Health Care Supply Chain Design for Reducing Disparities in the Delivery of Care: Evaluating the Effects of Resource Dependence and IT Leveraging Competence

Abstract

Fundamental to health care supply chain management, is the need to acknowledge that not everyone enjoys the same opportunities to access quality health care. As a quality improvement initiative, health information technology has been regarded as a critical component in reducing health care disparities. Yet, evidence supporting such benefits is scarce, more so in under-resourced clinical settings. Using clinic level data from 450 clinics in the Midwest, this study evaluates the effects of resource dependence and IT leveraging competence on the delivery of quality care in primary care settings. We find that clinics that operate in lower socioeconomic areas and provide care to a greater proportion of patients who are uninsured or with government assistance insurance are associated with lower quality care. We also find that leveraging an IT infrastructure, IT functionalities, and IT inter-organizational information exchange is associated with high quality care. Contrary to expectations, we find that the positive effects of higher levels of IT functionality utilization and IT inter-organizational information exchange on the delivery of high quality care do not increase, but potentially decrease as enabling resources decrease. These findings provide support to a growing concern of whether policy mandated health information technology interventions are further increasing the disparities in accessing quality health care and whether a more targeted approach that emphasizes alignment between need and resources is more appropriate.

Key Words: Health Care Supply Chain; IT Leveraging Competence; Resource Dependence Theory; Digital Divide.

1. Introduction

Fundamental to health care supply chain management is the need to acknowledge that not everyone enjoys the same opportunities to access quality health care. Chronic conditions, which require ongoing access to primary care, are a leading cause of disparities in health. Globally, disparities are particularly associated with poverty, lower socioeconomic-status (SES) and children due to limited choices and access to a healthy lifestyle (World Health Organizatoin 2005). Taking a macro supply chain centric view of the health care sector which is concerned with the interdependencies of key constituents in linking the development of care with the delivery of care, we focus on the downstream elements of the health care supply chain, namely health care delivery, where patients interact with various elements of the health care supply chain in order to be diagnosed and treated for their respective disease conditions (Sinha and Kohnke 2009). Health care "has become such a complex and technically sophisticated enterprise that providing the best possible care

often requires the involvement of many parties" which often operate as silos working towards self-interest goals (Blumenthal 1996, p.892).

As an integral part of the health care supply chain, primary care not only helps prevent illness and death, but as a point of first contact can also reduce the difficulty in accessing needed health services. It is in the context of primary care where a large majority of health care needs and the management of health related problems can be addressed before they become acute enough to require hospitalization or emergency services (Starfield et al. 2005). Yet, variation in primary care delivery associated with race, ethnicity, socioeconomic status, and other factors not attributable to clinical manifestations are prevalent which leads to inefficiencies and additional costs contributing to longstanding disparities in health status and outcomes (Clancy 2008).

Ironically, even with major causes of chronic diseases well known and understood, vulnerability and impact are particularly associated with inadequate health care and treatment. Care for socially disadvantaged patients is often under-resourced and lower in quality (Fiscella and Epstein 2008). The Agency for Health Care Research and Quality (AHRQ) considers under-resourced settings as "settings that provide care for people who have insurance with low reimbursement rates or those who have no insurance, thus leading to a relatively low level of resources to make the required capital and human resource investments" (AHRQ 2010). Resource constraints have been argued to influence health care delivery decisions which can result in reduced quality and ultimately negatively impact health outcomes (Kc and Terwiesch 2009; Kc and Terwiesch 2011). Thus, the relationship between quality health care and the ability to secure resources requires further attention.

Following the well-accepted view of technology as one that serves as an enabler of supply chain transformation and an important component of supply chain innovation, there is an unprecedented momentum for information technology (IT) to lead the transformation effort in the U.S. health care sector (Agarwal et al. 2010). In support for the expected benefits of leveraging IT in

the delivery of care, the Centers for Medicare & Medicaid Services (CMS) has created incentive programs to provide payments to eligible professionals and hospitals as they demonstrate "meaningful use" of health IT (Department of Health and Human Services 2010). As a quality improvement initiative, health information technology has been regarded as a critical component in reducing health care disparities. Ultimately, technology-enabled interventions are sought that can address the variation in care delivery not only between organizations, plans and regions, but also between health care units and health care providers (Sequist et al. 2008). Such interventions can provide greater uniformity and consistency in care and therefore reduce the disparities in care delivery. In order to address disparities, patients from traditionally underserved groups need to have access to these benefits. Therefore, the unique characteristics of under-resourced settings should be considered when assessing the impact of health information technology on quality outcomes (Millery and Kukafka 2010).

Given the impact of chronic conditions on disparities in health, we consider the interdependence between the patient who must access the health care system in order to be diagnosed and treated, the primary care provider who traditionally serves as the gatekeeper for health care services, and the community where services are provided. We specifically look at the interplay of resources and information technology to address the 'gap' between the supply of and demand for quality health care which demands major progress in preventing or delaying illness and death by crafting inexpensive and cost-effective interventions that take advantage of the information and knowledge available across the supply chain for the proper diagnosis and treatment of chronic disease conditions. The overarching research question that guides this study is: does technology-enabled intervention in the health care supply chain improve the delivery of and reduce disparities in the delivery of high quality health care? In addressing this question, we develop a framework that highlights the dependence on external resources that impact clinical settings and how leveraging information technology can compensate for the lack of resources available.

