems that could assist providers and healthcare facilities with collaboration efforts were retrieved from current implementations of health information. We also identified possible confounding factors that could impact the EHR system implementation, and hence undermine the care coordination's effect on care outcomes. These factors belong to the social determinants of health and are community-specific. Two specific questions were addressed.

A) How can technology significantly impact care coordination and healthcare outcomes?

A-1) Build a model/framework to demonstrate the link between Electronic Health Records and care coordination strategies.

A-2) Estimate the significance of the care coordination strategy measures on healthcare outcomes.

B) How will social factors impact the relationship between care coordination, technology, and healthcare outcomes?

B-1) Through a review of the literature, identify the social determinants that are impactful on healthcare outcomes.

B-2) Measure the social determinants' potential impact on the link between care coordination technology measures and healthcare outcomes.

2. LITERATURE REVIEW

In this chapter, after defining care coordination and its primary elements, we review similar studies that have attempted to measure the impact of care coordination on care outcomes. Next, we introduce care coordination as a "systems thinking" model in order to build a framework that connects care coordination strategies with current health information system tasks. Finally, we discuss the socio-technical variables that may impact health information technology implementation, and hence undermine the significance of care coordination on healthcare outcomes.

2-1. Care Coordination Significance

Providing effective care has been demonstrated to be linked to several key factors such as: promoting patient-centered care, improving patient compliance to recommended medications and self-care regimens, improving clinical communication, and increasing evidence-based decision-making (Peikes, Chen, Schore, & Brown, 2009). A growing number of patients with chronic diseases or care complexities require effective use of resources and care integration to reduce wasteful expenditure. In order to control rising healthcare costs, in addition to cost reduction strategies, care delivery services must identify achievable goals, create systemic incentives, and make specific process improvements (Bentley, Effros, Palar, & Keeler, 2008). Care coordination has been emphasized as a key component of newly developed care delivery methods like Accountable Care Organizations (ACOs) and Patient Centered Medical Homes (PCHMH), which focus on improving care quality measures and transforming reimbursement methods.

Care coordination improvement will benefit all stakeholders in the care delivery system. Patient, provider, and payor satisfaction will improve due to increased efficiency in the care process. Improving care outcomes; enhancing care quality; reducing medical errors, non-emergency ER visits and unnecessary hospitalizations; and lowering care cost are potentially direct outcomes of an improved care coordination. Studies have shown that patients with chronic diseases account for a substantial portion of healthcare expenditures, (Stanton, 2006) and that traditional approaches to care produce fragmentation of services resulting from inadequate coordination.

2-2. Essential Elements of Care Coordination

Care coordination impact varies in different settings. There is a large variety of definitions available for care coordination; however, the most important concept, which is constantly repeated in these definitions is: delivering the appropriate care, at the right time, in the right setting (McDonald et al., 2007). Care coordination measures are implemented to achieve certain goals and, due to differences in clinical settings (such as patient characteristics and capabilities combined with provider preferences and resources) these goals could vary considerably. This variation can also ultimately impact care coordination across different settings. Communication initiated from a primary care facility to a specialty care setting could differ from communication from the same primary care facility to a community health center, and therefore goals and expectations should accommodate these differences.

Standardization in defining care coordination is a very important concept in determining coordinated measures embedded within EHR systems. According to Agency for Healthcare Research and Quality (AHRQ), the main elements in care coordination are: identifying all relevant stakeholders in the process of care, determining their roles and resources, establishing clear channels of communication between all care participants, and integrating care activities to ensure the appropriate delivery of healthcare services (McDonald et al., 2007). Each of these elements could include several sub-elements that must be clearly identified in clinical settings; for example, care providers in the case of a healthy patient may only include a primary care physician, while in the case of an elderly patient with multiple co-morbidities will include several practitioners (primary and specialty practitioners) combined with community health resources. These differences in sub-elements will consequently influence the interdependence between the care participants and impact the degree of stakeholder interoperability required and the complexity of all participant roles. Understanding such differences will highlight the value of communication channels between care participants using health information technology, and the purpose of formulating adequate assessment measures to evaluate efforts in collaborative practice. Information exchange in a coordinated system depends not only on the content of the information exchanged, but also on the credibility of the information. The aspect of information credibility will help clinical staff to clarify the role of collaborating participants. For example, messages sent from an ER facility to a specialty physician should be classified based on the role of the sender – in this case, a provider of emergency services – and not merely the content.

- The impact of care coordination has been shown to be significant in complex settings such as emergency rooms and intensive care facilities (Hoffer Gittell et al., 2000). Patient focus groups have further identified care coordination as one of the seven factors that influence their perception of care quality (Hoffer Gittell et al., 2000). When considering care coordination implementation, however, healthcare facilities must review their resources and capabilities to prioritize the coordination elements most applicable to their facility. In many cases, the adoption of health IT systems has been considered an investment to enhance care coordination. Although accurate information exchange (via reliable IT systems) in a coordinated system is invaluable, several additional phases are required to ensure a fully coordinated system in different clinical settings. Receiving accurate patient health information and applying it appropriately after verifying its quality is considered a full cycle of a reliable clinical data exchange. Coordinated care goes a step further by highlighting the value of tracking and recording the flow of information exchanged to update stakeholders about the patient care process. Such updates, aside from informing clinicians about the exact status of their patients, can also prevent waste of time and money (Traver, 2013). A successful care coordination program targets the [optimum] identification of next steps in the process of care and the right clinical (or non-clinical) staff that must perform this step (Traver, 2013).

2-3. **Studies on Care Coordination Impact**

There have been numerous studies that provided methods of measuring the impact of care coordination strategies on care outcomes and quality. We discuss several of these below to highlight important concepts and provide a perspective that forms the basis of our study.

To measure the relational coordination on patient outcomes, a group of researchers conducted a multisite cross-sectional study on nine hospitals (from New York, Dallas, and Boston) assessing the impact of coordination on hip and knee surgeries (Hoffer Gittell et al., 2000). Care outcomes were evaluated based on questionnaires provided to patients and providers in addition to hospitalization records. Assessment was based on patient-provider communication and patient-centered measures (respect for patient wishes and ample training). Relational coordination is based on communication (frequent, timely, accurate, and problem-solving communication) and relationship (shared goals, shared knowledge, and mutual respect) between stakeholders (Hoffer Gittell et al., 2000). The study found that relational coordination dimensions were significantly associated with improved quality of care (Hoffer Gittell et al., 2000). This study is valuable as it provides insight into the relational coordination, but it addresses only a specific case of medical procedure in a limited number of states/hospitals. Also, the mean average of the patient age was 69.9 years, which also limits the generalizability of the results achieved.

A study funded by Centers for Medicare and Medicaid Services (CMS) assessed the impact of a strategic partnership between a nursing care coordination telephone support program and a home healthcare agency on clinical efficacy in managing chronic illness (Alzheimer's disease), use of community services, caregiver satisfaction, inpatient healthcare use, and cost (Engelhardt et al., 2008). It found that the pilot program was successful in reducing average inpatient cost and improved use of community services. However, this study only followed 36 subjects with the mean age of 78 years who were patients in one medical center and an affiliated home health center. This could be considered a limitation in the generalizability of the findings.

In a comprehensive study, the CMS funded 15 demonstration programs to become Medicare Coordinated Care Demonstration (MCCD) sites (Peikes et al., 2009). Unlike previous attempts, these programs allowed facilities to structure heir interventions based on their target population (chronically ill patients) for an extended time (2002-2006) by utilizing care coordinators. The results did not show a significant improvement in reducing expenditures, but two of the hospitals demonstrated a positive impact on hospitalization rates (Peikes et al., 2009). The study highlighted the value of implementing care coordination interventions as part of chronic patient hospitalization, which is considered to be a time when a patient needs the most assistance, to achieve optimum results in reducing cost (Peikes et al., 2009). Some programs focused on physician adherence to clinical guidelines and others targeted their efforts towards patient education and training (role play with physician to ensure comprehension). Not all the programs implemented were fully successful, but the study found some success in the case of two hospitals that used care coordinators. Unfortunately, no additional assessments were conducted that could have provided specific information on the environmental conditions that potentially could have had considerable influence on the results of implementing the coordination programs at these two facilities. More comprehensive studies are required to identify methods of standardizing coordination efforts. Furthermore, the use of patient coordinators adds a unique dimension to the study, as each professional could utilize a different combination of coordination methods that could exceed the capabilities provided through health information systems. Although these combinations might enhance the success rate, they could also impede the generalizability or standardization of such techniques, especially if a reliable tracking method has not been utilized.

2-4. Health Information Technology and Care Coordination

Demand for care coordination is becoming ever clearer as the population ages and a larger number of patients with multiple co-morbidities are seeking healthcare services. These chronic conditions require the collaboration of several clinical settings that in many cases are part of different systems. In 2011 Medicare beneficiaries with more than one chronic disease accounted for 93% of Medicare cost (Centers for Medicare & Medicaid Services, 2013). Coordinating care for chronic patients requires gathering, processing, and exchanging all patient health information that is assembled in multiple clinical settings. Clinical collaboration requires dedicated effort in organizing patient information and an elevated level of commitment to apply accurate information to contributing clinicians.

Health IT plays a key role in improving care coordination. Healthcare facilities have implemented information systems such as EHRs while adopting Meaningful Use act and other federal provisions that highlighted the value of health information exchange (HIE). Although EHRs provided a large array of services in storing, retrieving, and processing patient health information, they have not been able to ensure care coordination functionalities (Bates & Rudin, 2013). EHR systems can have a significant impact on increasing care coordination by integrating, organizing, and facilitating the proper distribution of health information to all contributing care participants. Medical alerts and notifications are examples of effective tools within the EHR systems that could assist providers with coordinating their treatment tasks. Standardized data availability in the EHR also plays a vital role in informing clinicians about patient care status, and consequently improving the data exchange process.

2-5. Care Coordination as a Healthcare System

A system is a purposeful structure containing interdependent entities that are constantly influencing each other. All systems have a) input, output, and feedback mechanisms; b) a steady internal state despite the external environmental conditions; c) properties that are different from the entire system's behavior and are not possessed by any of the individual entities; and d) different system definitions/boundaries depending on the observer (WebFinance Inc, 2017). Systems can be divided into two main categories: 1) Closed systems are considered theoretical systems and do not interact with the environment and hence less likely to be influenced by their surroundings. 2) Open systems can influence their external environment by taking the input and processing it to produce output for their external environment (WebFinance Inc, 2017).

According to the World Health Organization (WHO), a health system is one that includes all organizations, individuals, and actions involved in promoting, restoring, or maintaining health (World Health Organization, 2007). This involvement could be in the form of efforts that target improvement in health determinants as well as activities that directly target health improvements. WHO defines overall health system goals as: improving health and health equity in responsive and financially sound ways that make the best and most efficient use of resources (World Health Organization, 2007). In this study, care coordination is considered a health system that focuses on all the contributing stakeholders that are participating in providing health care services.

2-6. Theoretical Lens of Analysis

In the sections below, we discuss the theoretical frameworks that were utilized to describe the care coordination system and its components.

2-6-1. Using Systems Thinking Model to Evaluate Care Coordination System

Due to the complexities involved in coordinated systems, we use systems thinking model to discuss care coordination components. Systems thinking is considered a general conceptual orientation that encompasses the interrelationships between system entities, and their relationships with a functioning whole (Trochim, Cabrera, Milstein, Gallagher, & Leischow, 2006).

A coordinated care system involves significant interdependence between participating stakeholders. Experts are increasingly realizing that improving methods that are able to solve individual issues is not sufficient in solving problems inherent in complex coordinated systems. Therefore, using a systems thinking model is vital in improving our ability to comprehend complex systems (Arnold & Wade, 2015).

One definition of systems thinking is:

> "*A set of synergistic analytic skills used to improve the capability of identifying and understanding systems, predicting their behaviors, and devising modifications to them in order to produce desired effects. These skills work together as a system.*" (Arnold & Wade, 2015, pp. 669-678).

A care coordination system includes many stakeholders that are affected by each other's roles and are constantly impacted by the care outcomes, which inherently influence the entire set of stakeholders. In fact, according to the AHRQ definition of care coordination, we can summarize that care coordination is defined by the stakeholders, their roles, and the communication channels that connect them to one another. To understand a system well, it is critical to identify the events that are included within the system and the patterns of behaviors associated with these events. Identifying the interactions that produce these patterns will help the analysis and design process to outline the components/stakeholders that trigger such interactions, and also assist in defining a boundary for the system. The key events in a care coordination system are: patient-clinician encounter, patient diagnosis and treatment, clinical documentation, clinical communication, and health outcomes. Drafting a care coordination boundary map will require defining the behaviors that are produced by these events and ultimately drawing a detailed top-down analysis map that includes all stakeholders. Identifying the boundaries will also reveal the environmental factors that are produced from the larger [external] area that contains the system.

Care coordination systems share some key characteristics. They are:

Open systems: A care coordination system is an open system since it does not exist in isolation and continuously interacts within its environment. Care providers, payors, and patients are continually impacted by their environmental conditions while they exist in a care coordination system.

Probabilistic systems: The output in a care coordination system is not fully predictable due to patient characteristics and treatment specifications. Hence in a care coordination system, as a probabilistic system, the output could be estimated based on probability values with a certain margin of error.

Man-machine systems: A care coordination system consists of individuals and health information systems and as such it is a man-machine system.

Concrete systems: Several of the stakeholders/components in a care coordination system are considered to be objects such as the healthcare facility and their information systems.

Adaptive systems: A care coordination system includes elements that are constantly adapting themselves and modifying their roles to improve the outcome. Patients, clinicians, and payors are participating in plans to increase care coordination efforts and in the process, they implement updates and changes to their routines and care processes. These changes could be in the form of training or adopting new technology that enhances their capabilities and resources.

Complex systems: Care coordination is considered a complex system due to the numerous interrelated entities that are communicating with each other (Thakur, n.d.).

Figure 1 displays a care coordination system in three layers (stakeholders, interdependence or relationships, and system goals), allowing us to visualize the system utilizing the systems thinking framework. Entities and properties are shown in each layer, and layers are connected to each other by diverse types of interactions. The 'Primary Stakeholders' include patients, providers, and payors, not including regulatory bodies and policymakers (which are beyond the scope of this study). The 'Relationships' layer focuses on information systems technology characterized by multiple properties such as accountability, communication, and patient support. These properties are rooted in care coordination dimensions that could significantly impact stakeholder interdependence and care outcomes. The third layer represents the 'System Goals,' which are presented in three primary areas: population health, patient experience, and cost. This study discusses, the impact of care coordination on patient experience domains (patient-provider communication and patient accessibility to health) According to Barry Richmond's definition of systems thinking, a comprehensive view of a systems thinking is one that can see the forest and the trees at the same time and have one eye on each (Arnold & Wade, 2015). Through analyzing the interrelationships in systems thinking, we sought to evaluate interdependence properties that form patterns of interaction between elements to assist in

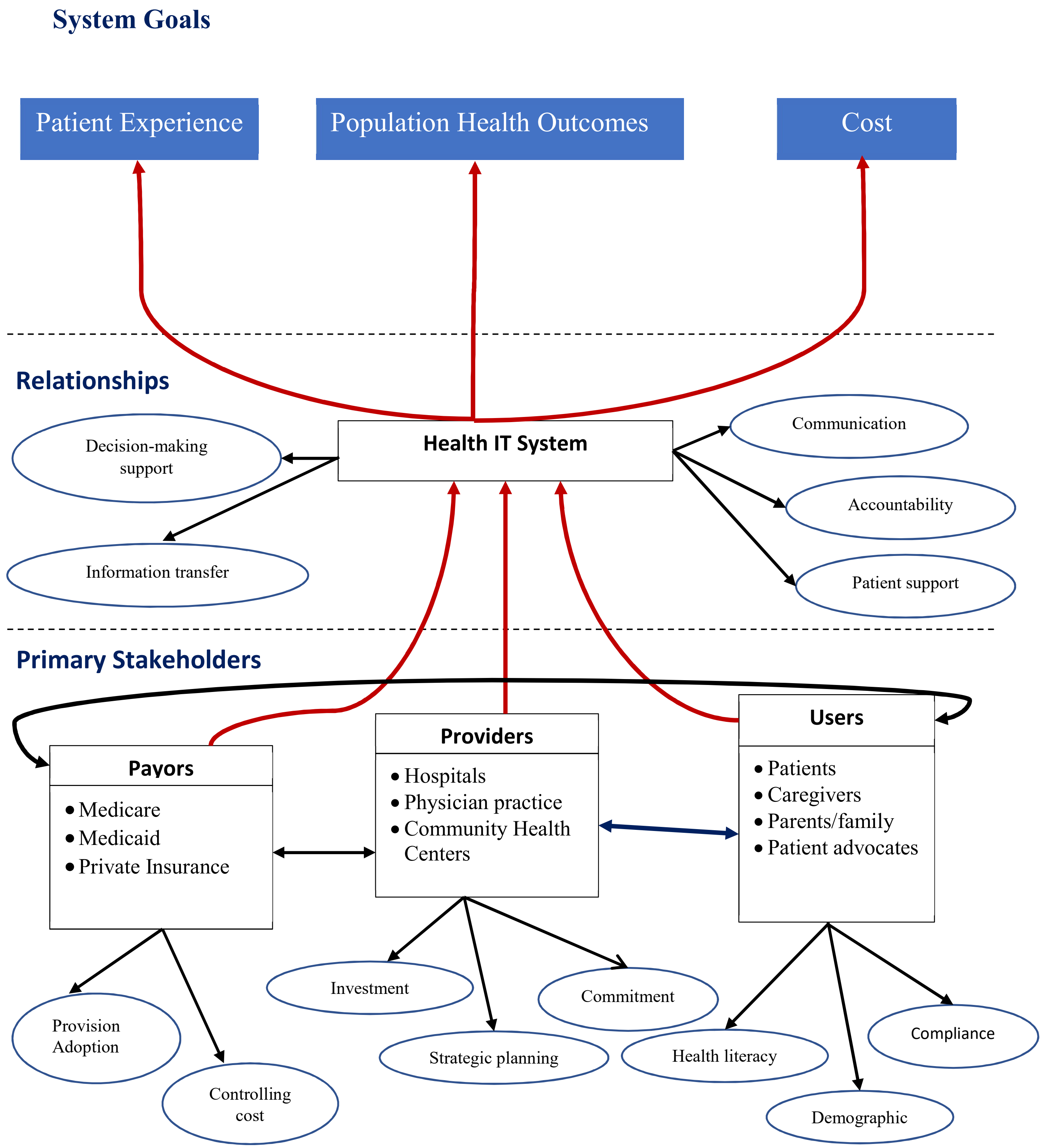


Figure 1. Proposed conceptualization of care coordination using systems thinking

outcomes evaluation. In a patient-provider interaction (such as during an office visit), a patient's expectations will be influenced by the concept of accountability– in other words, the patient will be interested to ensure that the system could assist in providing best treatment available. At the same time, a physician will be more interested in utilizing the system optimally to achieve the best communication objectives with their patient and remaining clinical staff. A successful system is one that provides all office visit information relevant to the patient's conditions and assists physicians with supportive material that will improve the quality of care through patient training and collaboration. Coordination systems can vary based on the importance they assign to each category of collaboration, depending on their patient populations and resource availability.

The care coordination system above also resembles Donabedian's conceptual model (see Figure 2), which is familiar to the health care quality research community (McDonald et al., 2014).

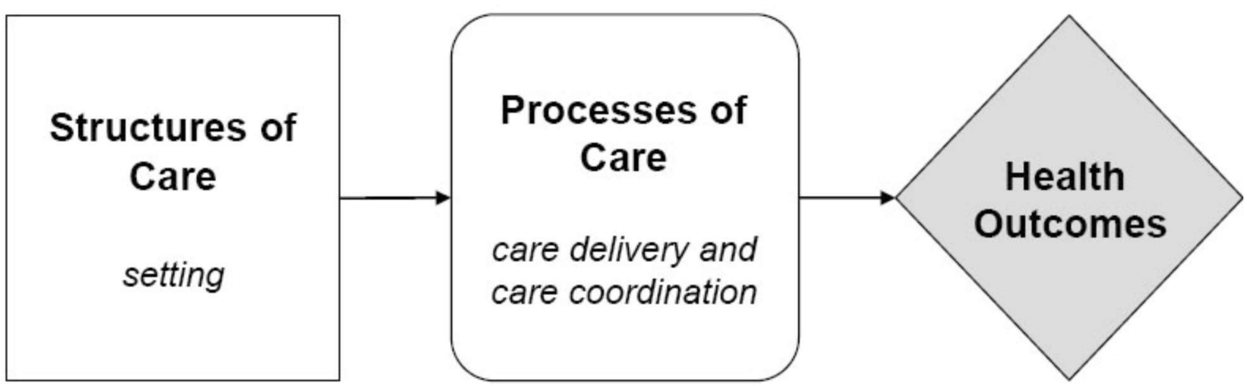


Figure 2. Donabedian's conceptual model *(McDonald K. M., et al., 2014)***.**

In Donabedian's model, the structure includes all the entities that participate in the care delivery process, which are translated into our system in the form of stakeholders including: patients, providers and payors who are contributing to the treatment process to varying degrees. The Relationships section of the model includes processes such as diagnosis, treatment, preventive care reminders, and patient support. There is a technical aspect associated to processes that encompass the health IT systems implemented by healthcare facilities. According to Donabedian, measuring the process of care is similar to providing a quality of care measure. In the model displayed in Figure 1 we measure the attributes of the relationships to identify their impact on the goals and outcomes (Perides, 2003). The outcomes element of the Donabedian model includes measures of patient satisfaction and experience as well as population health status. Health outcomes are considered in many studies as the ultimate measure of quality, as improving the quality of health is a significant goal in care processes.

2-6-2. Evaluating Feedback Control (Cybernetic Systems) in Care Coordination Systems

Information systems development is based on the conceptual foundation of systems theory (Austin & Boxeman, 2003). In order to comprehend healthcare information systems and their impact on management functionalities, facility leaders and policymakers must build upon the systems theory basics. The concept of cybernetic systems is an ideal approach to analyze and describe a care coordination system, as it provides a holistic view of healthcare processes and describes the roles of all system components that contribute to the system output. Implementing management control requires a clear comparison between system expectations and current performance. A cybernetic system provides continuous feedback and requires adjustment of the system when goals are not met. The feedback and adjustment processes are based on a comparison of actual outcomes with expected outcomes. Figure 3 displays a cybernetic model of the care coordination system.

To define a care coordination system, we must consider the components that build the system and the relationships between these components and their properties. Care coordination system relies heavily on **defining the relations** between system components. This reliance goes further than a basic system coordination between components that merely substitute a mismatched group of elements by providing basic information/protocol exchange approach. In addition to providing reliable relationships among the components, we also must identify a common goal for the entire system, which will assist in forming a care coordination system that entails all components in a given setting. The relations within a care coordination system must be based on the timeliness, precise demand, and accuracy of information exchanged. A definition of care coordination system is: the services are planned to be tailored to the needs of patients by effectively and efficiently utilizing existing resources which ultimately will control cost and involve all participating stakeholders.

As an **open** system, the care coordination model above is influenced by several environmental factors including social, financial, political, and environmental elements. In the social factors category, human engineering plays a critical role as an outcome-influencing determinant. Human behavior patterns, including staff interactions and clinician-patient (or caregiver) communication methods, could influence the process of care coordination. Staff characteristics, their level of training and technical background will have a direct impact on the adoption of EHR systems. Unless these social determinants are considered during planning for health information systems and accounted for during their implementation, care outcomes could carry unintended consequences. In the financial category, the availability of resources plays a

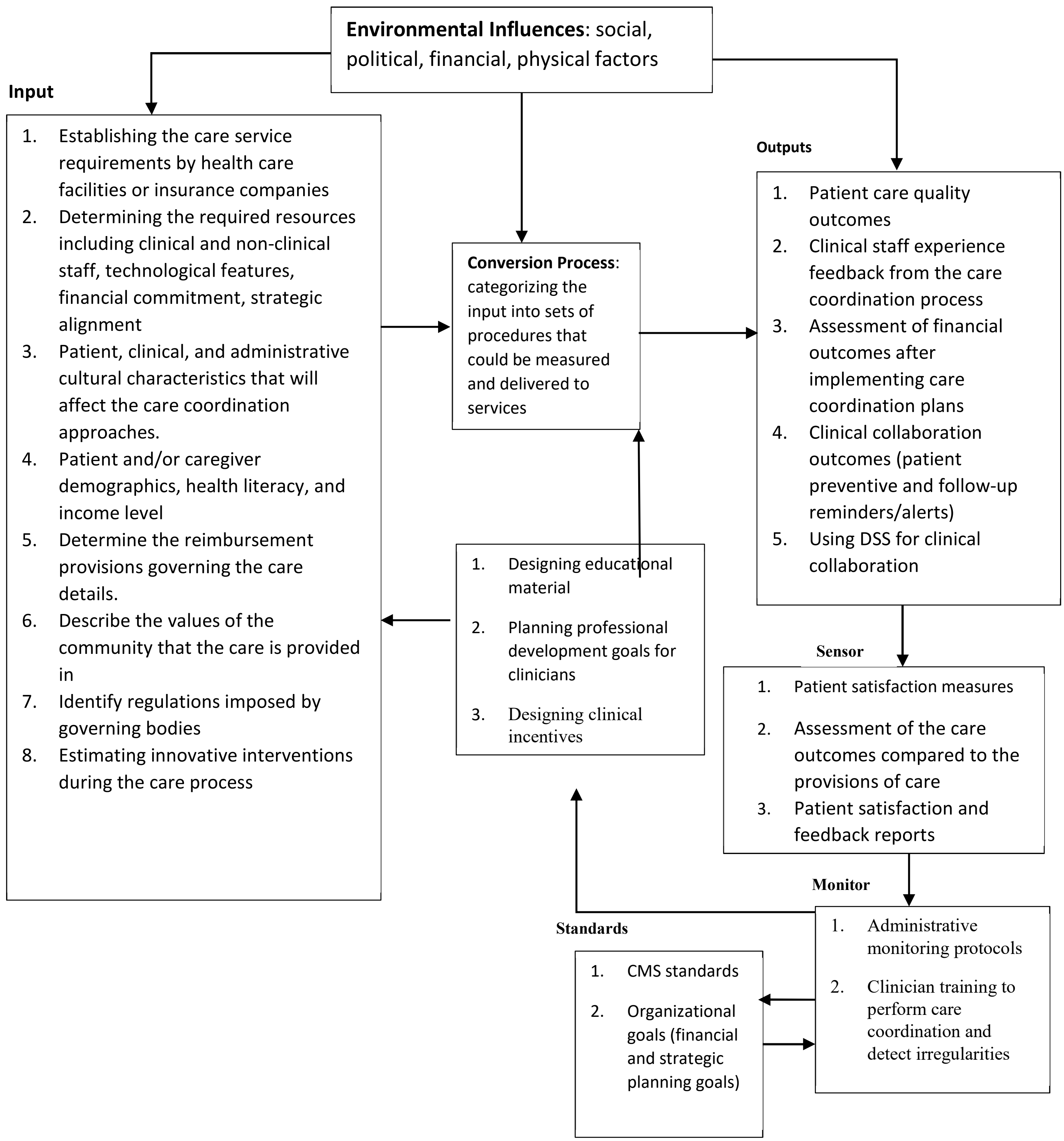


Figure 3. Proposed care coordination feedback processing (cybernetic) model.

significant role. Changes in the local economy, such as recession or increased unemployment, will impact the level of investment in healthcare organizations and patient participation (or willingness) in the treatment plans. Political factors will also impact the care coordination system. Regional politics and strategic organizational planning will affect prioritization of projects in healthcare facilities, potentially impacting new information system adoption-related tasks and progress. Finally, physical environment also plays an important role in the success of health information system adoption. The space allocated to system terminals and the proximity of this equipment in relation to service delivery points is highly relevant to their proper use and efficiency. Computers in intensive care units that are not closely positioned to the patient’s bed and rely on clinical staff for long data entry processes, could potentially become distracting tasks that may have negative impact on outcomes and on the successful implementation of the healthcare information system.

In the above cybernetic model, the care coordination system is considered a complex system due to its potential for producing outcomes that are more sophisticated than its individual component outcomes. The model has a self-regulating aspect that is performed by the feedback processing units: sensors, monitors, standard setting units, and control units. An effective healthcare system must consider the potential of forming different patterns within care facilities. Biological variation among patients, combined with differences in clinical preferences, treatment approaches, and training will result in a large number of outcome permutations that must be monitored and tracked. For this reason, a cybernetic care coordination system will enable facility managers to compare their outcomes by utilizing the sensor unit data, and to produce input for the monitoring unit that is constantly referencing (via mutual interaction) the standard unit. This standard unit could be a combination of the regional policies and organizational planning methods that will set boundaries for system implementation and development. The final stage of the feedback is produced in the control unit, which will provide input for the conversion and input components of the system. The control unit will take signals that identify the type of changes required in conversion and input processes based on the current output and the feedback process. In a care coordination system, a successful implementation of a cybernetic model could be presented by an elaborate information system that provides the ability to accurately track care coordination functionalities and to report and improve on future treatment and patient-provider encounters. The output of the control unit can include training programs, recommendations for information system updates and enhancements; or it could include more substantial measures such as changing the workflow of the healthcare organization to incorporate transparency and accountability in order to ensure better care coordination measures.

In developing a cybernetic care coordination system, the information transferred must have several important characteristics that will influence the total process. The information must be relevant to the process of coordination, timely, unbiased, comprehensive, action-oriented, and cost-effective (Austin & Boxeman, 2003). Ensuring these qualities in preparing the information will increase the success rate of the system in general. Investing time and resources to produce information that is not relevant to the care process or clinical collaboration methods will not produce improvement in the management of change and decision-making.

2-6-3. Care Coordination Strategies in EHRs

The goal of implementing coordinated care is to improve patient care transition between settings and enhance patient care continuation capabilities by providing sufficient support and knowledge to all care contributors. The care coordination system's main elements could be summarized in four categories: assuring accountability, providing patient support, participating provider communication, and ensuring proper information exchange (McColl Institute for Healthcare Innovation, 2011). In Table 1, we describe each category of care coordination as represented by clinical processes that could be translated into EHR-based tasks.

TABLE I. PROPOSED CARE COORDINATION COMPONENTS WITH MAPPED STRATEGIES

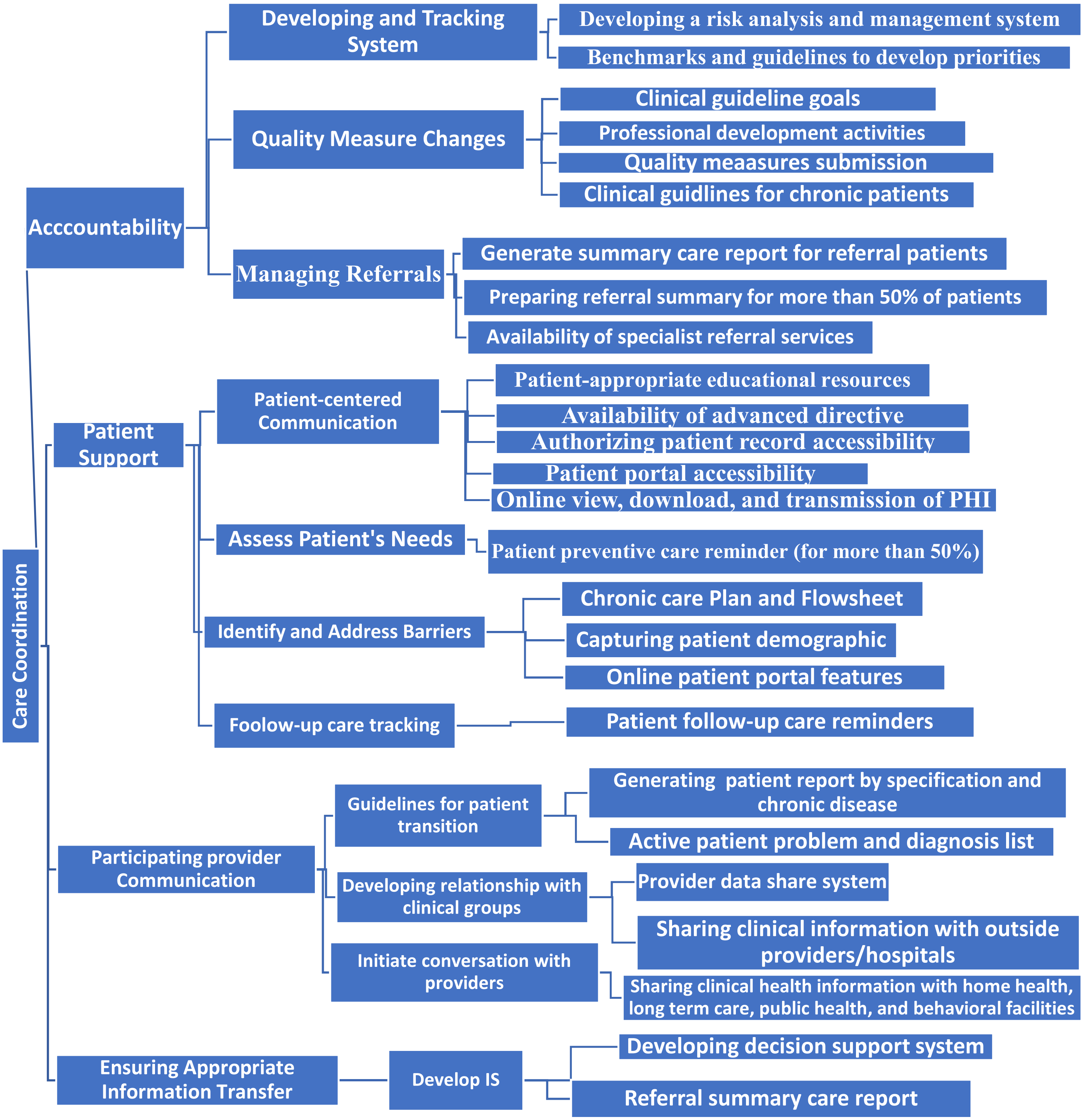
Care Coordination Components	EHR functionalities mapped to care coordination
Accountability	• Developing a tracking system • Developing quality improvement changes and measure progress • Managing referrals specialist consults, hospitalization, and ER visits
Patient Support	• Promote patient centered communication • Assess patient's needs • Identify patients with barriers and help them to address these issues • Provide follow-up post referral
Participating Provider Communication	• Identify and develop relationship with clinical groups • Initiate conversations with key clinical groups • Develop guidelines for transition processes
Ensuring Appropriate Information Transfer	• Develop information transfer system • Develop shared EHR or shared e-referral system

The four care coordination categories are meant to offer practical steps in implementing accountable and effective care. By measuring the degree of IT systems' coordinating abilities, providers will be able to improve care transition and referral systems. Also, facilities and policymakers can utilize the categories to structure improvement efforts via pay-for-performance reimbursement. Most healthcare facilities focus on implementing the EHR systems to fulfill the meaningful use requirements and have limited interest in enhancing a comprehensive care coordination program that will increase efficiency and control cost (Bates & Rudin, 2013). For this reason, it is important for policymakers to sponsor research that will evaluate health IT capabilities that include care coordination and to implement pilot programs that advocate such strategies (Bates & Rudin, 2013).

Figure 4 maps the functions of EHR systems to the dimensions/components of care coordination. Patient-centered care measures in EHR tasks across the care continuum and patient transition will highlight the fundamentals of coordinated care. The collaborative aspects of EHR tasks create a practical assessment field that will allow for more-detailed evaluation of care coordination within the services delivered.

EHR functionalities are based on several important principles: Gathering and storing patient health information, presenting clinical guidelines and protocols, and managing and generating patient care plans.

All EHR functionalities require a degree of collaboration, depending on the outcomes expected; however, many care coordination strategies explicitly rely on EHR functionalities. The degree of coordination relevance for each EHR task will depend on resources, goals, and capabilities present in each organization. Another issue that could impact the coordination relevance of EHR tasks is lack of standardization in this area. Standardization in care coordination could rely on several factors such as payor-enforced reimbursement policies and research studies.



Care Coordination
Acccountability
Developing and Tracking System
Developing a risk analysis and management system
Benchmarks and guidelines to develop priorities
Quality Measure Changes
Clinical guideline goals
Professional development activities
Quality meaasures submission
Clinical guidlines for chronic patients
Managing Referrals
Generate summary care report for referral patients
Preparing referral summary for more than 50% of patients
Availability of specialist referral services
Patient Support
Patient-centered Communication
Patient-appropriate educational resources
Availability of advanced directive
Authorizing patient record accessibility
Patient portal accessibility
Online view, download, and transmission of PHI
Assess Patient's Needs
Patient preventive care reminder (for more than 50%)
Identify and Address Barriers
Chronic care Plan and Flowsheet
Capturing patient demographic
Online patient portal features
Foolow-up care tracking
Patient follow-up care reminders
Participating provider Communication
Guidelines for patient transition
Generating patient report by specification and chronic disease
Active patient problem and diagnosis list
Developing relationship with clinical groups
Provider data share system
Sharing clinical information with outside providers/hospitals
Initiate conversation with providers
Sharing clinical health information with home health, long term care, public health, and behavioral facilities
Ensuring Appropriate Information Transfer
Develop IS
Developing decision support system
Referral summary care report

Figure 4. Proposed care coordination components linked to EHR functionalities

Many countries are taking initiatives to improve their healthcare investments and hence the quality of care provided. The World Health Organization and the Organization for Economic Cooperation and Development (OECD) have supported health system performance measurement efforts (Onyebuchi, Westert, Hurst, & Klazinga, 2006). Effectively utilizing indicators of healthcare quality, and ensuring their meaningful contribution to performance evaluations, requires a detailed conceptualization of the factors involved. Identification of these factors will draw upon assessments of all activities and infrastructures that impact patient care or characterize the population health. Providing effective care that produces desirable outcomes is possible by performing evidence-based health care services to all who could benefit from such services (Onyebuchi et al., 2006).

2-6-4. Healthcare Outcomes

Healthcare organizations are focused on identifying and measuring outcomes that are relevant to their care environment. According to the World Health Organization, an outcome measure is defined as: "change in the health of an individual, group of people, or population that is attributable to an intervention or series of interventions." (Tinker, n.d.). Healthcare outcome measures fall in three main categories: improving patient experience, improving population health, and reducing/controlling cost. Unlike other industries, the healthcare field must consider several aspects in measuring outcomes:

- Identifying the proper areas that require intervention and the degree of change that is needed in each area.

- Establishing evidence-based measures in each intervention that will best serve certain types of patients under given circumstances.
- Comparing and identifying most effective interventions as part of care processes (Tinker, n.d.).

Defining proper healthcare outcomes depends on the area and the domain that is being measured. According to the International Consortium for Health Outcomes Measurement (ICHOM), healthcare outcomes are results that matter most to patients rather than to physicians and healthcare organizations; while the Centers for Disease Control and Prevention states that the ideal health outcome should be representative of a population's dynamic state of physical, mental, and social well-being (Ferguson, n.d.). Another important concept in measuring healthcare outcomes is who is being asked to provide responses to the evaluation measures, and whether the questions target the intervention's impact on the outcome measured rather than broad aspects of satisfaction or care status.

2-6-5. Defining External Determinants that Impact Health Information System Implementation

Accurately evaluating healthcare outcome measures after Health Information System (HIS) implementation will allow care facilities to focus on areas that require most improvement. Identifying external and socio-technical variables that could impact healthcare outcomes during and after the implementation of health information systems is critical in measuring the impact of care interventions. To evaluate these interventions the three main components of health informatics systems must be identified and evaluated. Health informatics systems include: hardware, software, and "peopleware" (Hannah, Ball, Marion, & Lorenzi, 2004). Evaluating all components equally will provide a comprehensive look at the final product, instead of a onesided view of the tools utilized during implementation. To improve the quality of health systems, implementation managers must consider all the skills that will impact these components: technical skills, project management skills, and people/organizational skills (Hannah, Ball, Marion, & Lorenzi, 2004). Failure to consider all the relevant skills and component combinations could cause either under-planning or overpromising, which could be considered indicators of shortcomings in the evaluation process rather than in the technology or system implementation (Hannah, Ball, Marion, & Lorenzi, 2004). Health information systems have introduced technical advancements such as data visualization and management, in addition to reliable clinical communication methods that represent a considerable improvement over paper-based medical records. HIT implementation in many healthcare facilities, however, has resulted in mixed outcomes. System implementations have not consistently produced positive impacts on care outcomes, due to the socio-technical factors existing in such facilities (Harrison, Koppel, & Bar-Lev, 2007). In many cases, HIT installations have resulted in the added steps or tasks which were unintended or unforeseen, and which could adversely affect the facility's operations or their patients. Implementing a new HIT system creates, in effect, a new layer of operations between clinicians and patients, which increase the efficiency with which tasks are performed. When a system introduction does not appropriately match patient and clinician expectations and conditions, it has the potential to produce adverse effects that must be addressed by the facility (Smith & Koppel, 2014).

2-6-6. Utilizing ISTA Framework to Evaluate Information System Implementation

Many conceptual models that assess the unintended consequences of information system implementation have been designed and studied to identify potential influences on health outcomes. Beside the newly adopted health IT systems, several external factors have also been considered influential on the healthcare outcome variables and are classified as: organization's sociotechnical system workflow, culture, social interactions, and existing technologies (Harrison, Koppel, & Bar-Lev, 2007). The Interactive Sociotechnical Analysis (ISTA) model depicts such interactions while focusing on feedback loops that could impact the newly implemented health IT system (Harrison, Koppel, & Bar-Lev, 2007). The ISTA model offers a new method of evaluating health IT implementation within unfolding sociotechnical processes which means that technology alone will not determine the success or failure of implementation outcomes. This vision will help facility leadership view their health IT implementation within the context of a greater system that could be impacted by elements in the encompassing system. These external elements, if they remain undetected, will produce unintended consequences that will impact the value of the information system implementation. ISTA interaction types are categorized into five main criteria:

1. *The impact of health IT implementation on existing clinical processes.* This impact could be viewed as any adjustment that the clinical staff experiences due to changes that are caused by the information system implementation (Harrison, Koppel, & Bar-Lev, 2007). For example, care coordination implementation might reduce the direct phone communication between a community health center and primary care practice staff due to reliance on the newly implemented computerized system. Although such a system might provide accurate information if populated on a regular basis, due to the heavy workload of clinicians, this could establish unrealistic expectations for the staff. As a result, the newly implemented health information system will result in replacing the regular phone communication (that played an important source of information for clinical

tasks) with a system that is not updated regularly and thus could actually adversely impact the clinical processes.

2. *The physical settings in the facility and their potential in adopting new health IT systems.* Lack of proper interface between clinical physical settings and newly adopted information system could create workarounds and redundancy that decreases care efficiency and quality (Harrison, Koppel, & Bar-Lev, 2007). Care coordination systems could add duplication in clinical tasks. If there is insufficient interoperability between existing EHR system and newly introduced care coordination system, clinical staff might be forced to log out of their existing system and log into the care coordination system to reenter the same patient information, which will introduce inefficient time management. Also, the location of the computers in the clinical setting must consider the volume of work required per each clinical process. Bedside documentation for chronically ill patients or complex ICU patients might force nurses and clinicians to spend a long time entering patient information into the system, which could distract them from monitoring the patients appropriately.

3. *The organizational/clinical workflow comprehension by the newly implemented information system.* When new systems are purchased and implemented by facilities, very often they do not offer all clinical procedures in the same format or a in the same order, which could either force clinicians to introduce changes into their busy routines or duplicate certain processes to adhere to health IT system implementation (Harrison, Koppel, & Bar-Lev, 2007). In the case of systems that require clinical staff to enter all patient communication at the point of care, staff might not be able to comply as they need to focus on patient needs in the emergency department and cannot afford such

distractions. If the care coordination system for the emergency room relies on the information entered for physician's quick response, the adoption of the information system will introduce a level of complication due to its reliance on unrealistic expectations from busy ER doctors.