2. Literature Review

A major theme in organization studies is "how managers go about ensuring their organization's survival" (Pfeffer and Salancik 2003, p.2). According to resource dependence theory, organizational survival is dependent on the ability to acquire and maintain resources, both tangible and intangible, and as such organizations must transact with elements in their environment to acquire the needed resources. Because an organization does not control all of the resources it needs, resource acquisition may be problematic and uncertain. This uncertainty is primarily associated with a lack of control over the environment and its associated vulnerability in resource acquisition (Bode et al. 2011). As such, not only do we focus on individual and organizational-level factors that influence care delivery, but also consider the community context and characteristics of the local population where the organizations operate.

Studies show that socio-demographic factors can negatively impact health outcomes. Although socioeconomic status (SES) is most often operationalized as a composite measure of economic status (i.e., income), social status (i.e., education), and work status (i.e., occupation), a single indicator as a measure for SES is often used (Adler et al. 1994). In studies that consider the effect of SES on health outcomes, most compare health outcomes between the lower (i.e., below poverty line) and the higher SES hierarchy. Adler and Ostrove (1999) comment that the evidence of social causation (SES influences health status) is more compelling than for social drift (health status contributes to SES). In looking at social causation, studies have looked at both the individual SES effects as well as the community SES effects on health outcomes. Andersen et al. (2002) have suggested that "access to medical care depends on who people are and where they live" (p.384). This contextual effect has been argued to add collective socioeconomic disadvantages that result from a lack of resources or opportunities on the community level.

From a technology perspective, supply chain can be viewed as a technology-enabled inter-organizational end-to-end process that can be improved with the effective application of technology-

enabled systems not only to support supply chain activities within organizations, but also to enhance relationships with supply chain partners and customers (Barua et al. 2004; Rai et al. 2006). Information technologies today are designed to support both intra- as well as inter-organizational activities, with intra-organizational systems frequently aiming to create integration and sharing of information and knowledge across organizations (Venkatesh 2006). The ability to leverage information technology therefore enables consistent and near real-time transfer of information and knowledge between functions that are distributed across supply chain partners ultimately reducing uncertainty in carrying out their respective tasks.

Technology assets both tangible and intangible, are resources available for a firm to use in its process for creating, producing and/or offering its goods and services to a market, whereas technology capabilities are repeatable patterns of actions in the use of technology assets (Barua et al. 2004). Although an IT infrastructure alone is a tangible and non-socially complex capability (Ray et al. 2004), it signals the internal readiness of an organization for leveraging IT capabilities which have been shown to enable information sharing and exchange (Barua et al. 2004). Benefits obtained from information sharing and exchange through the acquisition, distribution, and interpretation of information have been shown to be effective in operations and supply chain settings by improving quality, reducing cycle times, and improving overall operational excellence (Barua et al. 2004; Hult et al. 2007; Rai et al. 2006). In the information and knowledge intensive context of new product development (NPD), Pavlou and El Sawy (2006) introduce the construct of IT leveraging competence which they define as the ability to effectively use IT functionalities. They show that IT leveraging competence indirectly influences competitive advantage through functional competencies (the ability to effectively execute operational processes).

3. Theory and Hypotheses

We evaluate the quality of care at the process level which consists of components of the care delivery encounter between the health care provider and the patient and if specified on the basis of

scientific and expert judgment it should also reflect excellence in care (Brook et al. 1996). Building on medicine's long tradition of rigorously applying scientific methods to clinical work, an emphasis on the technical aspects of quality can result in both improved care delivery and health outcomes (Blumenthal and Epstein 1996). It is at the process level were clinical decisions about care can result in underuse, overuse, or misuse of health care services preventing access to effective health care (Chassin and Galvin 1998). Our theoretical model, therefore, links resource dependence and IT leveraging competence perspectives to the delivery of quality health care.

[------ Insert **Figure 1** about here ------]

3.1 Resource Dependence

Health care takes place within the community with its resources and policies and within the health care organization with its payment structures and personnel (Bodenheimer et al. 2002). The potential for accessing health care services is influenced not only by the structural characteristics of the delivery system, but also by the resources and needs that a patient may bring to the health care-seeking process (Andersen et al. 1983). Most research on access to health care has focused on individual-level enabling resources (e.g., income and insurance) with a more recent emphasis on community-level enabling resources (e.g., per capita income and percent uninsured) that can enable or hinder individuals in accessing needed care (Andersen et al. 2002; Davidson et al. 2004; Kirby and Kaneda 2005).

Contrary to resource dependence theory which suggests that organizations will eventually fail if they cannot obtain the required resources, under-resourced clinical settings continue to persist. In contrast with settings where organizations can enter into cooperative agreements with various exchange partners for the acquisition of resources due to their potential profitability and growth opportunities, the persistence of the uneven allocation of resources in clinical settings is largely driven by the reliance on programs for socially disadvantaged populations which require federal, state, and community participation with varying degrees of support (Andersen et al. 2002). In return,

eligibility requirements for federal, state, and community participation are predominantly based on the requirement that services be provided to the socially disadvantaged. Kirby and Kaneda (2005) suggest that communities with a shortage of resources create physical, service, and social environments that impede access to quality health care. That the lack of enabling resources in communities becomes an 'emergent characteristic' that affects the ability of its residents to obtain needed services independent of an individual's enabling resources. After all, the quality, quantity, and diversity of community mechanisms that address the needs of individuals do not operate in a vacuum. Rather, they emerge mainly in environments where there are sufficient socioeconomic resources (Sampson et al. 2002). Therefore, the 'spill over' effects on care delivery become apparent when health care organizations are forced to cut back on care delivery services, not only for those who are less able to cover the costs associated with accessing care, but for everyone in the community.