4. *Potential changes in the clinical social system.* Clinical staff with certain duties and responsibilities could lose their authority if the new health IT system does not implement such requirements across all processes (Harrison, Koppel, & Bar-Lev, 2007). If a newly implemented care coordination application is enforcing all contributing practitioner's approval for a new medication prescription, or a lab test in the case of hospitalized patients, and only grants urgent medical order prescriptions to hospital staff (nurses, or physician assistants) with a confirmed physician reviewing option (that could be issued at a later time), this could create additional confusion for clinical staff. For example, if a nurse working in the night shift is required to increase a prescription dosage (that they consider a normal routine in the case of manageable complications) and this clinical task triggers a physician approval request in the newly adopted information system, then adding such prescriptions as "urgent changes" will produce a large number of review scenarios that require the primary care physician's approval (and that are not truly urgent), which will consume physician time inappropriately.

5. *Workflow incompatibility between the adopting organization and the new health IT system.* When newly adopted information systems force unattainable changes on clinical staff or facility managers, certain reconfigurations are introduced by staff to override or reinterpret the information system interaction. Physicians ignoring medical "low-harm" alerts due to "alarm-fatigue" are one example of such ISTA type (Harrison,

Koppel, & Bar-Lev, 2007). However, if the newly adopted information system relies on the responses to such alarms to produce the next steps in the clinical system workflow, the clinician's late response to such alarms might cause important distractions in the care process.

As many health IT systems are being introduced, we observe that implementation results vary in different settings. To achieve appropriate implementation of health IT, facilities must track the technology use and assess the results of the implementation. These types of trackings will allow facility leaders and implementation managers to consider the sociotechnical status of their facility and introduce balancing reconfiguration during the implementation process such that optimum outcomes are gained (Bates, 2005). When the Massachusetts General Care Management Program was initiated as a step to enhance care coordination for chronically ill patients and costly Medicare beneficiaries, although many physicians expressed satisfaction with the principles of this program there was an initial apprehension about the changes required (Konder, 2015). To address this, program leaders planned new approaches to identify the unique challenges that the program introduced per practice and proceeded to identify and recognize physician champions who were experiencing a better success rate in the adoption of this initiative as a step to motivate other practitioners to follow the same steps.

Introducing new applications is usually accompanied by challenges of introducing new elements within existing systems and finding the accurate applicability of the new entity. Purchasing a new care coordination application means involving vendors and developers in the healthcare facility workflow, which in turn introduces interdependencies that will require proper management. The changes and developments resulting from each step will have an impact on the remaining processes and must be planned to fit the existing business requirements and workflow. Based on the resource dependence theory, healthcare facilities with an elevated level of dependency on other organizations that possess different resources will experience a new set of environmental influences on their decisions (Kruse, DeShanzo, Kim, & Fulton, 2014). Resource dependence theory offers a perspective emphasizing the engagement of organizations and their encompassing environment to obtain resources which creates the dependence between different organizations (Singh, Power, & Chee Shoung, 2010). In a highly intertwined healthcare model, the information system and the social system are not seen as separate entities (King, 2000). Establishing accurate requirements and capabilities of a healthcare facility will identify the precise expectations from a newly implemented information system and reduce wasteful spending during development efforts. These efforts include the entire cycle of information system adoption, starting from requirement gathering to supporting the adoption phase and determining future enhancements and training needs. Such efforts will typically be influenced by both internal and external factors that will impact an organization's future plans of adopting modern technology systems.

2-6-7. Utilizing the FITT Model to Evaluate Information System Implementation

Healthcare facilities that implement information technology do not share the same success rates. Variation in results due to differences in organizational and staff characteristics could become costly when not balanced with accurate requirements in each facility. Multiple factors could influence the success or failure of the implementation. The accurate assessment of the organizational expectations could define the success level that managers are anticipating during and after the purchase of a new system. In order to precisely identify an organization's goals for a new information system implementation, it is necessary to determine the "socio-organizational" factors that will impact the adoption process (Ammenwerth, Iller, & Mahler, 2006).

The FITT framework ("Fit between Individuals, Tasks, and Technology") analyzes the interaction between users, tasks, and technology to better identify issues related to the HIT adoption and information system implementation (Ammenwerth, Iller, & Mahler, 2006). To evaluate and positively influence the best fit among all objects (individual, task, and technology), healthcare facility managers must determine each object's attributes and plan to improve the fit between e fit between task and technology could be achieved by reorganization of the facility documentation process, while providing better training opportunities for staff during and before the information system implementation will improve the fit between technology and individual. Software updates could improve the fit between individual and technology and technology and task.

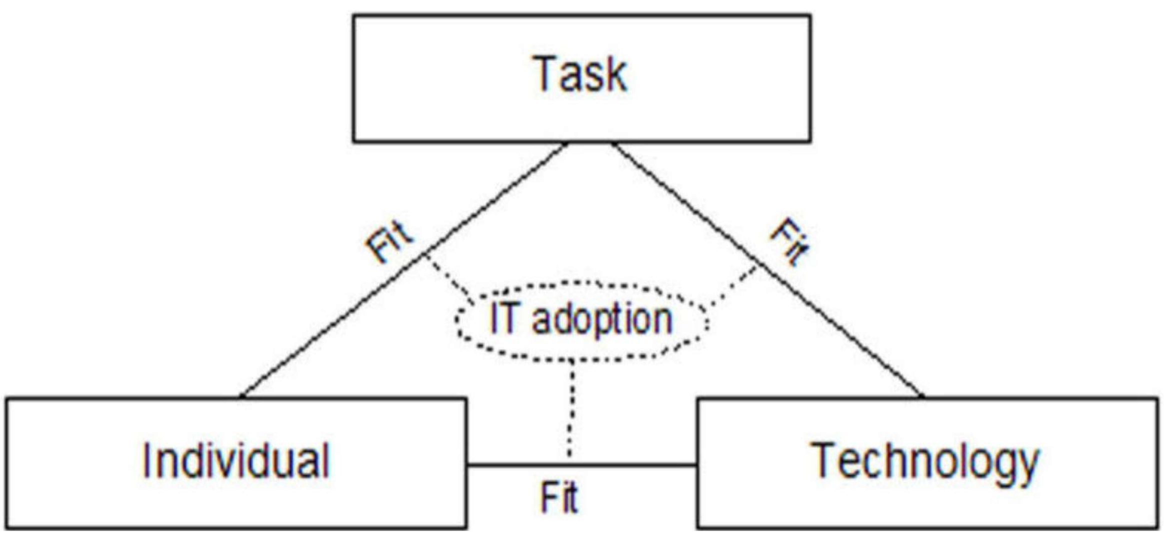


Figure 5. Fit framework: fit between individual, task, and technology *(Ammenwerth, Iller, & Mahler, 2006).*

- Intervention on individual level: User involvement in the system selection, training users on technology, providing technical support during implementation, and motivation support provided by management (Ammenwerth, Iller, & Mahler, 2006).
- Intervention on task level: Reorganization of task and working processes and identifying the responsibilities associated with tasks (Ammenwerth, Iller, & Mahler, 2006).
- Intervention on technology level: Providing hardware and software updates that will influence the information system adoption process (Ammenwerth, Iller, & Mahler, 2006).

In addition to the interventions that directly influence these objects, some external factors could influence the fit between all objects. These factors might not be manageable by the information system implementation leaders. Examples are staff changes; complexities introduced in the task level due to competitive measures and organizational strategic planning and updates in the software standards with new technological achievements. The bigger the difference between the planned fit and the actual fit the greater the problem will be during implementation (Ammenwerth, Iller, & Mahler, 2006). If implementation leaders and organizational managers are not fully aware of the business tasks and processes within their organization – including potential seasonal changes that could increase the demand and change their business flow in a significant way – they will experience failure as a lack of fit between task and technology. Also, being aware of the technical knowledge and background of the facility staff will increase the potential of individual and technology fit during the health information system implementation.

2-6-8. Mitigating the Influence of Factors that Impact HIT Implementation

Identifying unintended consequences that have the potential to affect technology implementation could provide the opportunity for health organizations to assess and consequently address such impact. This identification will improve strategic planning and investment objectives for organizational leadership and implementation managers. Introducing newly adopted information systems should not be viewed as a technology matter, but should be perceived as a complete organizational transformation that introduces new standards and measures. Increasing computerized dependency in healthcare facilities does not translate into efficient HIT implementation. An accurate comprehension of organizational needs and resources is required in preparing a complete plan for a compatible HIT system. Technical factors in some cases have been reported to account for 5% of HIT adoption failures, while in other places they have been responsible for 20% of implementation project failures (Lluch, 2011). These differences are most often associated with the socio-technical conditions in the facilities. Other issues such as organizational task priorities also play a key role in HIT adoption failures. With an increased focus on value-added and patient-centered care, there is a shift from a focus on provider-specific tasks to process-focused care that centers on patients (Lluch, 2011). Healthcare facilities are motivated to initiate various methods in order to promote the utilization of HIT. These methods include: training staff, providing additional technical support, and selecting most appropriate HIT. Implementation managers and healthcare facility leaders must include the socio-technical conditions of the adopting organization that could ensure the optimal use of HIT.

There are two fundamental issues to consider when implementing new HIT systems: The customization of the HIT to the needs and resources of the adopting organization, which is often an important aspect in the design of any application, and the socio-technical elements within the adopting organization that must be considered for optimal implementation. According to the Agency of Health Care Research and Quality (AHRQ), existing clinical practitioners may have to undergo structural and ideological reorganization to improve the chances of optimal integration with HIT systems (Lluch, 2011). By assessing all relevant issues in a healthcare facility, implementation managers will be able to identify the shortcomings that are related to HIT implementation and will improve their potential of selecting most compatible information system. Other factors, such as clinicians' beliefs about technological innovations and their expectations of the potential improvements that could result from the implementation, could also impact the fit between technology and individual attitudes (Vishwanath, Rajan Singh, & Winkelstein, 2010).

3. HYPOTHESES

These are the hypotheses that explore the research questions in more detail.

3-1. Research Question 1

H_0 1: Care coordination strategy measures embedded in health information technologies have no impact on healthcare outcomes related to patient experience such as patient-provider communication.

H_1 1: Care coordination strategy measures embedded in health information technologies could have a significant impact on healthcare outcomes related to patient experience such as patient-provider communication.

H_0 2: Care coordination strategy measures embedded in health information technologies have no impact on healthcare outcomes related to patient experience such as accessibility to health.

H_1 2: Care coordination strategy measures embedded in health information technologies could have a significant impact on healthcare outcomes related to patient experience such as accessibility to health.

3-2. Research Question 2

H_0 3: Social determinants have no impact on the relationship between care coordination, technology, and healthcare outcomes.

H_1 3: Social determinants could have significant confounding effects on the relationship between care coordination, technology, and healthcare outcomes.

4. DATA SOURCES

4-1. EHR Implementation in Minnesota

Minnesota has been a pioneer in the implementation of health reforms manifested through e-Health policies and Patient Centered Medical Homes (PCHMH). In 2007, the state enacted the Interoperable Electronic Health Record Mandate, legislation requiring all healthcare providers to implement EHR systems by 2015 (Soderberg, Rajamani, Wholey, & LaVenture, 2016). All hospitals and more than 98% of clinics completed their EHR adoption by the end of 2015. In 2008, Minnesota also planned and implemented additional healthcare reforms, including the health care home (HCH) program, which is Minnesota's version of the PCMH (Soderberg et al., 2016). The HCH concept was a joint effort by Minnesota Department of Health (MDH) and the Department of Human Services (DHS) to introduce a reliable approach for primary care providers, families, and patients to work in partnership and improve care outcomes and quality (Soderberg et al., 2016).

Minnesota regulations provided capabilities within healthcare organizations to improve effectiveness and quality of care even before the "meaningful use" was offered as an incentive program by CMS (Soderberg et al., 2016). Another major characteristic of the Minnesota EHR mandate is the inclusion of a broad range of providers that extends through the care continuum, making the information gathered a prime candidate for EHR's impact evaluation and increasing its relevance in coordinated care studies. Figure 6 shows all the HCH facilities in Minnesota.

4-2. Minnesota Data Set Study

We used data gathered from the 2015 Minnesota Health Information Technology clinic survey to discuss care coordination implementation in Health Care Homes. In this phase of the study, we analyzed the impact of information system-based clinical procedures (predictive variables/

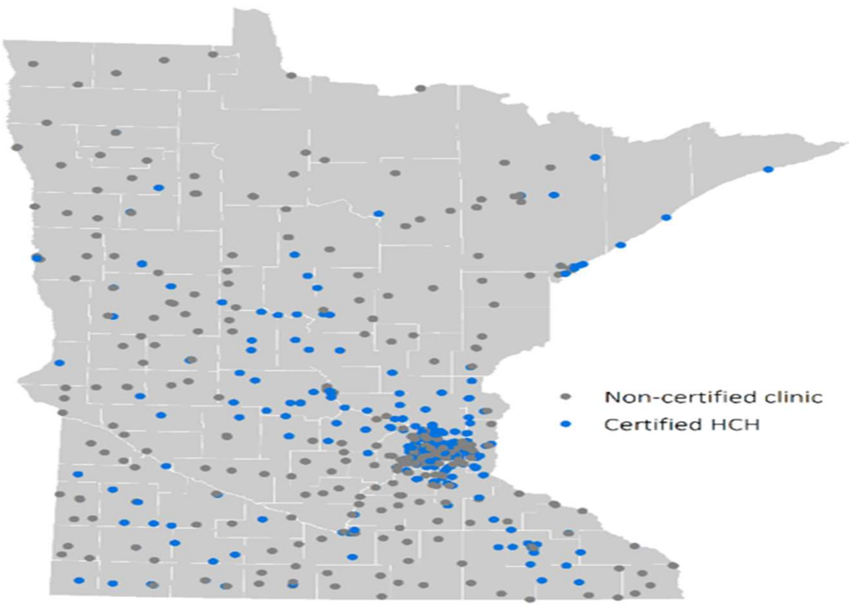


Figure 6. Certified HCH in Minnesota *(Soderberg, Rajamani, Wholey, & LaVenture, 2016)*

covariates) that are designed to coordinate care on patient experience (as outcome variables). The MDH conducts an annual cross-sectional study to compare between clinics that are implementing EHR systems and are certified as HCH entities to clinics that utilize EHR systems but are not HCH certified. The subjects comprised 80% of the ambulatory clinics in Minnesota that are operated by one or more physicians. The online survey was conducted between February and March of 2015, and it included sixty-five questions. The survey focused on the adoption and utilization of healthcare technology and information exchange. Of the 662 primary care clinics responding to the survey, 311 were HCH certified and 351 were not certified. The survey explored two main areas of: Care Management and Care Coordination. The main EHR specifications probed were decision support systems, clinical disease registries, summary care record exchange, and patient portals (Soderberg et al., 2016).

The Minnesota survey data helped us measure the relationship between care coordination measures embedded within EHR tasks and healthcare outcomes. The results could determine best practice guidelines for clinicians and practices who want to adopt care coordination models. Clinical decision support systems, patient care summary reports, patient portals, and electronic health data exchange were reviewed and assessed in all participating clinics. Our aim was to evaluate the impact of care coordination measures within EHR system's functionalities on care outcomes. To improve the accuracy of the study and determine a robust link between the EHR coordination strategies and health outcomes, we evaluated the effect of confounding variables that could influence this relationship. The sociotechnical factors considered in this study were gathered from the same clinics that implemented care coordination through their EHR systems.

The Minnesota HCH model was designed as a centerpiece of the state's health reform initiative. The main objective of HCH is to redesign the care delivery system and enhance patient engagement in the care process (Minnesota Department of Health, n.d.). Transforming the healthcare system is a major step toward developing a model of care that relies on linking primary care with patient wellness, self-management, and community resources (Minnesota Department of Health, n.d.). The three main goals outlined for the HCH were:

- Statewide access to primary care services that are team-based, coordinated, and patient centered.
- Increasing care coordination and collaboration between primary care providers and community resources.
- Improving quality and reducing cost.

4-3. Minnesota Primary Statistics

We used linear regression analysis to analyze the impact of care coordination elements that are embedded within EHR functionalities. The analysis included measuring the impact of these embedded elements on care outcome variables. The independent variables were grouped into four main care coordination component areas: 1) assuming care accountability, 2) providing patient support, 3) communicating with participating providers, and 4) ensuring appropriate information transfer. The dependent variables included patient accessibility to care and patient-provider communication.

We used the FITT framework to evaluate socio-organizational-technical (external) factors that can influence the information system adoption. We identified the survey questions under each of the FITT dimensions (technology, task, and individual) and assessed their impact on the relationship between EHR functionalities and care outcomes. Through this analysis, we assessed the role of user attributes in addition to the impact of processes implemented and the technology used during and after the adoption of information system.

4-4. Covariate Selection

In this section, we discuss the main components of care coordination strategies and the survey questions under each category.

4-4-1. Assuming Accountability for Care Coordination (AACC)

This category includes measures of the level of organizational security risk reviews; identifying EHR functionalities that have a direct role in creating clinical benchmarks, determining clinical guideline goals; supporting professional developments; generating summary care reports in addition to referral summary systems, and gathering quality reporting measures for outside organizations are directly related to enhancing culture of teamwork, ownership and accountability across the care continuum. These innovative care approaches are indicators of accountability embedded within EHR measures that could improve the quality of care in a coordinated setting.

4-4-2. Providing Patient Support (PPS)

Assessing level of support provided for patients in a coordinated care facility such as Health Homes is an important aspect of keeping the patient at the center of care during both transition and care continuum. Patient needs will vary based on the care setting and their unique characteristics. For this reason, we highlight EHR-supported patient educational material, advanced directives, chronic care plan and patient demographic information, follow-up care reminders, preventive care reminders, patient privacy standard settings, protected health information (PHI) view, PHI download, PHI transmission abilities, and patient portal access. These factors will target patient empowerment and shift the care process to include patient-centeredness.

4-4-3. Ensuring Appropriate Information Transfer (EAIT)

To ensure effective communication in the care process it is important to secure appropriate information transfer between clinicians and patients. Many factors play a key role in the appropriateness of the healthcare information: timeliness, accuracy, detecting actionable data for proper receiver, and organizing the structure of transferred data. We identify several points to evaluate this concept: EHR-based Decision support system lab results, EHR-supported clinical guidelines, EHR-supported high tech imaging, EHR-supported medication alerts, EHR-supported patient-specific reminders, EHR-supported patient summary reports for other providers, electronic summary report availability for more than 50% of the patients, electronic notification upon patient’s ER visit within same health system, and electronic notification upon patient’s ER visit outside of the health system. The data transition is meant to improve patient-centeredness in the care process both within care teams, across care teams, and with community resources.

4-4-4. <u>Communicating with Participating Providers (CPP)</u>

Participating provider communication is critical for improving fragmented care deficiencies. Robust communication must rely on a continuous and sustainable model that takes into consideration both sides of the communicating parties. EHR tools are designed to store and present patient data in an effective and comprehensive way. Care coordination is tightly correlated with data exchange and accurate transfer of information between settings and clinicians. Effective collaboration between participating providers has been associated with improved patient outcomes (Walsh et al., 2.13). We focus on two crucial factors for provider communication: Promoting guidelines that will enable a smooth patient transition, and data share system that includes providers and groups involved in patient care.

4-5. <u>Utilizing the FITT Framework to Evaluate External Factors in Information System Implementation</u>

Estimating the impact of socio-organizational factors that could influence health information system implementation plays a vital role in adjusting the expectations of the healthcare facility. Having this information could allow facility leaders and information system managers adjust their implementation plans/goals and intensify their investments in areas that directly influence the system adoption success rate. We therefore identified the socio-organizational factors included in the MDH survey and assessed their impact on the EHR system implementation that enhances coordinated care. Using the FITT model divided all such impactful elements groups based on their impact on the fit between individuals, tasks, and technology. By analyzing the data items that are categorized under each FITT dimension: information system users (individual), clinical tasks (task), and implemented EHR technology (technology) we identified their characteristics that are mapped to the survey questions. Failure in the accurate assessment of the fit between these three main factors of the framework will translate into ineffective investments by the healthcare facility leaders that most likely will not produce intended outcomes. Also, such failure will create unintended delays in the process of information system implementation goals that could be disruptive to the entire process of healthcare facility.

4-5-1. Evaluating Attributes at the Task Level

Information technology adoption in different facilities can produce different results due to the socio-technical factors within each organization. One important aspect/dimension in the FITT framework is the complexity of tasks that need to be performed by the information systems. The task-technology fit and task-individual fit both must be considered simultaneously in the process of the information system adoption. Identifying the organizational workflow and strategic planning processes will support accurate requirement gathering for the information system planning, design, and implementation. Also, assessing staff familiarity with the clinical processes will indicate the level of fit between task and individual/user. Information system design that does not consider the breadth and depth of the clinical procedures might result in limited functionality by the adopted application. Healthcare systems that rely on extensive clinician data entry to complete EHR processes will create distractions for clinicians which will negatively impact clinical services provided.

4-5-2. Evaluating Attributes at the Technology Level

Health information technology characteristics play a significant role in the success and failure of the information system adoption process. Large facilities often purchase information systems that have been previously implemented in similar-sized facilities to avoid adoption failures and to build upon previous implementation experience. Technology in the healthcare field included the hardware, software, and network equipment used in the information system implementation. The fit between technology-task and technology-user is highly valued in assessing the success rate in healthcare information system adoption. Scalable computer-based equipment that includes cloud-based technology and secure networking systems, could offer a robust/reliable set of clinical services. These services and processes have a great chance of success if their adoption is accompanied by strong staff technical backgrounds and a clear comprehension of clinical workflow. However, if the information system is not compatible with the necessary changes occurring within the facility and does not support regular updates required by clinical processes, healthcare facilities will encounter redundancy and inefficiency during the implementation process. Also, if the implementation requires equipment that is not available or not efficiently accessible in the care unit, clinicians will bypass the newly adopted system and reinvent new methods that have less dependency on the EHR system.

4-5-3. Evaluating Attributes at the Individual Level

The individual/user role in the process of health information system is critical as s/he is involved in all the processes of implementation, including matching proper technology to the facility and utilizing the appropriate technology in clinical procedures. User comprehension of the goals and precise features of the information system will enhance the technology-individual and the task-individual fit. Super users in HIT usually are best sources of information for system update and defect detection which emphasizes on the importance of fit between individual and technology and individual and task. Training staff on system functionalities, providing ample support during and after the information system implementation process, and providing user motivation through leadership support and commitment to the adoption process will have positive impact on the healthcare outcomes.