Health care organizations are a mechanism through which individuals obtain access to health care and as such will require community-level and individual-level enabling resources to provide access to required services through investments in human capital, facilities, and technology. Therefore, uncertainty in access to enabling resources can be detrimental to health care organizations through its impact on revenue streams which drive decisions regarding the quantity and quality of services provided (Pagan and Pauly 2006). In particular, the payer gap, due to lower SES patients more likely to be uninsured or hold government assistance insurance ultimately leading to lower reimbursement rates, means that those that offer care in concentrated lower SES settings do so at a significant resource disadvantage. In response to the resulting resource constraints, capacity decisions may promote over utilization and rationing that have been shown to be detrimental to the quality of care delivered (Kc and Terwiesch 2009; Kc and Terwiesch 2011). Given the dependence of health care organizations on enabling resources, we hypothesize that enabling resources have a positive influence on the ability to delivery high quality health care.

HYPOTHESIS 1A (H1A): *Community enabling resources are positively associated with the delivery of high quality health care.*

HYPOTHESIS 1B (H1B): *Individual enabling resources are positively associated with the delivery of high quality health care.*

3.2 IT Leveraging Competence

Health care organizations can be classified as having a high level of knowledge intensity and professionalized workforce (von Nordenflycht 2010). Ultimately it is the intellectually skilled workforce that applies their particular expertise or knowledge base in carrying out the activities, routines, and processes and hence the organizational units whom actively control and apply the knowledge that resides within the organization. Yet, maximization of clinical outcomes by individual decision makers cannot be readily accomplished because of the lack of complete information available to health care providers, their cognitive limitations, and the finite amount of time available to analyze and make rational choices (Balsa et al. 2003; Fiscella and Epstein 2008; Wennberg et al. 1982). Therefore, we view health care delivery capabilities as information and knowledge intensive which can be enhanced by the effective leveraging of IT resulting in improved functional competencies.

Although IT value can be analyzed at both the intermediate process level and the organization-wide level (Melville et al. 2004), we consider the impact of IT on the intermediate process level where the organization employs its resources and capabilities in order to accomplish its objectives (Ray et al. 2004). Given the nascent state to IT acquisition and deployment in the health care sector, we not only consider the acquisition of IT resources, but also the deployment and use of IT capability in our conceptualization of IT leveraging competence in health care delivery (Pavlou and El Sawy 2006). In contrast to managing 'general' knowledge, we focus on specifically designed IT systems that enable the collection, sharing, and exchange of health information and knowledge that is used to improve clinical decision making across the health care supply chain. Improving the visibility across the health care supply chain allows supply chain partners to retrieve, transmit,

combine, and process information for decision support (Barua et al. 2004). Therefore, in addition to benefits in the administrative tasks from the reduction of paper based documentation and providing more complete and accurate records, anticipated clinical benefits from the use of IT include increasing the speed and accuracy of communication between functions as well as increasing compliance with treatment recommendations (AHRQ 2010).

Employing IT in the clinical delivery process can also provide structure to an unstructured decision environment (Daft et al. 1987). Routinizing IT into the clinical workflow inevitably disrupts existing routines allowing for new pre-programmed ways of performing tasks. The introduction of these deliberate 'forcing functions' into the execution of clinical tasks is expected to ultimately result in improvements in care delivery outcomes by addressing underuse, overuse, and misuse quality problems (Bates and Gawande 2003; Chassin and Galvin 1998). Further, providing more structure to individual tasks in order to make them more predictable can also improve the coordination of activities which has been suggested to be a means for health care organizations to cope with the pressures to improve the quality of care (Gittell et al. 2000). Therefore, in addition to IT's benefit in accomplishing individual tasks, IT also has the ability to coordinate tasks between health care functions by increasing shared knowledge across functions and ultimately enabling users to engage in more timely and accurate communication with each other. We expect that 'IT'izing clinical care capabilities through increasing levels of IT leveraging competence will result in improvements in the quality of care delivery.