TABLE II. MAPPING THE FITT MODEL DIMENSIONS WITH CLINICAL DATA ELEMENTS

FITT Model Dimensions	Socio-Technical Determinants in Data Set
Attributes on task level	• Limited system functionality (Question 13D) • Requires a redesign of workflow processes (Question 13E) • Time too limited during patient encounter to use (Question 13I)
Attributes on individual level	• Lack of staff training (Question 13C)
Attributes on technology level	• Requires a system upgrade (Question 13F) • Requires system maintenance (Question 13G) • Hardware issues (e.g., computers not available in exam rooms)

4-6. Dependent Variables

4-6-1. Patient Experience Accessing Care when Needed and Patient Experience Related to Patient-Provider Communication

We gathered outcome variables from the Minnesota Health Scores website (mnhealthscores.org), which retrieves the data from the MDH for clinics/medical groups. The data is based on standardized measures from the Clinician and Group Visit Survey (CG-CAHPS) 2.0, one of the Consumer Assessment of Healthcare Providers and Systems (CAHPS) series, a standard that is sponsored by the AHRQ (U.S. Department of Health & Human Services, 2017). Patient experience in this model relies on the range of interactions that they had with their care system in highly valued aspects of care delivery; such as timely appointments, easy access to information, and excellent communication with their providers (U.S. Department of Health & Human Services, 2017). CAHPS surveys draw a distinction between patient experience and patient satisfaction. They consider patient experience to be whether something that should happen in the care system happened and how often was it performed. These measures do not merely rely on patient satisfaction (which is also an important indication in health care systems) from health encounters (U.S. Department of Health & Human Services, 2017). The data is gathered based on standardized and validated survey instruments that represent a consistent methodology across a large sample of respondents answering well-tested survey questions aimed at evaluating patient experience (U.S. Department of Health & Human Services, 2017).

4-7. Statistical Model

We performed a multiple linear regression analysis for each care coordination category to assess the impact of EHR-embedded coordination functionalities on patient experience. To find the best fit line in the regression model we followed the Least Square Method, which is commonly used for fitting best regression line for observed values (James, Witten, Hastie, & Tibshirani, 2013). We also considered the R-square or the Adjusted R Square factor to evaluate the model's performance and the relevance of the independent variables in explaining the output variables (James, Witten, Hastie, & Tibshirani, 2013). The coefficient of determination (R-square) was used to give the proportion of variability in the dependent variables that is explained by the independent variables (James, Witten, Hastie, & Tibshirani, 2013). If the coefficient of determination was not statistically significant. We would not proceed in interpretation of the regression covariates/coefficients (Negelkerke, 1991). After the linear regression analysis, we considered the F-score in each model to count for the relevance of the model and to assess the significance of coefficients of the covariates (James, Witten, Hastie, & Tibshirani, 2013).

4-7-1. Research Question 1

H_0 1: Care coordination strategy measures embedded in health information technologies have no impact on healthcare outcomes related to patient experience such as accessibility to health.

H_1 1: Care coordination strategy measures embedded in health information technologies could have a significant impact on healthcare outcomes related to patient experience such as accessibility to health.

Equation GCN-1:
[Variable significance is indicated in red]

$$Y_{GCN} = \beta_0 + \beta_1 X_{RA} + \beta_2 X_{BG} + \beta_3 X_{CLG} + \beta_4 X_{PD} + \beta_5 X_{QM} + \beta_6 X_{GC} + \beta_7 X_{TR} + \beta_8 X_{ES} + \beta_9 X_{PSR}$$

Equation GCN-2:

$$Y_{GCN} = \beta_0 + \beta_1 X_{ER} + \beta_2 X_{AD} + \beta_3 X_{RI} + \beta_4 X_{DI} + \beta_5 X_{CCP} + \beta_6 X_{PC} + \beta_7 X_{FC} + \beta_8 X_{VPI} + \beta_9 X_{DPI} + \beta_{10} X_{TPI} + \beta_{11} X_{APP}$$

Equation GCN-3:

$$Y_{GCN} = \beta_0 + \beta_1 X_{EXEHR} + \beta_2 X_{XDSS} + \beta_3 X_{EXST} + \beta_4 X_{EXInter}$$

Equation GCN-4:

$$Y_{GCN} = \beta_0 + \beta_1 X_{GCS} + \beta_2 X_{APPL} + \beta_3 X_{SSD} + \beta_4 X_{PHEH} + \beta_5 X_{PHED} + \beta_6 X_{PHEHA}$$

H_0 2: Care coordination strategy measures embedded in health information technologies have no impact on healthcare outcomes related to patient experience such as patient-provider communication.

H_1 2: Care coordination strategy measures embedded in health information technologies could have a significant impact on healthcare outcomes related to patient experience such as patient-provider communication

Equation PPC-1:
[Variable significance is indicated in red]

$$Y_{PPC} = \beta_0 + \beta_1 X_{RA} + \beta_2 X_{BG} + \beta_3 X_{CLG} + \beta_4 X_{PD} + \beta_5 X_{QM} + \beta_6 X_{GC} + \beta_7 X_{TR} + \beta_8 X_{ES} + \beta_9 X_{PSR}$$

Equation PPC-2:
[Variable significance is indicated in red]

$$Y_{PPC} = \; = \beta_0 + \beta_1 x_{ER} + \beta_2 x_{AD} + \beta_3 x_{RI} + \beta_4 x_{DI} + \beta_5 x_{CCP} + \beta_6 x_{PC} + \beta_7 x_{FC} + \beta_8 x_{VPI} + \beta_9 x_{DPI} + \beta_{10} x_{TPI} + \beta_{11} x_{APP}$$

Equation PPC-3:

$$Y_{PPC} = \beta_0 + \beta_1 x_{EXEHR} + \beta_2 x_{XDSS} + \beta_3 x_{EXST} + \beta_4 x_{EXInter}$$

Equation PPC-4:

$$Y_{PPC} = \beta_0 + \beta_1 x_{GCS} + \beta_2 x_{APPL} + \beta_3 x_{SSD} + \beta_4 x_{PHEH} + \beta_5 x_{PHED} + \beta_6 x_{PHEHA}$$

4-7-2. <u>Research Question 2</u>

H_0 3: Social determinants have no impact on the relationship between care coordination, technology, and healthcare outcomes

H_1 3: Social determinants could have significant confounding effect on the relationship between care coordination, technology, and healthcare outcomes

Equation GCN-FITT:
[External (socio-technical) variables are indicated in blue]

$$Y_{GCN} = \beta_0 + \beta_1 x_{VPI} + \beta_2 x_{ES} + \beta_3 x_{GS} + \beta_4 x_{LS} + \beta_5 x_{WR} + \beta_6 x_{LT} + \beta_7 x_{ST} + \beta_8 x_{SU} + \beta_9 x_{SM} + \beta_{10} x_{HI}$$

Equation PPC-FITT:
[External (socio-technical) variables are indicated in blue]

$$Y_{PPC} = \beta_0 + \beta_1 x_{VPI} + \beta_2 x_{ES} + \beta_3 x_{GS} + \beta_4 x_{LS} + \beta_5 x_{WR} + \beta_6 x_{LT} + \beta_7 x_{ST} + \beta_8 x_{SU} + \beta_9 x_{SM} + \beta_{10} x_{HI}$$

4-8. <u>Dataset Description</u>

Prior to running linear regression model in each care coordination category, we run a descriptive analysis on the study variables to discuss the frequencies and important central tendency measures (mean, mode, median). The first step includes descriptive analysis of the dependent variables and following that the study will discuss a descriptive analysis of all the independent variables. As displayed in Table 3, it is determined that the mean of patient-provider communication is considerably higher than the mean of care accessibility based on patient experience which means that patients have rated their communication with their respective providers at a higher satisfactory rate than their accessibility to care when needed. Also, the standard deviation or the closeness of the data values to the mean on average in the **patient-provider communication (PPC)** is smaller at 2.97 than the standard deviation of **getting care when needed (GCN)** variable. Comparing the variance of care accessibility with patient-provider communication also displays a considerable difference. The variance in patient care accessibility variable is at 30.64, while it is only equal to 8.84 for the patient-provider communication variable. The difference in variation could be translated to a relatively lesser difference in the patient responses/views related to their experience of patient-provider communication than patient accessibility to care, and it could also mean that in general the patient-provider communication has a smaller amount of variation in the patient responses than the care accessibility variable. It could be concluded that there is a better consensus among patients regarding their communication with their providers compared to their accessibility to care, which also displays a higher satisfaction when it comes to communicating with providers. This could also mean that when it comes to patient-provider communication, patients are more definitive in their answers which could result from clear guidelines of communication implemented by providers.

TABLE III. DESCRIPTIVE STATISTICS FOR DEPENDENT VARIABLES

	Getting Cate when Needed (Y_{GCN})	Patient Provider Communication (Y_{PPC})
Number of valid records	662	662
Number of missing records	0	0
Mean	58.736	83.624
Standard deviation of Mean	.2151	.1156
Mode	58.736	83.624
Median	58.7	83.6
Variance	5.5355	2.9743
Range	30.642	8.846
Minimum	54.0	25.0
Maximum	31.0	69.0
Sum	85.0	94.0

Before conducting further analysis on the study data, the missing data issue must be resolved. A good statistical method in treating missing data is identifying whether the missing data is missing at random (MAR). Treating missing data is very important in statistical analysis as it may lead to bias and loss of information in clinical studies (Sterne, et al., 2009). The exclusion of an entire proportion of the study data that includes missing variables could result in the exclusion of a substantial proportion of the original sample, which could cause loss of precision and power of conclusion (Sterne, et al., 2009). Risk of bias is associated with reasons for missingness and randomness in missing data is used as a type of classification for categorizing those reasons (Sterne, et al., 2009).

Instead of deleting any observation case with a missing value that can contribute to the study and its output, the mean substitution is used in this study to preserve all the cases by replacing the missing data with values that are extracted from existing values (Kang, 2013). The theoretical background of the mean substitution is a reasonable assumption for the randomly missing observations that are forming a normal distribution (Kang, 2013). We run the Estimation

TABLE IV. FREQUENCY AND PERCENTAGES OF ALL PREDICTOR VARIABLES

Variable	Label	Frequency (Yes)	Frequency (Other)	Percentage (Yes)	Percentage (Other)	Study Question
Assuming Accountability for Care Coordination (AACC)						
X_{RA}	Risk analysis	645	17	97.4	2.6	31
X_{GC}	Clinic guidelines for chronic patients	428	234	65	35	33H
X_{BG}	EHR-supported benchmarks a guidelines to develop priorities	605	57	91.4	8.6	34A
X_{CLG}	EHR-supported clinical guideli goals	592	70	89.4	10.6	34C
X_{PD}	EHR-supported professional development activities	391	271	59.1	40.9	34D
X_{QM}	EHR-supported quality measu submission	584	78	88.2	11.8	37
X_{TR}	EHR-supported summary care report for transition or referra	545	117	82	18	38
X_{ES}	EHR-supported electronic summary report provided fo more than 50% of patients	214	448	34	66	39
X_{PSR}	EHR-primary and specialist referral services	221	441	33	67	54B
Providing Patient Support (PPS)						
X_{CCP}	EHR-chronic disease care plan and flow sheet	361	301	55	27.2	14B
X_{ER}	EHR-supported patient-appropriate educational resour	482	180	72.8	27.2	18
X_{AD}	EHR-supported advanced directive	625	37	94.4	5.6	19
X_{DI}	EHR-supported capturing demographic information	587	75	89	11	23(A: D)
X_{RI}	EHR-supported release of heal information to third party	529	133	81	19	29C
X_{PC}	EHR-supported patient preventive care reminder (for more than 50%)	492	170	74	26	35
X_{FC}	EHR-supported patient follow-care reminder (for more than 50%)	371	291	57	43	36
X_{VPI}	View health information online	604	58	91	9	50A
X_{DPI}	Download health information	451	211	68	32	50B
X_{TPI}	Transmit health information online	285	377	43	57	50C
X_{APP}	Access to patient portal	627	35	95	5	51

TABLE IV. FREQUENCY AND PERCENTAGES OF ALL PREDICTOR VARIABLES (continued)

Variable	Label	Frequency (Yes)	Frequency (Other)	Percentage (Yes)	Percentage (Other)	Study Question
Ensuring Appropriate Information Transfer (EAIT)						
X_{DSS}	Decision support tools	343	319	52	48	14D
X_{EXEHR}	Exchanging clinical health information built in the EHR	453	209	68	32	42A
X_{EXST}	Exchanging clinical health information with state-certifie HIE	322	340	49	51	42B
X_{EXInte}	Exchanging clinical health information with interstate H	166	496	25	75	42C
Participating provider communication (PPC)						
X_{APPL}	Active patient problem list and diagnosis kept for more than 5	648	14	99	1	17
X_{GCS}	Generate patient report list by condition	644	18	98	2	27
X_{SSD}	EHR-supported shared data wi providers	623	39	94	6	34B
X_{PHEH}	Electronically exchange patien information with hospitals	590	72	89	11	40B
X_{PHED}	Electronically exchange patien information with local health department	415	247	63	37	40C
X_{PHEHA}	Electronically exchange patien information with health agenci	443	219	67	33	40E

TABLE V. FITT MODEL VARIABLES

Variable	Label	Study Question
Evaluating FITT model task attributes		
X_{LS}	Health information system has limited functionality features to replace the clinica tasks	13D
X_{WR}	Health information system adoption requires further workflow process redesign	13E
X_{LT}	Health information system use requires more time during patient encounter that i not possible with current task implementation	13I
Evaluating FITT model individual attributes		
X_{ST}	Health information system adoption requires more staff training	13C
Evaluating FITT model technology attributes		
X_{SU}	Health information system requires system upgrade	13F
X_{SM}	Health information system requires system maintenance	13G

X_{HI}	**For the successful implementation of health information system hardware issues must be addressed**	**13B**

Maximization (EM) (see Appendix B) method in the statistical tool (SPSS) to determine whether the data is missing at random. Using Little's MCAR test and p-value= 0.000, we can conclude that there is a randomness in the patterns of the data, which means the data is missing at random.

We can thus proceed with the mean substitution method to replace missing data. In this method the mean value of a variable is used to replace the missing data for the same variable. We test and we find that both output variables are normally distributed (see Appendix C). We also examine the correlation between the two outcome variables and find through the Pearson bivariate correlation two-tailed test that the two outcome variables are positively correlated with 0.386 with the significance of 0.000 at the 0.01 (reported as significant here). We can say there is a fair correlation between the patient-provider communication and patient access to care in the data set.

TABLE VI. OUTPUT VARIABLE CORRELATION ANALYSIS (PEARSON)*

	Getting Cate when Needed (Y_{GCN})	**Patient Provider Communication (Y_{PPC})**
Getting Cate when Needed (Y_{GCN})	1	0.386
Getting Cate when Needed (Y_{GCN})	0.386	1

*Correlation is significant at the 0.01 level (2-tailed).

4-9. Predictor Variable Impact Expectation

Active care coordination requires efficient and effective clinical communication during patient transfer and care continuity. Different care settings like primary care physicians, emergency room departments, hospitals, and long-term-care facilities require reliable and timely patient health information during their care process, which could pose significant challenge to the care facility when considering differences in the clinical information storage and exchange platforms. Factors such as information accuracy, reliability, and timeliness (asset validity), combined with a patient-centered approach that determines the appropriateness of care services performed, logged, and tracked, will help in forming a coordination evaluation system. Utilizing care coordination classification (accountability, ensuring appropriate information transfer, providing patient support, and participating provider communication) will structure an evaluation method that utilizes practical care aspects that implement HIT (EHR-based functionalities). Each category is discussed by sub elements that are identifiable within EHR systems. This approach is building an association between assessable and obtainable care coordination measures and healthcare outcomes that are based on patient experience. A significant gain from forming this connection is the promotion of effective coordinative clinical tasks per patient settings and clinical resources.

Several healthcare models that tie care quality to the value of clinical services delivered have been designed and introduced. One such model is the Accountable Care Organization (ACO), which promotes collaboration among care entities and staff to improve outcome and quality (Summers, De Lisle, Ness, Kennedy, & Muhlestein, 2015). ACOs emphasize improving the quality of care by enhancing coordinated care and increasing meaningful use of health information technologies to directly include patients and their caregivers as contributing stakeholders in the decision-making process. ACOs largely rely on the effective use of EHRs between caregivers and patient population to empower the main elements of accountable care, which are care coordination and quality improvement (Summers, De Lisle, Ness, Kennedy, & Muhlestein, 2015).

Ensuring accurate and timely transformation of health information has proven vital to the process of care and clinical collaboration. Initial goals of health information technologies and systems were to provide accuracy and reliability of the enormous amounts of health information. However, with the addition of measures of care quality, the reliability aspect of information has become even more significant. Reliable health information will improve patient involvement in the care process by emphasizing the technology concept. Information technology can increase patient-centered care by enabling patients and their caregiver to provide timely and critical information about themselves to the clinical staff (Snyder, et al., 2012). A solid form of information transfer will also allow clinicians to act upon the patient related information provided on a timely manner and to enrich this information with clinical and medical knowledge from all providers involved in the care (Snyder, et al., 2012). Accurate communication in the clinical process relies on several main components: 1) Patient summary health record that is standardized between several care facilities; 2) Structures designed and implemented by local and federal regulatory bodies that encourage patient health information exchange; and 3) Financial incentives provided for the meaningful use of electronic health records (Burton, Anderson, & Kues, 2004). Another important concept in implementing EHR systems is the appropriate organization of clinical data to be presented in logical clinical groupings that is accessible by all care providers (Burton, Anderson, & Kues, 2004).

The provision of patient support in healthcare services has undergone a series of advancements that have had a significant impact on patient and clinician satisfaction. Patient support includes providing patients with health care information management capabilities that will ensure their effective involvement in the process of care and their inclusion in the decision-making process as contributing stakeholders. Implementing EHR functionalities that provide patient portals will help ensure that patient preferences and updates are transferred to clinical care providers and will also empower patients to view and organize their involvement in the progress of their care. Research has shown that patients who are engaged in their care receive better-quality health care and are more likely to avoid potential medical errors (Ricciardi, 2012). To ensure the best possible state of health for patients, the actions of health professionals must be accompanied by the efforts of the patient, their family, or caregiver, and finally these efforts must be supported by the community resources and coproducers of health (Coulter, 2012). There are indications that patient engagement in the process of care enhances patients' trust in the clinical care and their adherence to medical recommendations (Haynes, Ackloo, Sahota, McDonald, & Yao, 2008). Patient involvement also has been shown to decrease the likelihood of death in patients with chronic conditions from acute causes (myocardial infarctions) (Meterko, Wright, Lin, Lowy, & Cleary, 2010).

Enhancing participating provider/clinician communication is considered a key aspect of utilizing health information systems and improving care. Clinical teams that rely on standardized collaboration methods will experience faster communication and better patient outcomes. EHR use primarily was intended to assist physicians with improved outcomes by increasing patient information storage capacity and providing organized care-related data features. Increased care collaboration due to advancements in care and the growth of medical specialties have added additional requirements for these systems. Clinicians who utilize standardized patient care records will reduce redundancy and enhance efficiency by relying on accurate and cost-effective clinical services. In a recent study of 4,720 practitioners, practices that reported a lack of proper communication of patient referrals also reported lower confidence in their ability to provide high-quality care compared to those that utilized timely and appropriate communication and referrals (Shannon, 2012).

One of the main reasons for ineffective provider communication was lack of incentives (mainly financial motivations) for physicians to invest in tools and methods that will standardize and improve such communication (Shannon, 2012). Physician-to-physician communication is meant to decrease and hopefully eliminate fragmented care. Physicians operating in silos force patients and their caregivers (families in most cases) to become care managers by contacting different care facilities to coordinate care and reduce duplication in the treatment processes. Clinical communication should incorporate two important concepts: 1) Patient transferred information follows a general template that is free from the educational level or organizational preferences of the sender; and 2) Patient information should support the appropriate clinical processes and as such it must be timely and evidence-based (O'Daniel & Rosenstein, 2008).

5. STUDY RESULTS

This study analyzed each linear regression model for each care coordination category to assess independent variables impact on both outcome variables. Prior to conducting the regression analysis, we studied the collinearity between the predictor variables to reduce redundancy in estimating the impact of the predictor variables and to remove the highly correlated independent variables from the category models (James, Witten, Hastie, & Tibshirani, 2013). High collinearity might cause inaccuracies in the estimation of regression relationships, which could be displayed in the degree of change in the variance of coefficient when an elevated level (between 5-10) of collinearity exists (James, Witten, Hastie, & Tibshirani, 2013). By resolving multicollinearity, we were able to reduce the standard errors of the coefficients in general and to identify the impactful factors/coefficients with higher accuracy. Since it is possible that correlation exists between more than two variables (see Appendix D) while no pair of variables show any particularly high correlation, the correlation matrix might not be an optimal solution or the only solution in detecting correlation in a study with multiple variables (James, Witten, Hastie, & Tibshirani, 2013). The analysis below, in addition to the correlation matrix inspection, include the computation of the Variance in Inflation Factor (VIF) (James, Witten, Hastie, & Tibshirani, 2013)

5-1. Regression Analysis for AACC Category Variables

We display the Pearson correlation matrix for the AACC category variables to identify any correlation between pairs of variables:

TABLE VII. AACC CORRELATION MATRIX

	X_{RA}	X_{GC}	X_{BG}	X_{CLG}	X_{PD}	X_{QM}	X_{TR}	X_{ES}	X_{PSR}
X_{RA}	1	.220**	.325**	.286**	.098*	.178**	.200**	-0.01	.095*
X_{GC}	.220**	1	.314**	.362**	.239**	-0.006	.262**	.207**	0.007
X_{BG}	.325**	.314**	1	.788**	.369**	.222**	.352**	.085*	.137**
X_{CLG}	.286**	.362**	.788**[a]	1	.413**	.194**	.356**	.112**	.129**
X_{PD}	.098*	.239**	.369**	.413**	1	.353**	.242**	-0.009	-0.049
X_{QM}	.178**	-0.006	.222**	.194**	.353**	1	.089*	.162**	-.258**
X_{TR}	.200**	.262**	.352**	.356**	.242**	.089*	1	.312**	.177**
X_{ES}	-0.010	.207**	.085*	.112**	-0.009	.162**	.312**	1	.189**
X_{PSR}	.095*	0.007	.137**	.129**	-0.049	-.258**	.177**	.189**	1

** Correlation is significant at the 0.01 level *Correlation is significant at the 0.05 level
[a] ***higher correlation indicated with orange color***

The multiple linear regression model equations in this category are shown below.

Result Equation - 1:
[Variable significance is indicated in red]

$$Y_{GCN} = \beta_0 + \beta_1 X_{RA} + \beta_2 X_{GC} + \beta_3 X_{BG} + \beta_4 X_{CLG} + \beta_5 X_{PD} + \beta_6 X_{QM} + \beta_7 X_{TR} + \beta_8 X_{ES} + \beta_9 X_{PSR} + \mathcal{E}$$

We ran **Result Equation - 1** where dependent variable is accessing care when needed in the multiple linear regression model and we select the Collinearity diagnostics option to ensure the identification of multicollinearity in the model results. The VIF value establishes the link between the variance of an estimated regression coefficient's increase and possible collinearity with other variables which will detect model variable collinearity (James, Witten, Hastie, & Tibshirani, 2013).

VIF values equal to 1 indicate minimum/negligible collinearity, values greater than 5 indicate high collinearity that must be considered prior to predictor variable evaluation (James, Witten, Hastie, & Tibshirani, 2013). After running the multiple linear regression, we identify X_{BG} and X_{CLG} as covariates that have relatively higher VIF values (2.7 and 2.8 respectively) compared to remaining predictor variables. These collinearity values are still within acceptable range (<5) but we will consider the possible impact of such increase in the regression model analysis.

Due to the collinearity observed in the Pearson correlation matrix between X_{BG} and X_{CLG} which is equal to 0.788 and the relatively higher value of VIF for both, we then run the model after removing one of these variables to reduce the potential redundancy impact that could be introduced by both (correlated) variables. After removing X_{BG} we find that the R^2 factor in the model is equal to 0.033 and shows a 3% variability in the dependent variable that is explained by the regression model predictors. This value is considered low variability explained by the predictor variables. The coefficient of determination or R^2 will show how close the data is to the regression line (James, Witten, Hastie, & Tibshirani, 2013). The F test in the analysis is equal to 3.8 (p-value=0.000), which shows that the significance of the relationship between predictors and dependent variables (James, Witten, Hastie, & Tibshirani, 2013) is acceptable, and hence we reject the null hypothesis that the covariate coefficients in the regression model are equal to zero and have no impact on the dependent variable. Below we discuss the coefficients and their confidence interval after running the regression model.

The model also shows that one of the predictor variables (X_{RA}) displays a negative coefficient (-2.78) that is significant (p-value= 0.04). One clarification for such a negative impact in the model could be due to the data gathering methods and limitations in the study size. It is expected that information gathering in the area of security risk analysis and updates as part of the risk management process in a healthcare organization represented by (X_{RA}) would have a positive impact on the healthcare outcomes. We observe a significant (p-value= 0.00) intercept value in the model which is equal to 60.2. The intercept represents the outcome variable (getting care when needed) while all predictor variables in the model are equal to zero. The intercept is considered the model's estimate of the mean outcome when predictor values are equal to zero (Seltman, 2012). In this model we observe that several of the explanatory variables are near zero (confidence interval) which means a reasonable demonstration to explain the intercept value. The confidence interval for the intercept is 57.47-62.96, which means that it could be claimed with 95% confidence that patient accessibility to care without considering any of the AACC values is in the range of approximately 57-62 rate. If we assume that all predictor variables in this model are equal to zero, we could deduce that there exist other coordinating factors that have effective impact on the patient's accessibility to care outcome variable and their impact could impact the outcome to the range of 57-62 rate.

TABLE VIII. AACC REGRESSION ANALYSIS OUTCOMES (FIRST VARIABLE)

Accessing Care When Needed as dependent Variable					
Variables	Coefficients	Significance	95% Confidence Interval		VIF
			Lower bound	Upper Bound	
X_{RA}	-2.781	0.058	-5.653	0.092	1.196
X_{GC}	0.954	0.060	-0.041	1.949	1.311
X_{CLG}	0.409	0.627	-1.243	2.060	1.494
X_{PD}	-0.853	0.098	-1.864	0.158	1.432
X_{QM}	1.397	0.075	-0.142	2.935	1.426
X_{TR}	-0.888	0.165	-2.141	0.366	1.325
X_{ES}	1.582	0.002	0.572	2.591	1.291
X_{PRS}	-0.744	0.135	-1.720	0.232	1.227

Result Equation - 2:
[Variable significance is indicated in red]

$$Y_{PPC} = \beta_0 + \beta_1 X_{RA} + \beta_2 X_{BG} + \beta_3 X_{CLG} + \beta_4 X_{PD} + \beta_5 X_{QM} + \beta_6 X_{GC} + \beta_7 X_{TR} + \beta_8 X_{ES} + \beta_9 X_{PSR} + \varepsilon$$

We run **Result Equation - 2**with the dependent variable as patient-provider communication in the multiple linear regression model and we select the collinearity diagnostics option to ensure the identification of multicollinearity in the model results. After running the multiple linear regression, we identify X_{BG} and X_{CLG} as covariates that have relatively higher VIF values (2.7 and 2.8 respectively) compared to remaining predictor variables. These collinearity values are still within acceptable range (<5).

After removing one of the highly correlated variables (X_{BG}) we re-run the multiple linear regression. The model displays the R^2 factor as equal to 0.032 and shows almost 3% variability in the dependent variable that is explained by the regression model predictors. The F test in the analysis is equal to 3.76 (p-value=0.000), which shows the significance of the relationship between predictors and dependent variables is acceptable, and hence we reject the null hypothesis that the covariate coefficients in the regression model are equal to zero and have no impact on patient-provider communication. Below we discuss the coefficients and their confidence intervals after showing the relevance of the coefficients.

The model shows two significant variables that are more likely to have a considerable impact on the outcome variable (patient-provider communication): X_{GC} , X_{ES}. This model also shows an intercept = 83 with a p-value=0.000. As several of the coefficient confidence intervals contain zero we can discuss the intercept value by stating that the model displays 95% confidence that the patient-provider communication could have a value between 81.53 – 84.48 if there does not exist any impact from the predictive variables in this model.

TABLE IX. AACC REGRESSION ANALYSIS OUTCOMES (SECOND VARIABLE)

Accessing Care When Needed as dependent Variable					
Variables	Coefficients	Significance	95% Confidence Interval		VIF
			Lower bound	Upper Bound	
X_{RA}	0.741	0.346	-0.803	2.285	1.196
X_{GC}	0.790	0.004	0.256	1.325	1.311
X_{CLG}	-0.097	0.830	-0.985	0.790	1.494
X_{PD}	-0.537	0.053	-1.080	0.006	1.432
X_{QM}	-0.205	0.626	-1.032	0.621	1.426
X_{TR}	-0.091	0.791	-0.765	0.583	1.325
X_{ES}	0.688	0.013	0.146	1.231	1.291
X_{PRS}	-0.707	0.008	-1.232	-0.183	1.227

5-2. Regression Analysis for PPS Category Variables

We display the correlation matrix for the PPS category variables to identify any correlation between two (pair) variables, as shown in Table X.

The linear regression model equations in this category will be as below.

Result Equation - 3:
[Variable significance is indicated in red]

$$Y_{GCN} = \beta_0 + \beta_1 X_{CCP} + \beta_2 X_{ER} + \beta_3 X_{AD} + \beta_4 X_{DI} + \beta_5 X_{RI} + \beta_6 X_{PC} + \beta_7 X_{FC} + \beta_8 X_{VPI} + \beta_9 X_{DPI} + \beta_{10} X_{TPI} + \beta_{11} X_{APP} + \varepsilon$$

TABLE X. PPS CORRELATION MATRIX

	X_{CCP}	X_{ER}	X_{AD}	X_{DI}	X_{RI}	X_{PC}	X_{FC}	X_{VPI}	X_{DPI}	X_{TPI}	X_{APP}
X_{CCP}	1	.170**	.185**	-0.022	.172**	.503**	.389**	.285**	0.036	-.135**	.240**
X_{ER}	.170**	1	.309**	.146**	.236**	.273**	.358**	.399**	.383**	.387**	.311**
X_{AD}	.185**	.309**	1	.284**	.091*	.202**	.160**	.413**	.186**	.198**	.442**
X_{DI}	-0.022	.146**	.284**	1	.215**	.179**	.129**	.214**	0.057	.128**	.294**
X_{RI}	.172**	.236**	.091*	.215**	1	.226**	.219**	.378**	.207**	.131**	.252**
X_{PC}	.503**	.273**	.202**	.179**	.226**	1	.392**	.279**	-0.027	-.087*	.205**
X_{FC}	.389**	.358**	.160**	.129**	.219**	.392**	1	.078*	-0.041	-0.025	.126**
X_{VPI}	.285**	.399**	.413**	.214**	.378**	.279**	.078*	1	.453**	.269**	.762**
X_{DPI}	0.036	.383**	.186**	0.057	.207**	-0.027	-0.041	.453**	1	.595**	.345**
X_{TPI}	-.135**	.387**	.198**	.128**	.131**	-.087*	-0.025	.269**	.595**	1	.205**
X_{APP}	.240**	.311**	.442**	.294**	.252**	.205**	.126**	.762**	.345**	.205**	1

*** Correlation is significant at the 0.01 level - *Correlation is significant at the 0.05 level*

We run **Result Equation - 3** for accessing care when needed as the dependent variable in the multiple linear regression model and we select the collinearity diagnostics option to ensure the identification of multicollinearity in the model results. We observe that the VIF in this model ranges between 1.1 and 2.9, which is far from the considerable range of VIF 5-10.

After running the multiple linear regression, we identify X_{VPI}, and X_{APP} as covariates that have relatively higher VIF values (2.6, 3.2). These collinearity values are still within acceptable range (<5); however, we remove one of the correlated variables X_{APP} to reduce the potential redundancy impact on the outcome variables. The R^2 factor in the model is equal to 0.21 and shows a 21% variability in care accessibility is explained by the regression model predictors. The F test in the analysis is equal to 2.37 (p-value=0.000) that shows the significance of the relationship between predictors and dependent variables, and hence we reject the null hypothesis that the covariate coefficients in the regression model are equal to zero and have no impact on the dependent variable. Below we discuss the coefficients and their confidence interval after showing the relevance of the coefficients.

The model shows one significant variable that is more likely to have a considerable impact on the outcome variable (accessing care when needed): X_{PC}. This model also shows an intercept = 58 with a p-value=0.000. As several of the coefficient confidence intervals contain zero, we can discuss the intercept value by stating that the model displays 95% confidence that patient accessibility to care could have a value between 54.83 – 60.93 if there does not exist any impact from the predictive variables in this model.

TABLE XI. PPS REGRESSION ANALYSIS OUTCOMES (FIRST VARIABLE)

Patient-provider communication as dependent Variable					
Variables	*Coefficients*	*Significance*	*95% Confidence Interval*		*VIF*
			Lower bound	*Upper Bound*	
X_{CCP}	-0.867	0.196	-2.183	0.448	1.575
X_{ER}	-0.946	0.127	-2.160	0.268	1.595
X_{AD}	-0.824	0.476	-3.094	1.446	1.219
X_{DI}	4.022	0.048	0.034	8.010	1.073
X_{RI}	-0.030	0.960	-1.217	1.156	1.230
X_{PC}	2.26	0.001	0.921	3.61	2.03
X_{FC}	0.536	0.310	-0.500	1.573	1.480
X_{VPI}	0.995	0.343	-1.062	3.051	1.728
X_{DPI}	-1.152	0.073	-2.411	0.106	1.893
X_{TPI}	-0.414	0.474	-1.551	0.722	1.774

Result Equation - 4:
[Variable significance is indicated in red]

$$Y_{PPC} = = \beta_0 + \beta_1 \, x_{CCP} + \beta_2 \, x_{ER} + \beta_3 \, x_{AD} + \beta_4 \, x_{DI} + \beta_5 x_{RI} + \beta_6 \, x_{PC}$$

$$+ \beta_7 \, x_{FC} + \beta_8 \, x_{VPI} + \beta_9 \, x_{DPI} + \beta_{10} \, x_{TPI} + \beta_{11} \, x_{APP} + \varepsilon$$

We run **Result Equation - 4** for patient-provider communication as outcome variable in the multiple linear regression model and we select the collinearity diagnostics option to ensure the identification of multicollinearity in the model analysis.

After running the multiple linear regression, we identify X_{VPI} , and X_{APP} as covariates that have relatively higher VIF values (2.6, 3.2). These collinearity values are still within acceptable range (<5), but we will remove one of the relatively highly correlated variables like X_{APP}. After re-running the model, the R^2 factor is equal to 0.036 and shows almost 3% variability in the dependent variable that is explained by the regression model predictors. The F test in the analysis is equal to 2.19 (p-value=0.013), which shows the significance of the relationship between predictors and dependent variables is acceptable and hence we reject the null hypothesis that the covariate coefficients in the regression model are equal to zero and have no impact on the dependent variable. Below we discuss the coefficients and their confidence interval after showing the relevance of the coefficients.

The model shows one significant variable that is more likely to have a considerable impact on the outcome variable (accessing care when needed): X_{VPI} . This model also shows an intercept = 83 with a p-value=0.000. As several of the coefficient confidence intervals contain zero, we can discuss the intercept value by stating that the model displays 95% confidence that patient-provider communication could have a value between 81.52 – 84.84 if there does not exist any impact from the predictive variables in this model.

TABLE 1. PPS REGRESSION ANALYSIS OUTCOMES (SECOND VARIABLE)

Patient-provider communication as dependent Variable					
Variables	*Coefficients*	*Significance*	*95% Confidence Interval*		*VIF*
			Lower bound	*Upper Bound*	
X_{CCP}	-1.217	0.000	-1.778	-0.656	1.542
X_{ER}	0.168	0.604	-0.468	0.805	1.585
X_{AD}	-0.216	0.713	-1.364	0.933	1.378
X_{DI}	0.186	0.828	-1.497	1.869	1.160
X_{RI}	-0.115	0.724	-0.754	0.524	1.298
X_{PC}	0.289	0.439	-0.445	1.024	2.035
X_{FC}	0.128	0.674	-0.471	0.727	1.748
X_{VPI}	1.207	0.028	0.129	2.286	1.838
X_{DPI}	-0.245	0.471	-0.914	0.423	1.920
X_{TPI}	-0.297	0.330	-0.896	0.301	1.738

5-3. Regression Analysis for EAIT Category Variables

We display the correlation matrix for the PPS category variables to identify any correlation between pairs of variables, as shown in Table XII.

TABLE XII. EAIT CORRELATION MATRIX

	X_{DSS}	X_{EXEHR}	X_{EXST}	$X_{EXInter}$
X_{DSS}	1	.652**	.261**	.558**
X_{EXEHR}	.652**	1	.147**	.393**
X_{EXST}	.261**	.147**	1	.281**
$X_{EXInter}$	.558**	.393**	.281**	1

** Correlation is significant at the 0.01 level - *Correlation is significant at the 0.05 level

The linear regression model equations in this category will be as below.

Result Equation - 5:

$$Y_{GCN} = \beta_0 + \beta_1 X_{EXEHR} + \beta_2 X_{DSS} + \beta_3 X_{EXST} + \beta_4 X_{EXInter} + \varepsilon$$

We run **Result Equation - 5** with care accessibility as a dependent variable in the multiple linear regression model, and observe the R^2 factor in the model is equal to 0.003 and shows almost 0.3% variability in the dependent variable that is explained by the regression model predictors. The coefficient of determination or R^2 will show how close the data is to the regression line. The F test in the analysis is equal to 0.535 (p-value=0.710), which shows the significance of the relationship between predictors and dependent variables is not acceptable, and hence we cannot reject the null hypothesis that the covariate coefficients in the regression model are equal to zero and have no impact on the dependent variable. This model shows that the variables are not displaying any significant impact on the patient accessibility to care (dependent variable).

Result Equation - 6:

$$Y_{PPC} = \beta_0 + \beta_1 X_{EXEHR} + \beta_2 X_{DSS} + \beta_3 X_{EXST} + \beta_4 X_{EXInter}$$

We run **Result Equation - 6** with patient-provider communication as a dependent variable in the multiple linear regression model, and observe the R^2 factor in the model is equal to 0.004 and shows almost 0.4% variability in the dependent variable that is explained by the regression model predictors. The coefficient of determination or R^2 will show how close the data is to the regression line. The F test in the analysis is equal to 0.647 (p-value=0.629), which shows the significance of the relationship between predictors and dependent variables is not acceptable, and hence we cannot reject the null hypothesis that the covariate coefficients in the regression model are equal to zero and have no impact on the dependent variable. This model shows that the variables are not displaying any significant impact on patient-provider communication (dependent variable).

5-4. Regression Analysis for PPC Category Variables

We display the correlation matrix for the PPS category variables to identify any correlation between the pair of variables.

TABLE XIV. PPC CORRELATION MATRIX

	X_{APPL}	X_{GCS}	X_{SSD}	X_{PHEH}	X_{PHED}	X_{PHEHA}
X_{APPL}	1	.427**	.409**	.b	.b	.b
X_{GCS}	.427**	1	.353**	.b	.b	.b
X_{SSD}	.409**	.353**	1	.b	.b	.b
X_{PHEH}	.b	.b	.b	.b	.b	.b
X_{PHED}	.b	.b	.b	.b	.b	.b
X_{PHEHA}	.b	.b	.b	.b	.b	.b

** Correlation is significant at the 0.01 level - *Correlation is significant at the 0.05 level

The linear regression model equations in this category will be as below.

Result Equation - 7:

$$Y_{GCN} = \beta_0 + \beta_1 X_{APPL} + \beta_2 X_{GCS} + \beta_3 X_{SSD} + \beta_4 X_{PHEH} + \beta_5 X_{PHED} + \beta_6 X_{PHEHA} + \mathcal{E}$$

We run **Result Equation - 7** with the patient access to care as a dependent variable in the multiple linear regression model to observe the R^2 factor in the model equal to 0.015 and shows almost 1.5% variability in the dependent variable that is explained by the regression model predictors. The F test in the analysis is equal to 1.710 (p-value=0.116), which shows the significance of the relationship between predictors and dependent variables. However, the significance of this relationship is minor, and thus we cannot reject the null hypothesis stating that the covariate coefficients in the regression model are equal to zero and have no significant impact on the dependent variable. This model shows that the variables are not displaying any significant impact on the patient accessibility to care (dependent variable).

Result Equation - 8:
[Variable significance is indicated in red]

$$Y_{PPC} = \beta_0 + \beta_1 x_{APPL} + \beta_2 x_{GCS} + \beta_3 x_{SSD} + \beta_4 x_{PHEH} + \beta_5 x_{PHED} + \beta_6 x_{PHEHA} + \mathcal{E}$$

We run **Result Equation - 8** with the patient-provider communication as a dependent variable in the multiple linear regression model to observe the R^2 factor in the model equal to 0.009 and shows almost 0.9% variability in the dependent variable that is explained by the regression model predictors. The F test in the analysis is equal to 2.036 (p-value=0.059), which shows the significance of the relationship between predictors and dependent variables. Hence, we cannot reject the null hypothesis that the covariate coefficients in the regression model are equal to zero and have no impact on the dependent variable.

5-5. Evaluating FITT Variables

Our analysis in all four care coordination categories indicated that five covariates were likely to have significant impact on the outcome variables:

- X_{ES} EHR-supported electronic summary report provided for more than 50% of patients
- X_{GC} Clinical guidelines for chronic patients
- X_{PC} EHR-supported patient preventive care reminder (for more than 50%)
- X_{VPI} View patient information online
- X_{DI} EHR-supported captured demographic information

We further analyzed the impact of these five covariates above confounded by the FITT model variables that are attributes of socio-technical determinants. The confounding effect assessment allows analysis of the regression model after adjusting for the impact of the confounding variable, which will consequently produce an rational link between the significant predictors and the dependent variables. Below we perform multiple linear regressions by including the confounding variables per each outcome variable:

5-5-1. <u>Dependent Variable: Accessing Care when Needed</u>

After estimating the effect of care coordination measures, we identified five variables with significant impact on patient accessibility to care. The impact of these measures could be revised after assessing whether the FITT model variables that represent the attributes of the user, technology and task after the EHR implementation could have sizable impact on the predictors. To analyze this relationship accurately, we form the multiple linear regression model below.

Result Equation - 9:

[FITT variables indicated in blue and significance is indicated in red]

$$Y_{GCN} = \beta_0 + \beta_1 X_{ES} + \beta_2 X_{GC} + \beta_3 X_{PC} + \beta_4 X_{VPI} + \beta_5 X_{DI} + \beta_6 X_{LS} + \beta_7 X_{WR} + \beta_8 X_{LT} + \beta_9 X_{ST} + \beta_{10} X_{SU} + \beta_{11} X_{SM} + \beta_{12} X_{HI}$$

We run **Result Equation - 9** with patient accessibility to care as the dependent variable in the multiple linear regression model, and observe the R^2 factor in the model equal to 0.071 and shows almost 7.1% variability in the dependent variable that is explained by the regression model predictors. The coefficient of determination or R^2 shows how close the data is to the regression line. The F test in the analysis is equal to 3.79 (p-value=0.000), which shows the significance of the relationship between predictors and dependent variables. Hence, we reject the null hypothesis that the covariate coefficients in the regression model are equal to zero and have no impact on the dependent variable. Below we discuss the coefficients and their confidence interval after showing the relevance of the coefficients.