> **HYPOTHESIS 2A (H2A):** *IT leveraging competence is positively associated with the delivery of high quality health care.*

3.3 IT Leveraging Competence as Moderator

A key assumption in reducing disparities in health is by increasing access to relevant information resources and support (Chang et al. 2004). As such, information technology has the potential to reduce disparities in care delivery by improving the awareness of both care-givers and

patients through timely availability of information for the management of chronic disease conditions. As a source of uncertainty for organizations, input uncertainty increases the information processing requirements for decision making (Argote 1982). "Input uncertainty is particularly relevant in health care settings due to variation among the patients themselves" (Gittell 2002, p.1412). This uncertainty is further magnified by the difficulties in diagnosing a disease and prescribing appropriate treatment given the lack of thoroughness and reliability of information regarding the disease and the outcomes of alternative treatments (Wennberg et al. 1982). In particular, some of the mechanisms that generate disparities in care delivery can be traced to the clinical discretion in health care where the physician is who defines the needs and the diagnostic studies, evaluates therapy, and makes utility judgments on behalf of the patient given the provider and patient uncertainty about clinical decisions (Balsa et al. 2003; Wennberg et al. 1982). Yet, time constraints severely limit informed decision making which is more evident with socially disadvantaged patients who more commonly have multiple and complex problems (Fiscella and Epstein 2008). Such constraints are routinely described as a barrier to adherence to explicit process criteria in health care delivery (Cabana et al. 1999).

We argue that digitizing elements of the health care delivery process allows health care organizations to substitute technology for other resources. In particular, as a technological resource, the deployment of IT can enable organizations to provide and process more information more often without overloading the decision makers (Galbraith 1977). Given the existing resource constraints, the resulting benefits obtained from increased information capacity should be greater as available resources decrease. The degree of fit between processes and an underlying technology that facilitates information sharing and coordination will ultimately reduce uncertainty (Barua et al. 2004). Therefore, in addition to leveraging an IT infrastructure which enables automational capabilities that allow organizations to do more with less and informational IT capabilities which bring vast amounts of detailed information into a process to improve decision making, we expect that leveraging more proactive IT capabilities that can bring more complex methods to bear on a process (Davenport and

Short 1990) will be associated with decreasing the gap in quality of care delivery by compensating for enabling resources.

> **HYPOTHESIS 2B (H2B):** *The relationship between community enabling resources and the delivery of high quality health care is moderated by IT leveraging competence, such that IT leveraging competence has a greater positive effect on the delivery of high quality health care under lower levels of community enabling resources compared to higher levels of community enabling resources.*

> **HYPOTHESIS 2C (H2C):** *The relationship between individual enabling resources and the delivery of high quality health care is moderated by IT leveraging competence, such that IT leveraging competence has a greater positive effect on the delivery of high quality health care under lower levels of individual enabling resources compared to higher levels of individual enabling resources.*

4. Research Design

4.1 Disease Context

Diabetes is a chronic disease condition that is characterized by abnormally high levels of glucose in the blood due to a shortage of insulin or a decreased ability to use insulin. With the number of adults with this disease condition more than doubling since 1980, diabetes is considered as a rising global hazard (Danaei et al. 2011). Although there has been great progress in managing diabetes and its associated complications, there is an urgency to better understand the impact of quality improvement interventions aimed at prevention and treatment of this chronic disease condition.

4.2 Data Collection

Quality Health Care. MN Community Measurement (MNCM) is a collaborative effort that includes medical groups, clinics, physicians, hospitals, health plans, employers, consumer representatives and quality improvement organizations in the state of Minnesota. These stakeholders support the notion that greater transparency in the health care system will lead to better health outcomes. Minnesota HealthScores was developed based on data provided by Minnesota health plans as well as data submitted directly by medical clinics statewide. Minnesota HealthScores is used by medical groups and clinics to improve patient care, by employers and patients as vital

information about the cost and quality of health care services, and by health plans for their pay-for-performance programs. This study is based on information from patient medical records for diabetes care received in clinics in 2009 and made available through the MNCM quality report and online portal (MNCM 2010a; MNCM 2010b).

Clinics collected data from medical records by either extracting the data from an electronic medical record through a data query or by abstracting the data from a paper-based medical record. All data elements were specified by MNCM with clinics reporting their diabetes quality data directly to MNCM. A validation process consisting of quality checks of the submitted data files as well as on-site audits is performed in order to "build trust that the data that will be used to calculate publicly reported performance rates are reliable, complete and consistent" (MNCM 2010a, p.208). While every clinic within a medical group must submit data to MNCM, a performance measure is not publicly reported if a minimum threshold of 30 patients is not met.

Individual Enabling Resources. As part of the Minnesota Statewide Quality Reporting and Measurement System, the Minnesota Department of Health (MDH) developed a standardized set of quality measures for hospitals and physician clinics to produce a public report on health care quality. All physician clinics are required to submit data to MDH. Only data on clinics submitting data on 30 or more patients for each measure were provided. In order to account for differences in patient populations that are beyond the control of a physician, information on the proportion of patients covered by commercial insurance, Medicare, and Minnesota health care programs or uninsured was reported and made available in the MDH 2010 quality report (MDH 2010).

Community Enabling Resources. Under contract by the Health Resources and Services Administration (HRSA), The Primary Care Service Area (PCSA) Project offers the first national database of primary care resources and utilization for small areas. A primary care service area (PCSA) represents health care market areas for primary care services. The database consists of geographic areas defined by aggregating ZIP Code areas to reflect Medicare patient travel to primary

care providers and includes information about pertinent health care resources, population descriptors, health care need measures, and health care utilization statistics. PCSAs were defined using 1999 Medicare claims data, 2000 Census data, and ZIP Code Tabulation Areas (ZCTAs), which are generalized area representations of ZIP Code service areas developed by the US Census Bureau. This standardized definition of primary care service areas allows for the comparison of primary care outcomes while accounting for differences in population characteristics (Goodman et al. 2003). In this study we use the 2005 and 2009 PCSA-level population socioeconomic estimates.

IT Leveraging Competence. The Minnesota Statewide Quality Reporting and Measurement Initiative requires that all physician clinics complete a health IT ambulatory clinic assessment specifically focused on the utilization of electronic health records (EHRs). The Minnesota Department of Health (MDH) contracted with MNCM to conduct the assessment which was performed between the dates of February 15, 2010 and March 15, 2010. This study is based on information from the 2010 health IT ambulatory assessment made available through the MNCM 2010 quality report and online portal (MNCM 2010a; MNCM 2010b).

4.3 Measures

Dependent Variable. The dependent variable is the proportion of patients with diabetes (Types I and II) ages 18-75 at each clinic who received high quality diabetes care (*D_COMPOSITE*) based on the five measures (known as the D5) as recommended by the Institute for Clinical Systems Improvement (ICSI): (i) test for blood pressure (less than 130/80 mmHg), (ii) test for bad cholesterol (LDL less than 100mg/dl), (iii) test for blood sugar (A1c less than 8%), (iv) recommendations to remain tobacco free, and (v) recommendation to take aspirin daily as appropriate. The composite rate is calculated using an all-or-none method by giving credit for achieving high quality care when all five components of the D5 are met. As a requirement by Minnesota Statute, a system of risk-adjusting quality measures was also provided. In order to standardize results by accounting for potential differences in patient populations beyond the control of providers, a risk adjusted measure

was provided which adjusts the quality measure using a Minnesota statewide average distribution across insurance products (*D_RISKADJ*). Although diabetes cannot be cured, when patients meet these treatment goals, they are less likely to experience complications and can lead a healthy life. Similar measures have been utilized in recent studies that study disparities in diabetes care in primary care settings (i.e., Sequist et al. 2008). Explicit process measures, like the D5, are especially valuable for health care quality assessment comparisons between providers and clinics (Brook et al. 1996). The D5 measures are also consistent with Stage 1 "meaningful use" clinical quality measures as defined by the Centers for Medicare & Medicaid Services (CMS) which include core measures and measures specific for diabetes.

Independent Variables. We operationalize one measure for community enabling resources at the PCSA level: the proportion of population that is below the 200% poverty level (*P_POV*). The measure is based on the 2005 PCSA poverty estimates which are the most recent estimates made available. Similar community-level enabling resources measures have been argued to provide an indication of the wealth in the community and therefore serves as a proxy for community resources (i.e., Andersen et al 2002; Davidson et al. 2004). This operationalization should be interpreted as the proportion of the population that is below the 200% poverty level increases, community enabling resources decrease. We operationalize one measure for individual enabling resources at the clinic level: the proportion of patients covered by government assistance health care programs or uninsured (*D_GOVNON*). Similar to the community enabling resources interpretation, as the proportion of a clinic's patient population covered by government assistance health care programs or uninsured increases, individual enabling resources decrease. Individual-level insurance has been argued to facilitate individual access to and use of needed health care services and therefore serves as proxy for individual resources (i.e., Andersen et al 2002; Davidson et al. 2004; Pagan and Pauly 2006).

We operationalize three dichotomous measures for IT leveraging competence at the clinic level: IT infrastructure (*ITINFRA*), IT functionalities (*ITFUNCT*), and IT inter-organizational

information exchange (*ITEXCH*). An organization's IT infrastructure has been suggested to be a resource that enables organizations to create IT services that facilitate adoption of other IT resources (Bharadwaj 2000; Byrd and Turner 2000; Chwelos et al. 2001). We code *ITINFRA* as 1 if the clinic has indicated that it has a fully installed EHR and therefore the ability to leverage the IT infrastructure available to provide IT services in the process of proving care. In contrast to IT infrastructure, the IT functionality utilization measure focuses on the use of IT functionalities in to support the various organizational activities in the execution of operational processes (Devaraj and Kohli 2003; Pavlou and El Sawy 2006; Ray et al. 2004). High IT functionality utilization implies a high use of health IT in the process of providing care. We code *ITFUNCT* as 1 if a clinic reports the use of IT for lab and test results, to track patients' health problems and track doctors' orders, as well as to create benchmarks and remind patients when they are due preventive care. As an integral part of supply chain management, the ability to exchange information with other entities enables organizations to integrate their processes in the delivery of products and services to end customers (Barua et al. 2004; Rai et al. 2006). Therefore, as an indication of the level of IT enabled inter-organizational information exchange in the process of delivering care, we code *ITEXCH* as 1 if a clinic reports electronic prescribing and exchanging data with hospitals inside and/or outside the doctors' network. Consistent with Stage 1 "meaningful use" criteria, IT leveraging competence in health care delivery requires that health care providers not only adopt IT, but also utilize the various functions and information exchange capabilities in order for IT to be employed in a meaningful way.