Table XV. Assessing FITT model variables on patient accessibility to care

Accessing care when needed					
Variables	Coefficients	Significance	95% Confidence Interval		VIF
			Lower bound	Upper Bound	
X_{ES}	1.950	0.001	0.987	2.91	1.20
X_{GC}	-0.042	0.942	-1.177	1.09	1.73
X_{PC}	0.92	0.120	-0.239	2.07	1.51
X_{VPI}	-1.81	0.32	-3.47	-1.55	1.29
X_{DI}	1.22	0.11	-2.42	1.75	1.15

The results in Table 16 indicate that not all variables remain significant after considering the socio-technical confounding (external) variables. After considering the sociotechnical variables and external factors in the regression model, we observe that the “EHR-supported electronic summary report provided for more than 50% of patients” (X_{ES}) will more likely continue to have some impact on the outcome variables.

5-5-2. Dependent Variable: Patient-Provider Communication

In a multiple linear regression that estimates the impact of the four main variables that resulted from care coordination component analysis combined with the FITT model factors, we evaluate the confounding effect of the socio-technical elements’ impact on patient-provider communication.

Result Equation - 10:
[FITT variables indicated in blue and significance is indicated in red]

$$Y_{PPC} = \beta_0 + \beta_1 x_{ES} + \beta_2 x_{GC} + \beta_3 x_{PC} + \beta_4 x_{VPI} + + \beta_5 x_{DI} + \beta_6 x_{LS} + \beta_7 x_{WR} + \beta_8 x_{LT} + \beta_9 x_{ST} + \beta_{10} x_{SU} + \beta_{11} x_{SM} + \beta_{12} x_{HI}$$

We run **Result Equation - 10** with patient-provider communication as a dependent variable in the multiple linear regression model, and observe that the R^2 factor in the model is equal to 0.044 and shows almost 4.4% variability in the dependent variable that is explained by the regression model predictors. The coefficient of determination or R^2 shows how close the data is to the regression line. The F test in the analysis is equal to 2.29 (p-value=0.006), which shows the significance of the relationship between predictors and dependent variables. Hence, we reject the null hypothesis that the covariate coefficients in the regression model are equal to zero and have no impact on the dependent variable. Below we discuss the coefficients and their confidence interval after showing the relevance of the coefficients.

Table XVI. Assessing FITT model variables on patient-provider communication

Accessing care when needed					
Variables	Coefficients	Significance	95% Confidence Interval		VIF
			Lower bound	Upper Bound	
X_{ES}	0.685	0.011	0.160	1.210	1.200
X_{GC}	0.433	0.119	-0.112	0.977	1.35
X_{PC}	0.36	0.910	-0.595	0.668	1.515
X_{VPI}	0.53	0.908	-0.851	0.957	1.299
X_{DI}	0.23	0.76	-0.87	0.67	1.45

The results in Table 17 indicate that not all variables remain significant after considering the socio-technical confounding variables. One variable, however, is likely significant after considering the FITT model factors (individual, task, and technology): “EHR-supported electronic summary report provided for more than 50% of patients” (X_{ES}).

6. LIMITATIONS

This study touches upon a large breadth of knowledge related to clinical care tasks that are classified as care coordination strategies, and on their impact on care outcomes. Thus, the first limitation of this study is the potential for additional care coordination related literature reviews that have not been covered due to time and resource constraints. As healthcare facilities are working to build systems that provide better patient care, motivated by incentives that are increasingly tying higher-value care to alternative payment models, newer models of coordinated care that promote teamwork and integration across different care settings with greater attention to patient-centeredness require improved facilities for information harnessing (Burwell, 2015). This information is a combination of clinical measures, patient feedback, and policies that are studied and analyzed in different formats. The development of a care coordination measurement atlas for the American healthcare community, promulgation of national recommendations to improve care coordination in US healthcare facilities, and current ongoing efforts to improve coordinated care in the UK, US, and Australia (Daveson et al., 2014) have initiated a massive number of research studies in various aspects of coordinated care that present a considerable challenge for future comprehensive review studies.

Another limitation of this study is related to vast range of patient care requirements when it comes to coordinated care tasks. Implementing coordinated care measures in practice do not produce seamless results for patients with multiple comorbidities (Rachev, 2015). Such differences will introduce a wide range of values that could be assigned to clinical tasks, depending on the patient group characteristics. A new system of weight values could be added to enhance the impact of certain clinical activities depending on the patient population. In this study, we did not consider any such distinction in the predictor variable impact assessment process, which resulted in an equal initial value for all clinical factors in the regression analysis. This approach could be considered a limitation in a comprehensive study that evaluates the impact of care coordination studies on patient outcomes.

A further limitation in this study is the classification of clinical tasks into the care coordination categories. As care coordination measures become increasingly important it is vital to accurately assess their impact on care outcomes. To evaluate such impacts systematically, a comprehensive analysis needs to be performed that defines the robust link formed between collaborative clinical procedures with improved care quality measures and their combined impact on care. Designing a strong mapping structure that connects care coordination measures and clinical tasks requires a comprehensive analysis that relies on clinical studies and experiences. This study established such connections based on literature review and clinical survey participation; however additional stakeholder input (patients, policymakers et al.) will enhance the validity and reliability of such a research study.

Care coordination is a deliberate cross-cutting action that requires the collaboration of informed staff, patients, and caregivers across different disciplines to produce high-quality outcomes (Daveson et al., 2014). Such collaboration requires efficient tracking, communication, and knowledge management systems. Experts agree that advances in care coordination standardization are limited by the theoretical knowledge in systems that are designed to implement such collaborative models (Daveson et al., 2014). As such a study is an attempt to build the foundation for creating such systems, it is beneficial to include expert field observations via interviews to collaborate such knowledge in mapping clinical tasks with coordination measures. Case managers and patient coordinators develop collaborative skills and optimum decision-making methods that enable them to identify point of contention between all participants and determine best resolution. Such skills and experiences could be obtained via interviews and discussions to be incorporated into developing care coordination measures. Due to limited time and resources, this study did not include expert interviews or insight, but we strongly recommend such inclusion for future studies.

7. DISCUSSION

The design and implementation of the clinical care assessment in this study was based on a systematic and innovative approach that focused on comprehensiveness and applicability of the HIT methods utilized. Through the initial phases of the study, a wide range of literature was selected and reviewed to first analyze previous significant attempts that could be used as blueprints for this type of study, and to create a reliable link that connects clinical tasks embedded within health information technology, with care coordination measures. The outcome of this process produced several variables representing clinical tasks that are performed within EHR systems. These variables were used in several regression models that assessed their degree of impact on patient outcomes. Evaluating coordination measures within commonly-used EHR systems, established a comprehensive approach in measuring clinical care effectiveness while using clinical response surveys to evaluate these variables will ensure the future applicability of the study results in care facility settings.

The study provides insights into creating monitoring and evaluation tools that will assist in quantifying clinical care tasks. Due to the number of stakeholders contributing to healthcare processes and the existing potential of their conflicting interests, it is imperative that a quality-assessment system or tool is evidence-based, includes the widest range of the care participants, and is progressively enhanced to include all the potential changes related to care encounters that are impacted by different stakeholders. This study was based on responses provided from clinical representatives and the questions were designed to capture the results and consequences of EHR functionalities in the health systems implemented in participating clinics.

The study analysis was divided into four main sections to discuss the four main categories of care coordination. The EHR-based clinical tasks were considered predictor variables that were analyzed for correlation and impact. In the correlation phase we determined that there was rarely very high correlation between the predictor variables and that the outcome variables were both normally distributed. However not all variables in this study displayed a significant impact on the outcome variables. All variables that were significant were also combined in a final regression model to be evaluated with confounding (external) variables. The external variables were a combination of task, technology, and user attributes that were identified from the survey responses (FITT model). These factors were analyzed in three groups (users, technology, and task) in the form of categorical variables and were included in a multiple linear regression model along with the predictive variables that showed higher likelihood of significance in their respective categories. In the two last multiple linear regression models, we evaluate the significant care coordination clinical tasks along with the FITT model and we conclude that only one variable remains significant in this evaluation.

To our knowledge this study is the first attempt of its type that considers a wide range of clinical tasks implemented via EHR systems as coordinated measures and attempts at measuring their impact on patient outcomes. Previously conducted studies were focused on a set group of patient populations or certain healthcare systems like Medicare or Medicaid that were implemented in given healthcare facilities. The study identified several variables that displayed significant impact on the outcome variables in their corresponding coordinating categories: EHR-supported patient summary reports, clinical guidelines for chronic patients, EHR-supported patient preventive care reminder, EHR-supported demographic capturing information, and viewing patient information online displayed relatively higher significance on the outcome variables. When external variables (FITT model attributes) were considered as part of the multiple linear regression model to assess the impact of the predictive variables, only one variable remained as significant: EHR-supported electronic summary report provided for patients.

Assessing existing health information technology systems that exemplify care coordination measures could provide an understanding about the stakeholder interdependence in care processes. As discussed in the conceptual framework, assessing, detecting, and resolving individual issues in complex systems such as healthcare systems are not sufficient in solving existing matters. Identifying care coordination measures in the survey responses highlights the value of stakeholders, their roles, and the communication channels represented in such collaborative measures. Assessing and analyzing care coordination measures in clinical processes will assist in determining the main stakeholders in the care process and will lead to tracking system patterns that have more significant impact on the outcomes.

As evident by healthcare performance in the U.S., value-based care is estimated as one of the lowest rankings in comparison to other developed countries while health care expenditure is far higher compared to the same developed countries (Berwick, Nolan, & Whittington, 2008). With a moderate progress that aims at addressing shortcomings in all six dimensions of care improvement: safe, effective, patient-centered, timely, efficient, and equitable (Institute of Medicine, 2001) healthcare facilities and policymakers are aligning their efforts to target care processes that will enhance collaborative measures and improve outcomes. According to several studies, redesigning care and enforcing care coordination trends must be configurable to the needs of corresponding clinical settings and must consider that care coordination factors and other "transformative" programs could have different impact on patient experience and the clinical staff (Capua et al., 2017). There is evidence that links between effective care coordination and reduced adverse patient experiences such as hospitalization and medical errors

(Penm, et al., 2017). However, there exists a major challenge in achieving integrated care and implementing coordination measures. This challenge is relevant to efficient policies that might be applicable and appropriate in all care settings and for different patient populations. The study outlines a method of categorizing clinical tasks into major coordination topics and provides assessment of these indicators. The value of these assessments could provide a valuable insight for building tools that practitioners can utilize to evaluate their care efforts.

Methodological Considerations are important facets of implementing comprehensive and effective health information technology systems that enhance coordinated care in healthcare facilities. Measuring the impact of collaborative tasks that are performed via information systems and assessing their impact on care outcomes will form an understanding about the prioritization and potentially standardization of the most effective coordinating measures. This assessment must be provided in a framework that includes stakeholders and their external factors.

8. CONCLUSION

Broad implementation of health information technology in healthcare fields will result in financial benefits and improved population health. Standardizing the widespread adoption and implementation of EHR systems will improve patient information exchange and provider collaboration in different settings. Estimated cost saving from effective EMR implementation and networking could be more than $81 billion annually by improving care efficiency and safety (Hillestad et al., 2005). Information systems implemented effectively will improve prevention and management of chronic disease and reduce medical errors and adverse events. This standardization of information system implementation and use requires considerable changes to the current health care system.

Health care system in the U.S. is considered to be the largest and arguably the most inefficient information enterprise in the world (Hillestad et al., 2005). With more than $1.7 trillion annual cost and twice the average expenditure of the Organization for Economic Cooperation and Development (OECD) the premature mortality in the U.S. is distinctly higher than the OECD average (Hillestad, et al., 2005). Lack of coordinated care and comprehensive quality measuring programs are leading healthcare facilities to higher medical error rates and prohibiting stakeholders from effective participation with informed decision-making care contributions.

A major barrier in the widespread adoption of healthcare systems is the lack of motivation in adopting such systems. High cost of adoption combined with lack of standardized but configurable adoption roadmaps that could be applicable in all care settings, create obstacles for care facilities that require systematic review and regulated guidelines for their resolution. In many cases care facilities and providers are reluctant to invest in health information systems that could enhance collaboration and coordination between contributing stakeholders, because they are not able to immediately detect the return on their investment. In this study, we aimed at identifying explicit EHR functionalities that are classified under coordination components and assess their impact on the healthcare outcomes.

8-1. Policy Implication

Due to the increased demand for coordinated care, policymakers and healthcare facility managers are determined to design and implement integrated systems that will include all stakeholders' inputs effectively and efficiently. Creating a healthcare service framework that fulfills all the requirements of an integrated and collaborative structure requires a methodical review of existing systems that can identify standardized and achievable goals. It is highly imperative that the process of evaluation for the existing healthcare systems includes accurate measurement principles that are capable of factoring in external/environmental determinants in the process of analysis. Also, these measurements must consider functionality aspects for different care settings to establish practical implementation standards.

Proper care management offers the capability of improving healthcare facilities' treatment process from a reactive system into an integrated and collaborative one. Unfortunately, a considerable proportion of healthcare expenditure is wasted on medical errors, hospital readmissions, and care that offers little or no effective value. Forty percent of Medicare beneficiaries who are hospitalized for issues related to Congestive Heart Failure (CHF) (most common reason for Medicare patient hospitalization) are readmitted within ninety days (Berwick, Nolan, & Whittington, 2008). Studies show that poor coordination can result in lack of access to medical records and test results at the point of care and furthermore it can lead to duplications of care services (Schoen et al., 2007). Sadly, the success rates for US healthcare system performance indicators such as coordinated care measures compared to other developed countries are ranked unsatisfactory considering the excessive cost of care. In 2015 and 2016 the US was ranked in the top five countries when poor care coordination was assessed based on several major areas: Duplication of lab results, lack of access to medical history at the point of care, receiving conflicting information from different providers, and any coordination problems (Osborn, Squires, Doty, Sarnak, & Schneider, 2016). This study emphasizes the value of applicable care coordination measures that should be further developed and analyzed based on medical advancements and patient needs.

Policymakers must apply evidence-based healthcare research to establish an interactive care management system that incorporates stakeholder input adequately. To achieve this objective, healthcare leaders must properly associate value to medical services in all care settings. Tying healthcare services to value requires active tracking of care service delivery systems while recognizing external determinants that have a noticeable impact on care outcomes. Tracking clinical tasks that directly contribute to or represent integrated care services and are mostly categorized under coordinated care components must occur on a consistent basis to cover care continuity and must include the largest number of stakeholders to cover care across multiple settings. Policymakers can promote the use of such systems by standardizing tracking methods similar to meaningful use measures that assist providers in enhancing care services. A growing body of literature shows that electronic health records improve patient safety, care coordination, and medical documentation (Chen, Carrido, Chock, Okawa, & Liang, 2009). However, accurate tracking and inclusion of stakeholder contribution that results in establishing care accountability in the process of care requires further research and analysis. The newly developed systems must balance between the input and expectation of each stakeholder based on care settings and community requirements.

8-2. Study Contribution

This study describes HIT's potential in promoting coordinated care through the utilization of EHR systems. To achieve this goal the study uses regression analysis to establish the relationship between care coordination measures embedded within EHR systems and patient experiences displayed as care outcomes. Few studies until now have attempted to build a direct link between widely used EHR system functionalities and patient experiences. The lack of comprehensive research in this area of healthcare services, could be due to the wide range of possibilities that exist in the stakeholder interactions and produce an extensive number of workflow permutations. This study analyzes survey responses of clinical representatives to establish care coordination measures' impact through the implementation of EHR tasks on healthcare outcomes. The study facilitates the formation of an evidence-based relationship between clinical tasks that emphasize coordinated care and care outcomes. In addition, a comprehensive literature review identifies several external factors (also extracted from clinical representative responses) that could have potential impact on the implementation of healthcare systems. We analyzed these variables under the FITT model categorization that includes the task-technology-user attributes. Due to their impact on clinical tasks that are assessed as predictor variables we determine that their analysis is essential for the factual estimation of care coordination factors.

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APPENDICES

Appendix A

List of survey questions

AACC Questions

31) Does your organization conduct or review security risk analysis information and updates as necessary as part of your risk management processes?

1 Yes
2 No
9 Not sure

34. Please indicated whether your clinic uses data from the EHR for the following internal quality improvement efforts:

34A To create benchmarks or develop clinical priorities
34C To set goals around clinical guidelines
34D To support professional development activities, such as certifications

1 Yes
2 No
9 Not sure

37. Does your clinic use the EHR to collect and submit quality measures to an outside organization (e.g., Centers for Medicare & Medicaid Services, Physician Quality Reporting Initiative, or Minnesota Community Measurement)?

1. Yes, we collect and submit quality measures using only our EHR
2. Yes, we collect and submit quality measures using our EHR and the patient's paper
3. No, we do not submit quality measures
9. Not sure

38. Is your EHR able to generate an electronic summary of care record (e.g., a continuity of care document) for patients who require a referral to another provider, or transition from one setting of care to another (e.g., hospital, primary care clinic, nursing home, home health)?

1 Yes
2 Yes, we have this functionality but it is turned off or we don't use it
3 No, we do not have this functionality
9 Not sure

****

39. For what percent of patients who require a referral or transition to another care setting does your clinic provide an electronic summary of care record to that facility (not including electronic fax or non-secure email)?

1 80-100% of patients who require referral or transition
2 50-79% of patients who referral or transition
3 25-49% of patients who referral or transition
4 Less than 25% of patients who referral or transition
9 Not sure

Appendix A (continued)

PPS Questions

14. Please indicate how often the following electronic clinical decision support tools are used by your

1 Used routinely
2 Used occasionally
3 Not available
4 Function turned off /Not in use

14B. Chronic disease care plans and flow sheets

****

18. Does your clinic's EHR automatically identify patient-appropriate education resources when appropriate (e.g., tobacco cessation resources for smokers)?

1 Yes
2 No
9 Not sure

19. Does your clinic document the existence of a patient's advance directive in your EHR?

1 Yes
2 No (skip to Q22)
9 Not sure (skip to Q22)

****

35. Does your clinic use your EHR to routinely identify and remind patients who are due for <u>preventive care</u> (e.g., colorectal cancer screenings, influenza vaccinations, etc.)?

1 Yes, for 80-100% of patients
2 Yes, for 50-79% of patients
3 Yes, for 25-49% of patients
4 Yes, for less than 25% of patients
5 No, we do not use the EHR to identify and remind patients of needed preventive care
9 Not sure
0 Not applicable – we do not provide primary care services

36. Does your clinic use your EHR to routinely send patients reminders for needed <u>follow-up care</u> (e.g., follow-up appointments, scheduled procedures, etc.)?

1 Yes, for 80-100% of patients
2 Yes, for 50-79% of patients
3 Yes, for 25-49% of patients
4 Yes, for less than 25% of patients
5 No, we do not use our EHR to send reminders to patients for follow-up care
9 Not sure

Appendix A (continued)

29. Indicate if your clinic's EHR allows patients to set each of the following privacy standards:

1 Yes
2 No
9 Not sure

29A Define permissions for who should have access to their health record and under what circumstances
29B Express preferences regarding how and under what circumstances health information may be shared with others
29C Authorize the release of health information to another provider or third party

50. Indicate which functions your clinic offers to patients to access and use their patient health information (select all that apply):

50A View online (patient or authorized representative can access their health information online)
50B Download (patient or authorized representative can download their health information to a physical electronic media (UBS, CD) or into a PDF document)
50C Transmission (patient or authorized representative can transmit their health information through any means of electronic transmission according to transport standards; this does not include downloading information to physical electronic media)
50D None of the above
50E Not sure

51. Does your clinic offer an online patient portal?

1 Yes, we have a patient portal
2 No, we don't have a patient portal (skip to Q54)
9 Not sure (skip to 54)

EAIT Questions

14. Please indicate how often the following electronic clinical decision support tools are used by your

1 Used routinely
2 Used occasionally
3 Not available
4 Function turned off /Not in use

14A. Automated reminders for missing labs and tests (e.g., overdue HbA1c labs)
14B. Chronic disease care plans and flow sheets
14C. Clinical guidelines based on patient problem list, gender, and age
14D. High tech diagnostic imaging (HTCI) decision support tools

Appendix A (continued)

14E. Medication guides/alerts
14F. Patient specific or condition specific reminders (e.g., foot exams for diabetic patients)
14G. Preventive care services due (e.g., mammograms for women who are not current with screening)

38. Is your EHR able to generate an electronic summary of care record (e.g., a continuity of care document) for patients who require a referral to another provider, or transition from one setting of care to another (e.g., hospital, primary care clinic, nursing home, home health)?

1 Yes
2 Yes, we have this functionality but it is turned off or we don't use it
3 No, we do not have this functionality
9 Not sure

(IF NO OR NOT SURE, SKIP TO Q40)

39. For what percent of patients who require a referral or transition to another care setting does your clinic provide an electronic summary of care record to that facility (not including electronic fax or non-secure email)?

1 80-100% of patients who require referral or transition
2 50-79% of patients who referral or transition
3 25-49% of patients who referral or transition
4 Less than 25% of patients who referral or transition
9 Not sure

****

43. Do your providers receive automatic electronic notification (i.e., an alert) when any of their patients visit a hospital emergency department? Select all that apply.

43A Yes, from hospitals within our health system
43B Yes, from hospitals outside of our health system
43C No
43D Not sure

PPC Questions

17. Does your clinic maintain an up-to-date problem list for each patient's current and active diagnoses?

1 Yes, for 80-100% of patients
2 Yes, for 50-79% of patients
3 Yes, for 25-49% of patients
4 Yes, for less than 25% of patients
5 No
9 Not sure

Appendix A (continued)

34. Please indicated whether your clinic uses data from the EHR for the following internal quality improvement efforts:

1 Yes
2 No
9 Not sure

34B To share data with providers

40. For each of the following types of health providers/organizations, indicate if your clinic needs to send and/or receive clinical health information. Then for each type of organization with which you need to exchange, indicate what types of information you electronically exchange. If you do not or cannot electronically transmit, select the right-most column. Select all types of information that apply for each provider.