Control Variables. We control for various clinic and PCSA level factors that we consider to be influential to the delivery of quality health care. At the clinic level, we control for size of clinic by taking the log of the number of diabetes patient records reported (*D_N*) to MNCM. We control for the scope of services offered with a continuous measure indicating the number of clinic level measures reported (*REPORT*) to MNCM. We control for the proportion of patients covered by Medicare (*D_MCARE*) to account for clinic level age effects. At the PCSA level, we control for

demographic effects with the proportion of the population that is non-white (*P_NONWHITE*). We further control for the size of the workforce by the proportion of population in the age group between 18 and 64 (*P_AGE18_64*). Similar individual and community-level variables have been argued to influence access of health care services (i.e., Andersen et al 2002; Davidson et al. 2004; Pagan and Pauly 2006) and quality of care delivery (i.e., Devaraj and Kohli 2003; Gittell 2002).

[------ Insert **Table 1** about here ------]

4.4 Statistical Methods

Using the ZIP Code for the individual clinics, we linked the individual clinics to their respective PCSA. In order to reduce the potential for biased standard errors in estimating effects of the PCSA level on a clinic's level delivery of quality care, we employ a mixed effects model that distinguishes a PCSA-level residual from the clinic-level one. The procedure estimates the slopes and two components of residual variance (σ^2): a residual variance at the clinic level (σ_ε^2) and a residual variance at the PCSA level (σ_v^2). Due to the dependent variable being a proportion with observations falling between 0 and 1, we employ a binomial logit link function by utilizing a generalized linear mixed model (GLMM) to estimate the *ODDS RATIO* for patients receiving high quality care vs. not receiving high quality care. Rather than using a simple proportion as is the case with OLS, logit link functions utilize more information (number of success, failures, and trials) in its estimation of the *ODDS RATIO*. This logit link GLMM modeling approach ensures that the response is bounded between 0 and 1 while the functional form remains linear. Multi-level linear functional forms are consistently employed in health care access and disparities research (i.e., Andersen et al. 2002; Gittell 2002; Ross and Mirowsky 2008; Sequist et al. 2008).

Let i denote the PCSAs and let j denote the clinics nested within PCSAs. We specify a GLMM logit link function which converts p_{ij}, the expected proportion of patients receiving high

quality care in clinic j given the observed number of successes and failures, to linear predictors with a single random effect for PCSA i as follows:

$$\log(ODDS\ Ratio) = logit(p_{ij}) = \boldsymbol{X}_i\boldsymbol{\beta} + \boldsymbol{Z}_{ij}\boldsymbol{\gamma} + (\boldsymbol{XZ})_{ij}\boldsymbol{\delta} + (\boldsymbol{ZZ})_{ij}\boldsymbol{\zeta} + v_i \quad (1)$$

where $\boldsymbol{X}$ is the vector of regressors at the PCSA level with effects $\boldsymbol{\beta}$, $\boldsymbol{Z}$ is the vector of regressors at the clinic level with effects $\boldsymbol{\gamma}$, $(\boldsymbol{XZ})$ is the vector for interaction between the PCSA level and clinic level with $\boldsymbol{\delta}$ effects, $(\boldsymbol{ZZ})$ is the vector for interaction at the clinic level with $\boldsymbol{\zeta}$ effects, and v_i is the random effect for each PCSA. v_i is assumed to be constant across clinics within PCSAs but random across PCSAs and assumed to be distributed as $N(0, \sigma_v^2)$. The parameter σ_v^2 indicates the variance in the PCSA distribution and therefore the degree of heterogeneity between PCSAs.

We utilize R and the *lme4* package to estimate the GLMM models which requires that the proportion dependent variable be operationalized as a two column vector of the number of "successes" and "failures". Interpretation of the coefficients is performed by exponentiating the coefficients which provides the effect of the predictor on the *ODDS RATIO*. In contrast to OLS specification models, goodness-of-fit is not as important as statistical significance for logit specifications (Wooldridge 2002, p.465). Therefore, although there is no single equivalent R^2 measure to evaluate model fit for GLMMs, we report the value of the log likelihood function along with McFadden's (1974) pseudo R^2 statistic for descriptive purposes only.

5. Results and Robustness Checks

After merging the various data sources, our sample included 450 clinics that provide diabetes care in 141 primary care service areas in the state of Minnesota. A total of 126,029 patient records where submitted with 36,215 records identified as meeting the D5 requirements and the remaining 89,914 missing one or more elements according to the D5. The continuous predictors where standardized for stability of models as well as for interpretation and comparison of coefficients.

Whereas coefficients greater than zero indicate an increase in the ODDS of delivering high quality care, coefficients less than zero indicate a decrease in the ODDS of delivering high quality care.

We use several estimation techniques beyond the full sample GLMM to test the robustness of our results. Similar to Argote (1982) and Ray et al. (2005), we performed subgroup analyses by splitting the sample into low and high enabling resource groups at the 50 percentiles. These analyses first split the sample into groups of clinics below and above the 50 percentiles of enabling resources and then show the relationships between IT leveraging and the delivery of quality health care. We test the difference between coefficients for the GLMM models for the different enabling resources groups using a Wald chi-square test statistic with one degree of freedom as described in Allison (1999). We follow Ho et al. (2007) to preprocess the sample with matching methods so that the treated group is as similar as possible to the control group. This form of matching is argued to be useful in reducing model dependence and bias by improving the degree to which the treatment and control covariate distributions resemble each other. The previous results do not disentangle the effects of IT leveraging selection and health care delivery. In order to determine if and to what extent health care organizations provide higher quality care even when we control for selective IT leveraging, additional analysis is needed. To address the potential endogeneity of IT leveraging competence, we use a two-stage nonparametric bootstrapping technique by including an instrumental variable in the first stage that accounts for the external competition influence on the decision to leverage IT. Lastly, we also performed analyzes on both the unadjusted (*D_COMPOSITE*) as well as the risk-adjusted (*D_RISKADJ*) quality of care measures. Since the results are consistent for the various estimation techniques as well as for both quality measures, we only report the results for the propensity score matching using the unadjusted quality measure.

5.1 Propensity Score Matching Tests

The matching procedure involves two main steps: (i) obtain a preprocessed sample by estimating the propensity score using logistic regression of the treatment on the covariates and (ii)

use the same parametric analysis on the preprocessed sample as was used on the original full sample prior to preprocessing. We used the *optimal* method in the *MatchIt* package in *R* to obtain a preprocessed sample by estimating the propensity for the high IT leveraging competence treatment (*ITLEVERAGE* = 1), namely high IT infrastructure (*ITINFRA* = 1), high IT functionality utilization (*ITFUNCT* = 1), and high IT inter-organizational information exchange (*ITEXCH* = 1) given the clinic and community level covariates resulting in a preprocessed sample of 270 clinics; 135 clinics in the treatment group of 135 clinics and 135 clinics in the control group.

Model (1) contains the propensity score matching main effect estimation results for enabling resources and IT leveraging competence and their association with the delivery of high quality health care. We find that the coefficient of *P_POV* is negative and significant. This result suggests that decreasing the level of community enabling resources as operationalized by the proportion of the population that is below the 200% poverty level is associated with a decrease in the ODDS of delivering high quality care (β = -0.1140, *p-value* = 0.068). Thus, if we hold other regressors equal, a standard deviation decrease in community enabling resources is associated with a 10.8% (= $1 - e^{-0.1140}$) decrease in the ODDS of delivering high quality care. This finding provides support for hypothesis 1A. In support for hypothesis 1B, the coefficient of *D_GOVNON* is negative and significant. Similarly to the community enabling resources results, decreasing the level of individual enabling resources as operationalized by the proportion of patients covered by government assistance health care programs or uninsured (γ = -0.3546, *p-value* < 0.001) is associated with decreasing the ODDS of delivering high quality care. A standard deviation decrease in individual enabling resources is associated with a 29.9% (= $1 - e^{-0.3546}$) decrease in the ODDS of delivering high quality care, holding all other regressors constant. As expected, the coefficients of *ITINFRA*, *ITFUNCT*, and *ITEXCH* are positive and significant, suggesting that IT leveraging competence as operationalized by a fully installed EHR (γ = 0.1374, *p-value* = 0.008), high IT functionality utilization (γ = 0.0466, *p-value* = 0.021), and high IT inter-organizational information exchange (γ = 0.0584, *p-value* = 0.011)

is associated with increasing the ODDS of delivering high quality care. All else being equal, *ITINFRA*, *ITFUNCT*, and *ITEXCH* are associated with a 14.7% (= $e^{0.1374} - 1$), 4.8% (= $e^{0.0466} - 1$), and 6.0% (= $e^{0.0584} - 1$) increase in the ODDS of delivering high quality care, respectively. These findings provide partial support for hypothesis 2A.

Models (2) and (3) contain the propensity score matching estimation results for the interaction between enabling resources and IT leveraging competence and its association with the delivery of high quality care. As expected, the coefficient of the interaction between *ITINFRA* and *P_POV* is positive and significant, suggesting that the effect of leveraging an IT infrastructure as operationalized by having a fully installed EHR ($\delta = 0.4346$, *p-value* < 0.001) increases as community enabling resources decrease as operationalized by the proportion of the population that is below the 200% poverty level. Holding the other regressors constant, a standard deviation decrease in community enabling resources is associated with a 54.4% (= $e^{0.4346} - 1$) increase in the ODDS of delivering high quality care due to leveraging an IT infrastructure (*ITINFRA* = 1). Similar to the community enabling resources results, we find that the coefficient of the interaction between *ITINFRA* and *D_GOVNON* is positive and significant. Thus, the effect of leveraging an IT infrastructure ($\zeta = 0.5181$, *p-value* < 0.001) increases as individual enabling resources decrease as operationalized by the proportion of patients covered by government assistance health programs or uninsured. When the other regressors remain constant, a standard deviation decrease in individual enabling resources is associated with a 67.9% (= $e^{0.5181} - 1$) increase in the ODDS of delivering high quality care due to leveraging an IT infrastructure (*ITINFRA* = 1).