40B Hospitals outside of your health system
40C Local public health departments

Appendix B

EM Estimated Statistics

EM Meansa,b

Patient_Experience_Getting_Care_When_Needed Patient_Experience_How_Well_Providers_Communicate @14B_Chronicdiseasecareplans @14D_Hightechimaging @17_Problemlist @18_Patientedresources @19_Advancedirective @23A_Race @23B_Hispanic @23C_Country @23D_Language @27_Diseasereports @29C_authorizerelease @31_Riskanalysis @33H_Chronicdiseasecare @34A_benchmarks @34B_sharewproviders @34C_setgoals @34D_Profdev @35_Remindforpreventive @36_Remindforfollowup @37_qualitymeasures @38_Generatesummaryofcarerecord @39_Summarycarerecordpercent @40B1_Unaffilhospit @40B_Exanytrx @40B2_Summary @40B3_Lab @40B4_Medhistory @40B5_Immuniz @40B6_Other @40B7_Donot @40C1_LPH @40C_Exanytrx @40C2_Summary @40C3_Lab @40C4_Medhistory @40C5_Immuniz @40C6_Other @40C7_donot @40E1_Homehealth @40E_Exanytrx @40E2_Summary @40E3_Lab @40E4_Medhistory @40E5_Immuniz @40E6_Other @40E7_donot @42A_EHR @42B_Certifiedsp @42C_Interstate @50A_View @50B_Download @50C_Transmit @51_Onlineportal

58.88 83.57 1.72 1.99 1.08 1.48 1.08 1.05 1.09 1.34 1.04 1.09 1.57 1.08 1.79 1.25 1.15 1.33 3.38 1.89 2.54 1.11 1.25 3.23 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.05

a Little's MCAR test: Chi-Square = 13201.500, DF = 5973, Sig. = .000

b The EM algorithm failed to converge in 25 iterations.

Appendix C

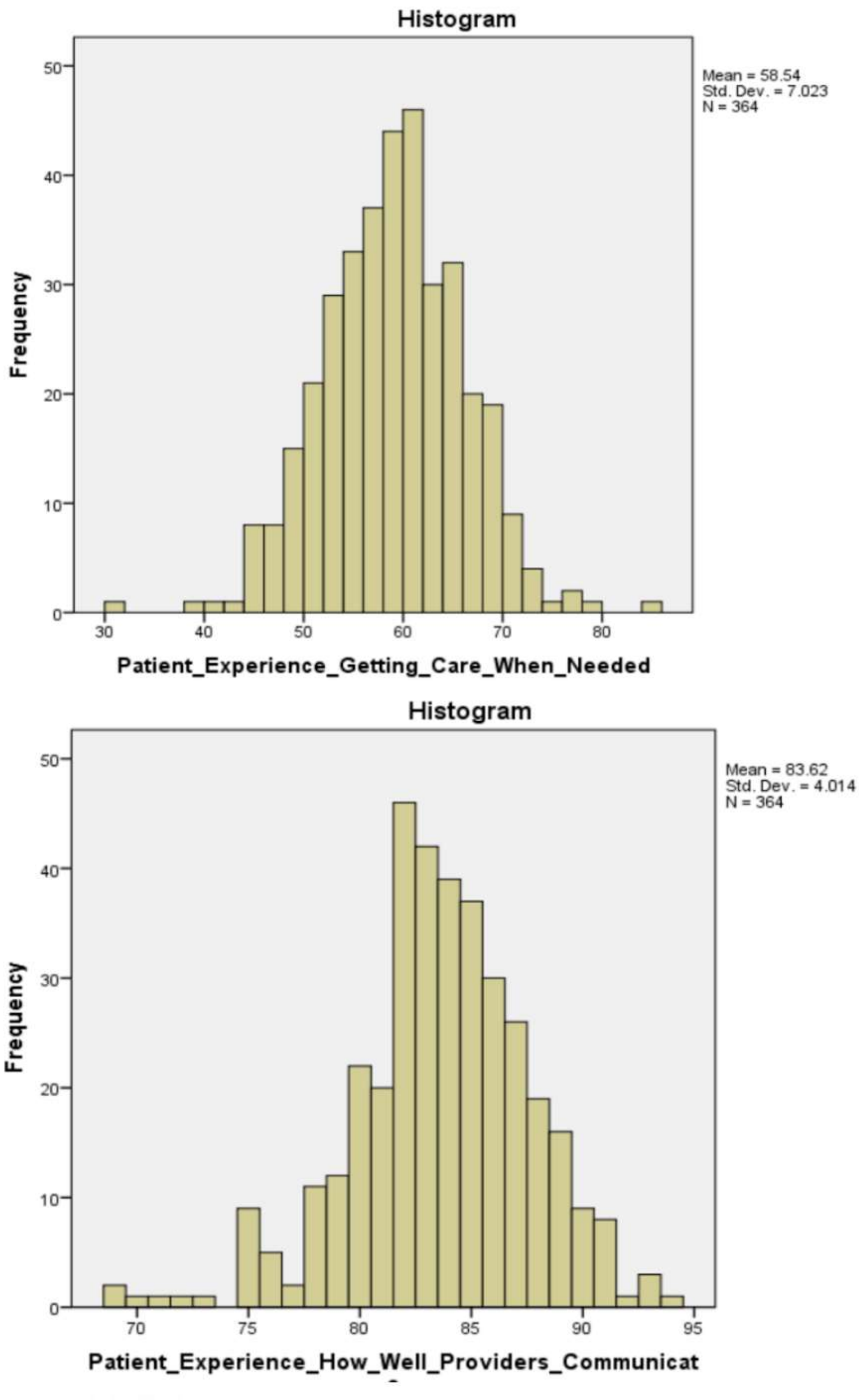

Figure 7. Dependent Variables Analysis

Appendix D

TABLE XVII. SPEARMAN'S CORRELATION: AACC CORRELATION MATRIX

	X_{RA}	X_{GC}	X_{BG}	X_{CLG}	X_{PD}	X_{QM}	X_{TR}	X_{ES}	X_{PSR}
X_{RA}	1.000	.220**	.325**	.286**	.098*	.178**	.200**	-0.010	.095*
X_{GC}	.220**	1.000	.314**	.362**	.239**	-0.006	.262**	.207**	0.007
X_{BG}	.325**	.314**	1.000	.788**	.369**	.222**	.352**	.085*	.137**
X_{CLG}	.286**	.362**	.788**	1.000	.413**	.194**	.356**	.112**	.129**
X_{PD}	.098*	.239**	.369**	.413**	1.000	.353**	.242**	-0.009	-0.049
X_{QM}	.178**	-0.006	.222**	.194**	.353**	1.000	.089*	.162**	-.258**
X_{TR}	.200**	.262**	.352**	.356**	.242**	.089*	1.000	.312**	.177**
X_{ES}	-0.010	.207**	.085*	.112**	-0.009	.162**	.312**	1.000	.189**
X_{PSR}	.095*	0.007	.137**	.129**	-0.049	-.258**	.177**	.189**	1.000

TABLE XVIII. SPEARMAN'S CORRELATION: PPS CORRELATION MATRIX

	X_{CCP}	X_{ER}	X_{AD}	X_{DI}	X_{RI}	X_{PC}	X_{FC}	X_{VPI}	X_{DPI}	X_{TPI}	X_{APP}
X_{CCP}	*1.000*	*.170***	*.185***	*-0.022*	*.172***	*.503***	*.389***	*.285***	*0.036*	*-.135***	*.240***
X_{ER}	*.170***	*1.000*	*.309***	*.146***	*.236***	*.273***	*.358***	*.399***	*.383***	*.387***	*.311***
X_{AD}	*.185***	*.309***	*1.000*	*.284***	*.091**	*.202***	*.160***	*.413***	*.186***	*.198***	*.442***
X_{DI}	*-0.022*	*.146***	*.284***	*1.000*	*.215***	*.179***	*.129***	*.214***	*0.057*	*.128***	*.294***
X_{RI}	*.172***	*.236***	*.091**	*.215***	*1.000*	*.226***	*.219***	*.378***	*.207***	*.131***	*.252***
X_{PC}	*.503***	*.273***	*.202***	*.179***	*.226***	*1.000*	*.392***	*.279***	*-0.027*	*-.087**	*.205***
X_{FC}	*.389***	*.358***	*.160***	*.129***	*.219***	*.392***	*1.000*	*.078**	*-0.041*	*-0.025*	*.126***
X_{VPI}	*.285***	*.399***	*.413***	*.214***	*.378***	*.279***	*.078**	*1.000*	*.453***	*.269***	*.762***
X_{DPI}	*0.036*	*.383***	*.186***	*0.057*	*.207***	*-0.027*	*-0.041*	*.453***	*1.000*	*.595***	*.345***
X_{TPI}	*-.135***	*.387***	*.198***	*.128***	*.131***	*-.087**	*-0.025*	*.269***	*.595***	*1.000*	*.205***
X_{APP}	*.240***	*.311***	*.442***	*.294***	*.252***	*.205***	*.126***	*.762***	*.345***	*.205***	*1.000*

Appendix D (continued)

TABLE XIX. SPEARMAN'S CORRELATION: PPC CORRELATION MATRIX

	X_{APPL}	X_{GCS}	X_{SSD}	X_{PHEH}	X_{PHED}	X_{PHEHA}
X_{APPL}	1.000	.427**	.409**	.286**	.147**	.164**
X_{GCS}	.427**	1.000	.353**	.210**	.101**	.198**
X_{SSD}	.409**	.353**	1.000	.366**	.205**	.138**
X_{PHEH}	.286**	.210**	.366**	1.000	.433**	.414**
X_{PHED}	.147**	.101**	.205**	.433**	1.000	.652**
X_{PHEHA}	.164**	.198**	.138**	.414**	.652**	1.000

TABLE XX. SPEARMAN'S CORRELATION: EAIT CORRELATION MATRIX

	X_{DSS}	X_{EXEHR}	X_{EXST}	$X_{EXInter}$
X_{DSS}	1.000	.652**	.261**	.558**
X_{EXEHR}	.652**	1.000	.147**	.393**
X_{EXST}	.261**	.147**	1.000	.281**
$X_{EXInter}$	.558**	.393**	.281**	1.000

Appendix E

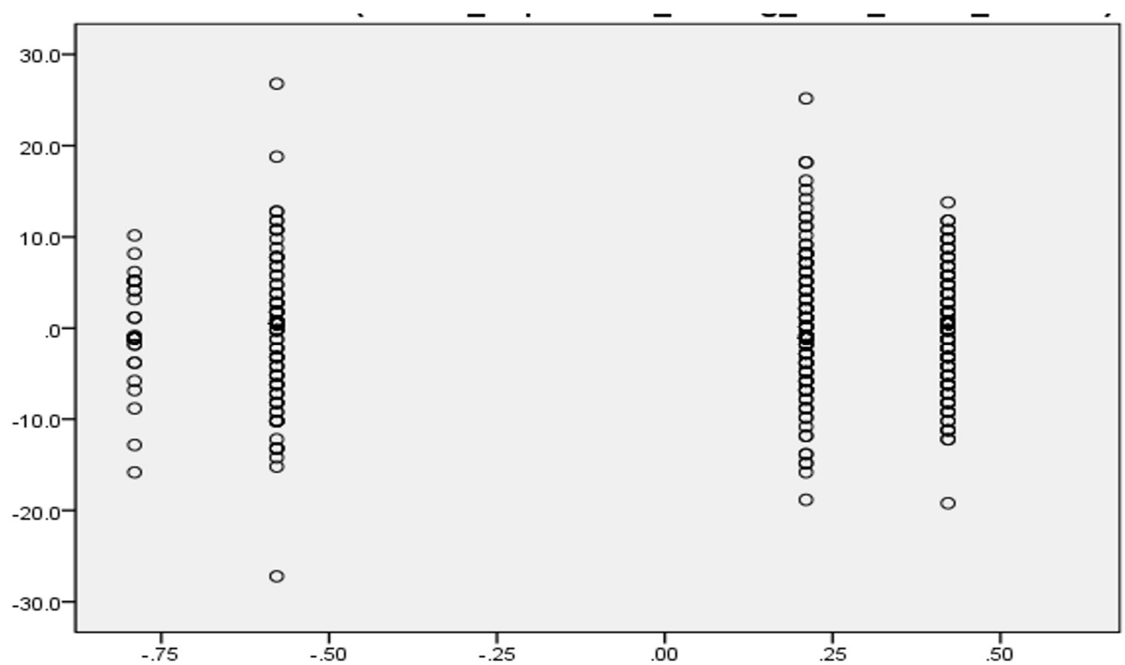

Figure 8. Partial regression plot: dependent variable: accessing care when needed/ predictor variable: X_{GC}

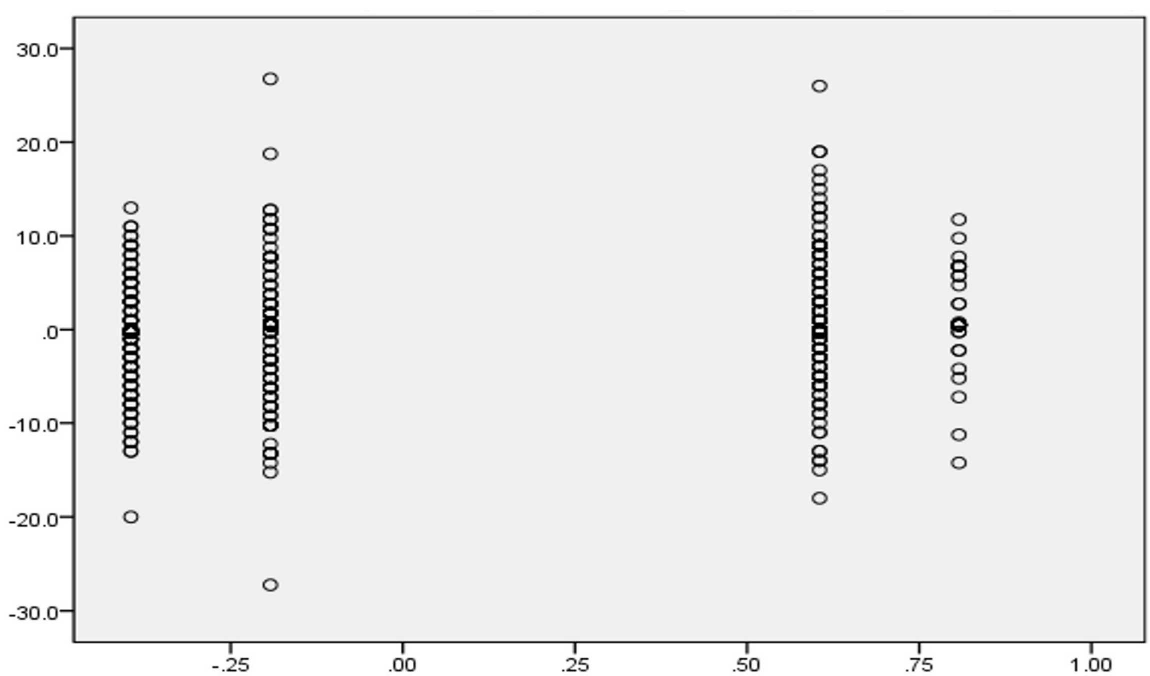

Figure 9. Partial regression plot: dependent variable: accessing care when needed/ predictor variable: X_{ES}

Appendix E (continued)

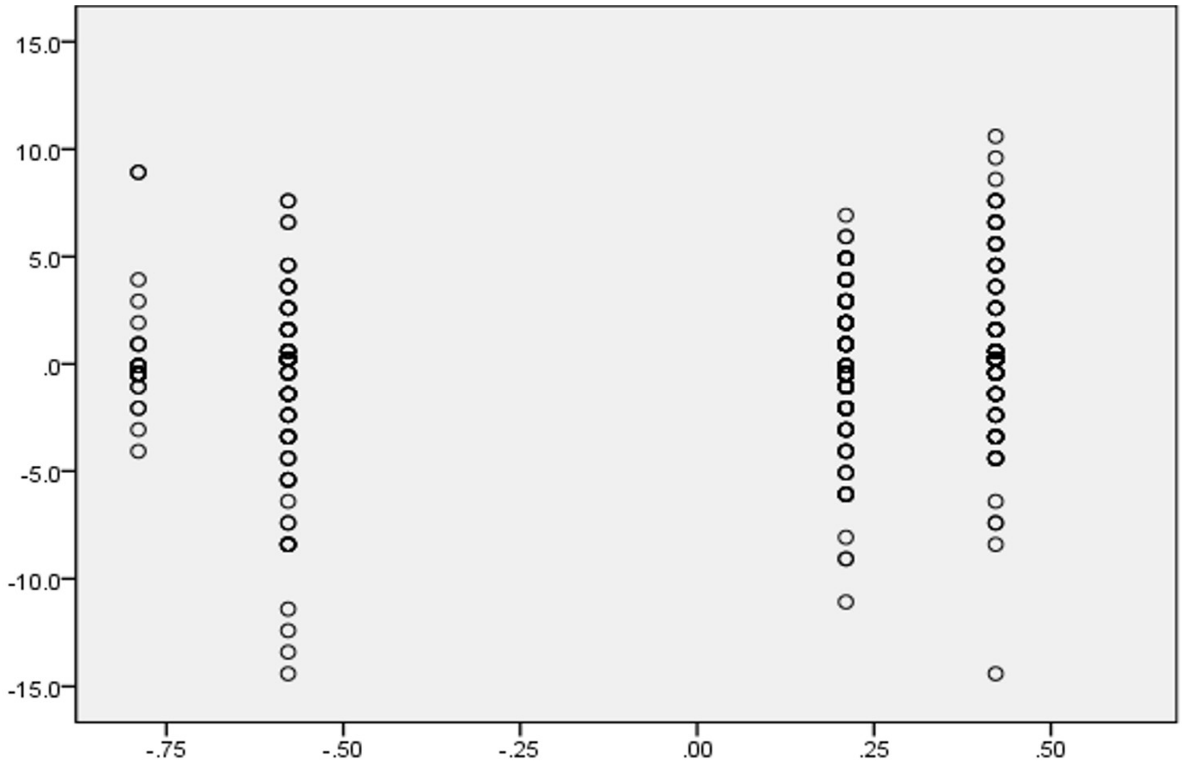

Figure 10. Partial regression plot: dependent variable: patient-provider communication/ predictor variable: X_{GC}

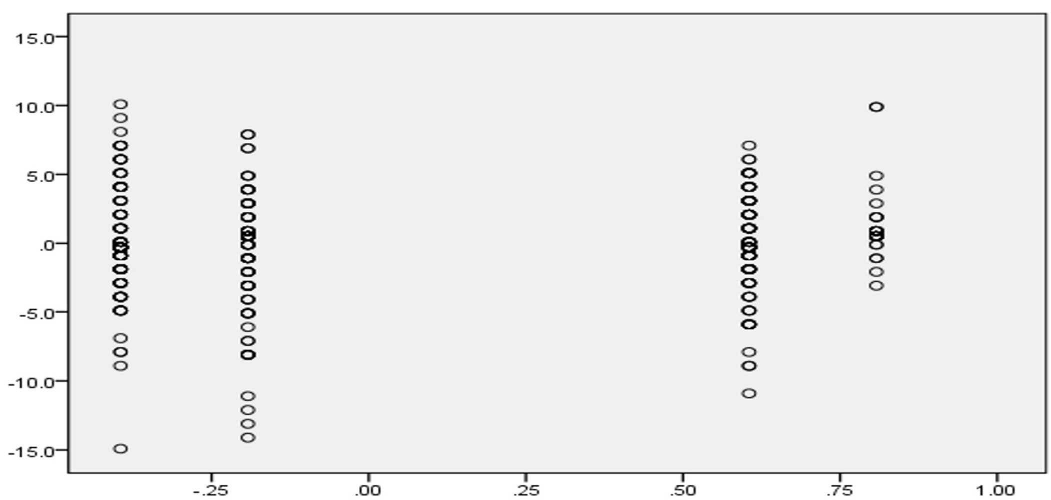

Figure 11. Partial regression plot: dependent variable: accessing care when needed/ predictor variable: X_{ES}

Appendix F

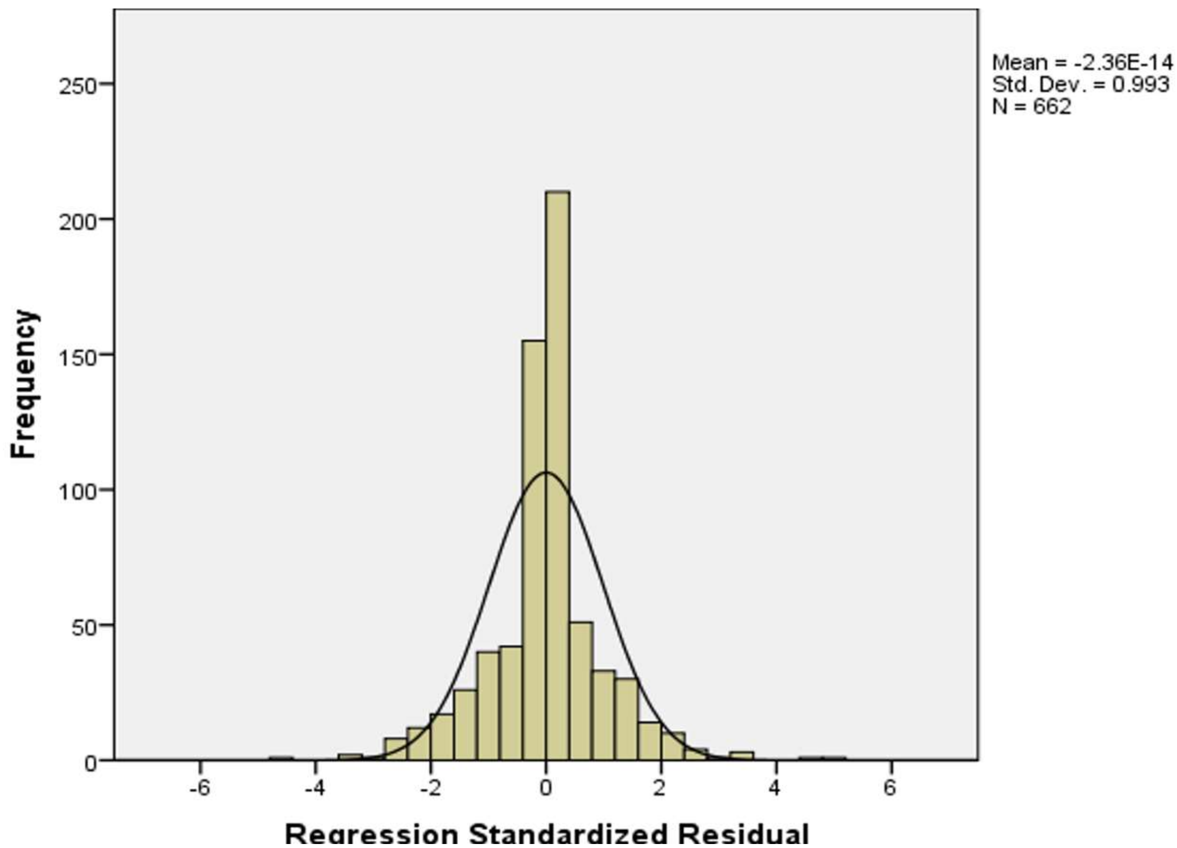

Figure 12. AACC regression analysis: Dependent variable: Y_{GCN}

Appendix F (continued)

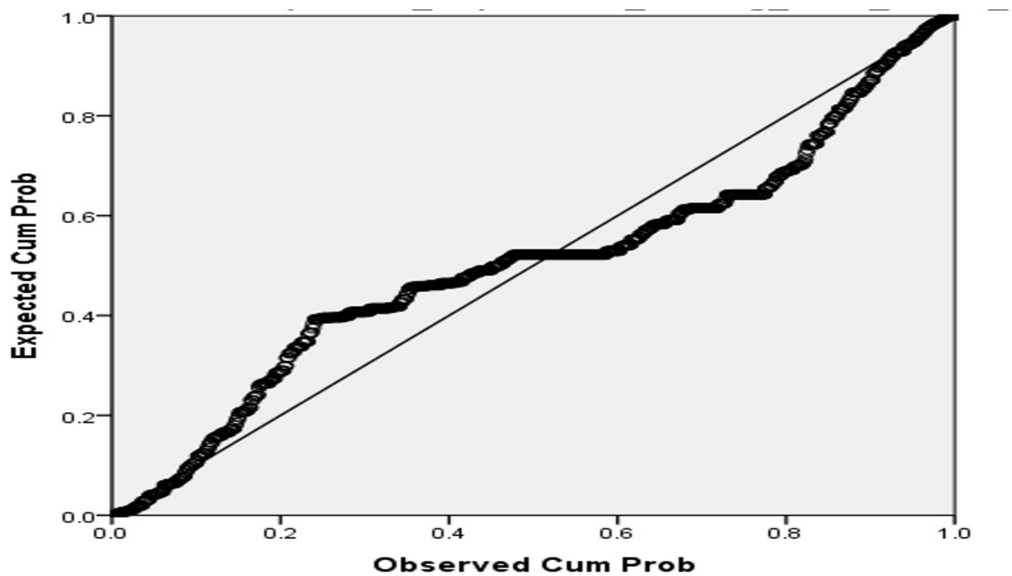

Figure 13. AACC regression analysis: dependent variable: $\boldsymbol{Y_{GCN}}$
Normal P-P Plot Regression Standardized Residual

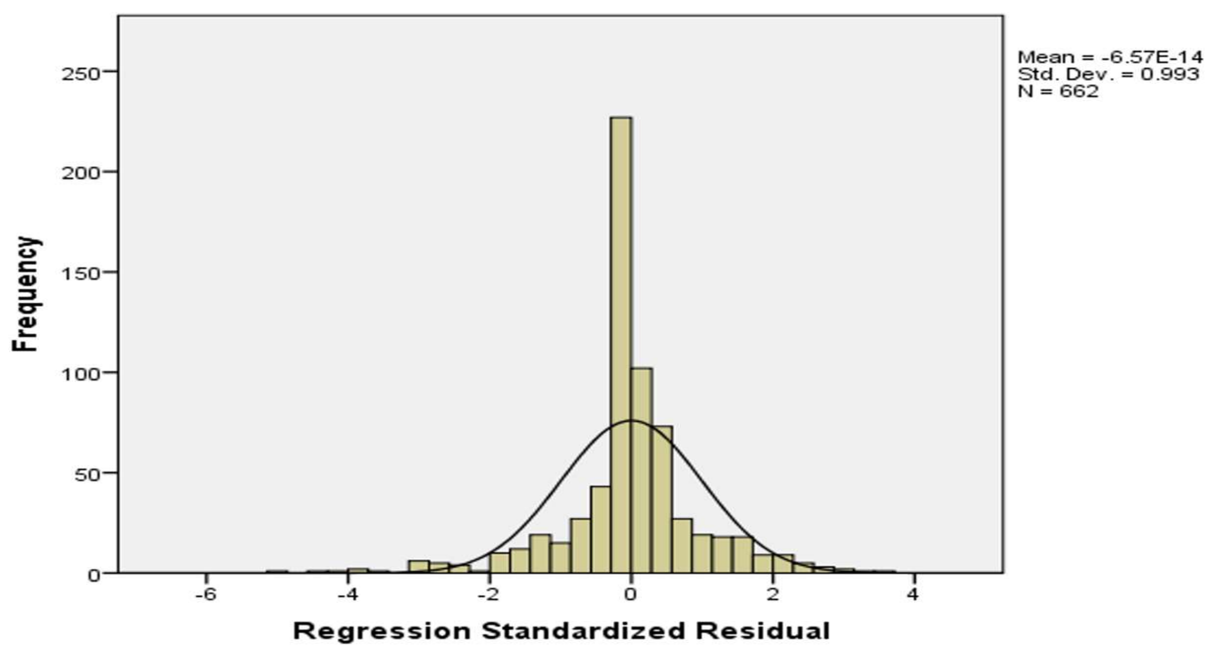

***Figure 14. AACC regression analysis: dependent variable*: $\boldsymbol{Y_{PPC}}$**

Appendix F (continued)

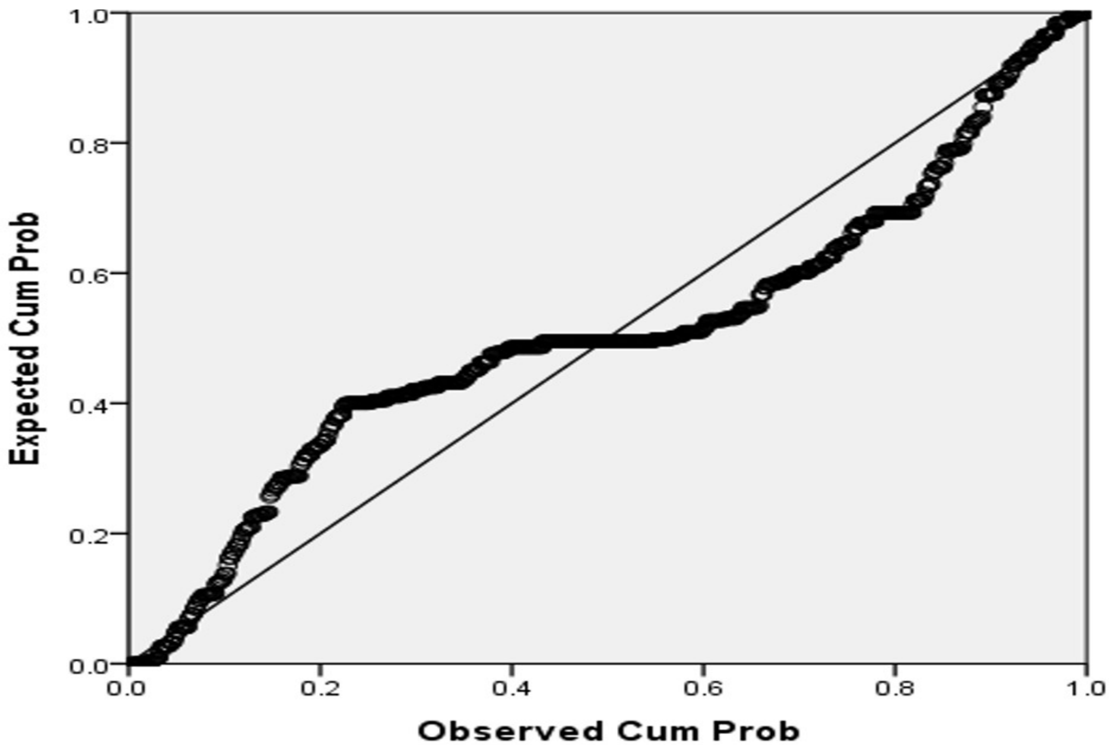

Figure 15. AACC regression analysis: dependent variable: Y_{PPC}
Normal P-P Plot Regression Standardized Residual

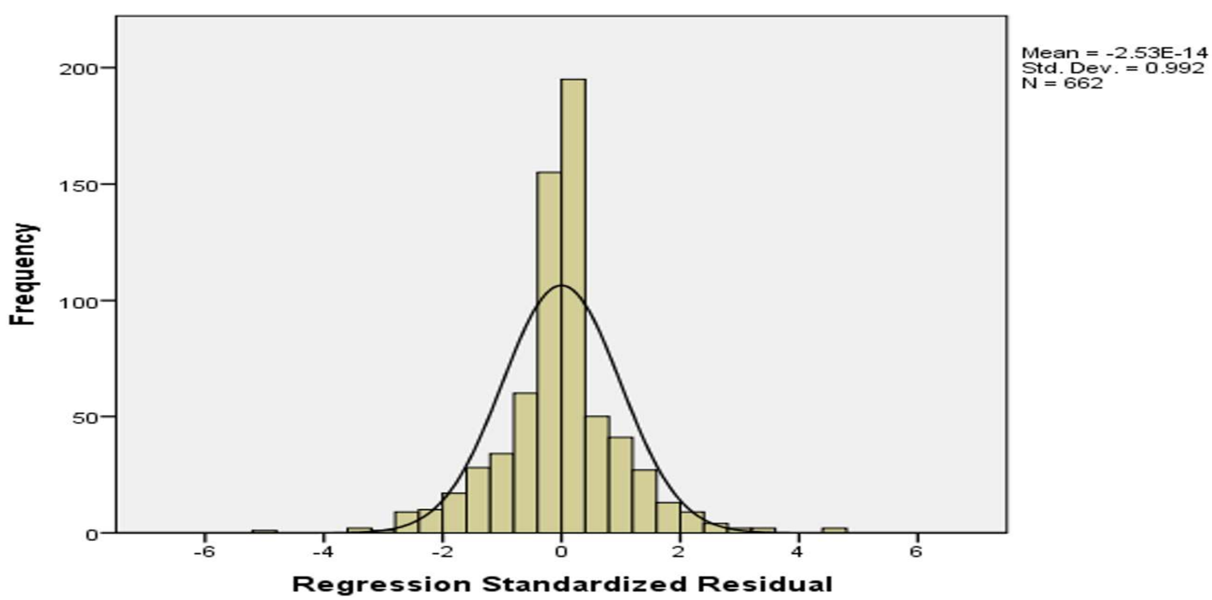

***Figure 16. AACC regression analysis: dependent variable*: Y_{GCN}**

Appendix F (continued)

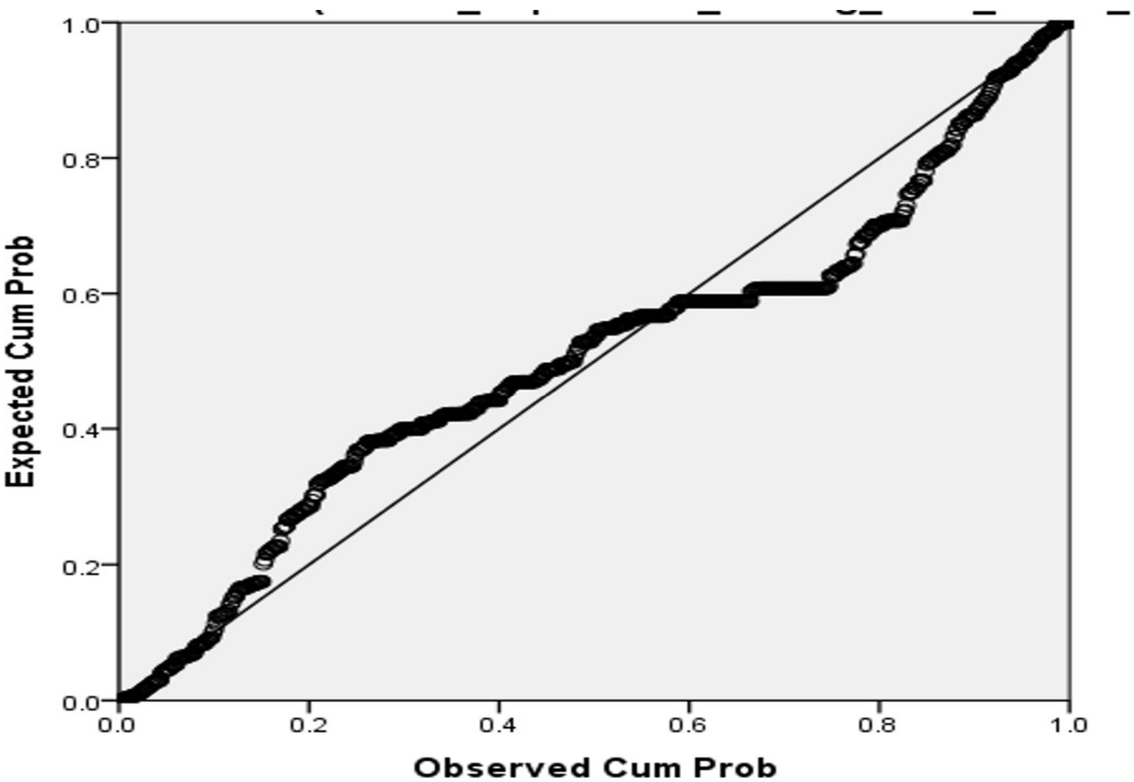

Figure 17. PPS regression analysis: dependent variable: Y_{GCN}

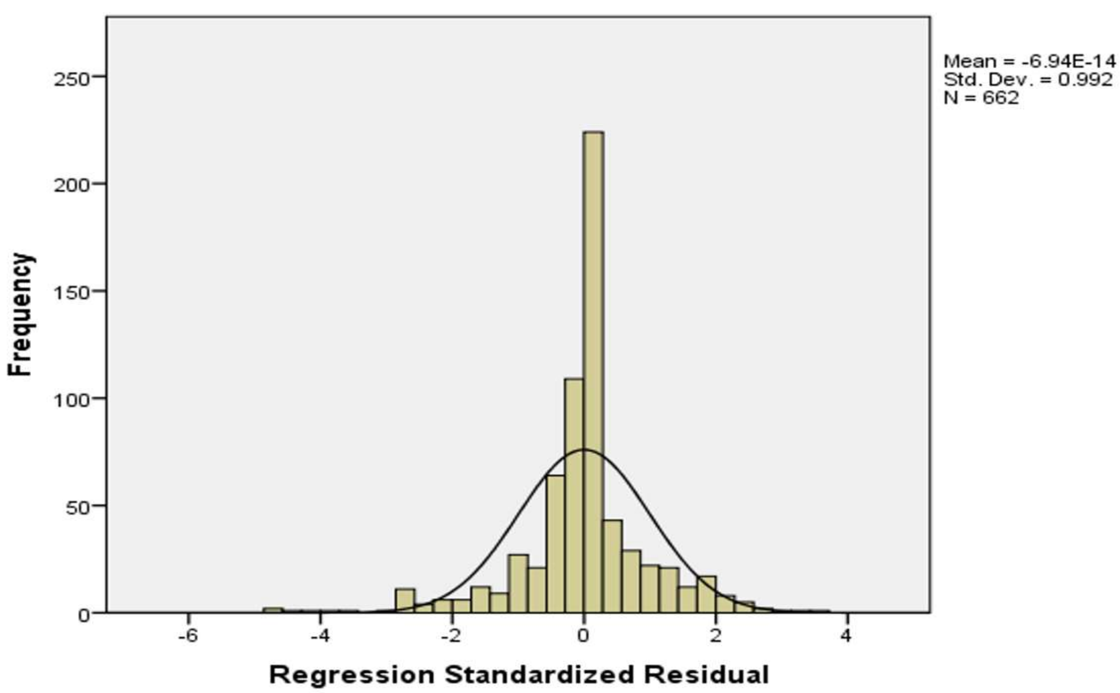

Figure 18. PPS regression analysis: dependent variable: Y_{PPC}

Appendix F (continued)

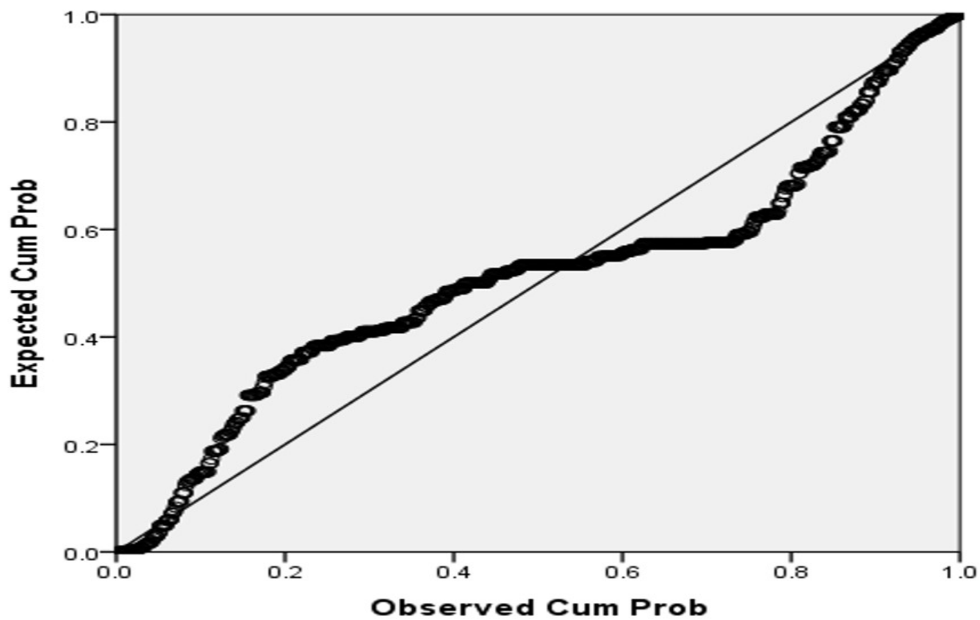

***Figure 19. PPS regression analysis: dependent variable*: Y_{PPC}**

VITA

Rima Artonian Gibbings

Public Health Informatician, PhD in Public Health Informatics, Health System Developer

Summary

Skilled professional with over nine years' progressive experience in health care system analysis, design, and development combined with completing PhD in healthcare informatics and health policy administration. Proven problem-solving ability with detailed-oriented approach and solid background in data analysis and project management who is working to close the gap between healthcare challenges and adopted technologies. Broad-minded and receptive to innovative/recent technology.

Education

University of Illinois at Chicago (UIC), Chicago, IL

- **PhD – Health Policy Administration - Health Informatics**
  - Successfully completed the qualifier exam, over 90 credit hours of PhD coursework (GPA 3.67), and defended dissertation in value-based care approaches.
  - Performing public health information and advanced database management projects through analytical tools such as Excel, MS Access, SQL Management Studio, and SQL server BI tool.
  - Completed several statistical course projects including descriptive health data analytics and data modeling (regression, T-test, Z-score, F-score) by using tools such as SAS, SPSS, and R. Tasks included data cleaning, integration, and establishing data quality measures.
  - Completed several courses related to environmental health system determinants. Social and organizational issues in health information systems. Conducted in-depth analysis using the socio-organizational determinants impact healthcare facilities and processes.
  - Leading several projects that assess and evaluate business aspects of healthcare facilities: principles of management in health systems, public health surveillance systems, health inequities, and strategic planning & budgeting.
  - Effectively presented research and analysis results for several papers and studies.

University of Illinois at Chicago (UIC), Chicago, IL

- **Master of Science – Computer Science – May 2007**

Azad Technical University, Tehran, Iran

- **Bachelor of Science – Software Engineering – May 2000**

Dissertation Information (University of Illinois at Chicago)

- Analyzing Health Information Technology adoption impact on patient care outcomes.
- Implementing comprehensive descriptive and regression analysis on predictive/dependent variables.
- Conducting in-depth literature review of socio-technical (confounding) variables effecting information system adoption.

Academic Experience

University of Illinois at Chicago (UIC) Health Policy Administration August 2014 – December 2017

Teacher's Assistant for Information Decision Support System/Patient Health Information

- Designing and presenting course content for graduate level students with minimal supervision.
- Providing regular updates and feedback to students (in-person and via online portal).
- Led several courses simultaneously as a TA: Healthcare application development, public health survey systems, Health information decision support system, and several integrative papers.
- Developed several health outcomes value-based studies/publishing that enhance technology role in healthcare systems (care coordination system, bundled payment system for claims)
- Managed several teams by clarifying team expectations, delegating responsibilities, modeling task allocation, and integrating multiple contributions.

Publications/Poster Presentations

- Coauthored the *"Theories to Inform Superior Health Informatics Research and Practice"* book by completing an entire chapter that discusses EMR systems (pending publishing by Springer). The chapter discusses EMR systems in detail and provides an assessment method and comparison criteria for ranking these systems.
- Published a poster contribution to MedInfo 2017-China: *"Using Health Information Technology to Enhance Care Outcome Accountability through Bundled Payments"*.

Professional Experience

Experian Health, Oak Brook Terrace, IL September 2013 – December 2016

Application Developer – System Designer

ATI Physical Therapy, Bolingbrook, IL December 2011- September 2013

Senior Application Developer

Passport Health Communication-Nebo, **Oak Brook Terrace, IL** March 2011– November 2011

Application Developer

Advance Technologies Group, Lombard, IL August 2007 – October 2010

Application Developer

Skills

Health Information Technology: Electronic Health Record design and development, extensive customer service skills, detail oriented, time and project management, leadership and team skills, Knowledge of health compliance and outcome value, good problem solving skills.

Computer/Technical: .NET, C#, VB, C++, ASP/, JavaScript, SQL, MVC, MS Office (MS Access, Excel, PowerPoint, Word, Visio)

Data Analysis Software: R, SPSS, EpiInfo, and SAS

Languages: speaking, reading, and writing Arabic, Armenian, and Farsi fluently.