Counter to what we expected, we find that the coefficient of the interaction between *ITEXCH* and *P_POV* is negative and significant, suggesting that the effect of high IT leveraging competence as operationalized by high IT inter-organizational information exchange ($\delta = -0.0744$, *p-value* = 0.018) decreases as community enabling resources decrease. A standard deviation decrease in community enabling resources is therefore associated with a 7.2% (= $1 - e^{-0.0744}$) decrease in the

ODDS of delivering high quality care due to high IT inter-organizational information exchange (*ITEXCH* = 1), holding all other regressors constant. Consistent with the previous result and counter to what we expected we also find that the coefficient of the interaction between *ITFUNCT* and *D_GOVNON* is negative and significant, suggesting that the effect of high IT leveraging competence as operationalized by high IT functionality utilization (ζ = -0.1302, *p-value* < 0.001) decreases as individual enabling resources decrease. All else being equal, a standard deviation decrease in individual enabling resources is associated with a 12.2% (= $1 - e^{-0.1302}$) decrease in the ODDS of delivering high quality care due to leveraging high IT functionality utilization (*ITFUNCT* = 1). We find that the coefficients of the interactions between *ITFUNCT* and *P_POV* and between *ITEXCH* and *D_GOVNON* are not significant. Consequently, we do not find support for a greater effect of high IT leveraging competence as operationalized by high IT functionality utilization as community enabling resources decrease (δ = 0.0264, *p-value* = 0.268) or high IT inter-organizational information exchange as individual enabling resources decrease (ζ = -0.0155, *p-value* = 0.628). Thus, we find partial support for hypotheses 2B and 2C which hypothesizes that the effect of high IT leveraging competence on the delivery of high quality health care should increase with lower levels of enabling resources. Results of the analyses on the preprocessed sample are summarized in **Table 2**.

[------ Insert **Table 2** about here ------]

5.3 Summary of Results

In summary, our results show a positive association between community and individual enabling resources and the delivery of high quality care, providing support for hypotheses 1A and 1B. Further, our results also suggest that there is a positive association between IT leveraging competence and the delivery of high quality care, providing support for hypothesis 2A. **Figure 2** demonstrates the positive association of enabling resources with the delivery of high quality care. As both the proportion of the population < 200% poverty level and the proportion of patients with government assistance or no insurance increase, there is a decreasing trend associated with the

proportion of patients who receive high quality care. Contrary to expectations, we find partial support for the moderating effect of IT leveraging competence on the relationship between enabling resources and the delivery of high quality care. As expected, the effect of leveraging an IT infrastructure on the delivery of high quality care is greater as community and individual enabling resources decrease, providing support for hypotheses 2B and 2C. Counter to what we expected, the effects of high IT functionality utilization and IT inter-organizational information exchange are at times reduced as enabling resources decrease. The sub-group analyses demonstrate that the coefficients of IT functionality utilization and IT inter-organizational information exchange are not negative in the lower enabling resources groups, but rather that their magnitudes are potentially smaller when compared to their corresponding higher enabling resource group. The previous results are consistent with the two-stage nonparametric analyses of the high IT leveraging competence instrumented variable, where we find that the effect of high IT leveraging competence depends on the level of both community and individual enabling resources. More specifically, we find that the effect of the high IT leveraging competence treatment decreases as community and individual enabling resources decrease.

[------ Insert **Figure 2** about here ------]

6. Discussion and Conclusions

6.1 Implications and Major Findings

This study focused on health care supply chain design for reducing disparities in the delivery of care. In particular, we highlight the critical roles of enabling resources and technology competence in the delivery of quality health care in primary care settings in order to address the growing gap between supply and demand of high quality care. Focusing on process level quality of care, we demonstrated that clinics operating in lower socioeconomic areas and providing care to a greater proportion of patients who are uninsured or with government assistance insurance are associated with lower quality health care. We also find support for leveraging an IT infrastructure,

IT functionalities, and IT inter-organizational information exchange as a quality improvement initiative and its positive association with the delivery of high quality health care.

In terms of technology's role in reducing disparities in care delivery due to differences in community and individual enabling resources, we find that the positive association between leveraging an IT infrastructure and the delivery of high quality health care increases as enabling resources decrease, therefore reducing the disparities in the delivery of high quality care by compensating for lower levels of enabling resources. Contrary to expectations, we find that the positive association between both, high levels of IT functionality utilization and IT inter-organizational information exchange, and the delivery of high quality health care potentially decreases as enabling resources decrease. These results suggest that IT functionality utilization and IT inter-organizational information exchange may be complementary IT capabilities that leverage other existing resources and skills. Whereas IT infrastructure may serve as a shared set of capital IT resources that can substitute for resources in performing certain functions (i.e., administrative), IT functionality utilization and IT inter-organizational information exchange may require the combination of other resources and capabilities related to the care delivery function (i.e., clinical) in order to realize the competitive potential of IT leveraging competence in health care (Bharadwaj 2000; Ray et al. 2005).

The results suggest the presence of structural differences in the provision of care due to socioeconomic characteristics of the communities and individuals that primary care clinics must contend with. Therefore, efforts to promote adoption of health IT "might exacerbate existing disparities in care by creating a new health care "digital divide" between providers that disproportionately care for the poor and those that do not" (Jha et al. 2009, p.1161). Whereas individuals obtaining care in clinical settings with greater access to enabling resources will increasingly benefit from improvements in health care delivery from such mandates, individuals obtaining care in under-resourced clinical settings are less likely to obtain similar benefits.

Therefore, incentives to provide care under different settings should be aligned in order to reduce a spiraling effect where clinical settings that have lower levels of enabling resources will continue to perform worse as compared to more munificent clinical settings that have greater access to enabling resources.

6.2 Contributions and Future Research Directions

This study makes the following contributions. First, in the domain of health care supply chain design, we incorporate literature from supply chain management and IT capabilities with health policy and health care disparities to evaluate the roles of community and individual enabling resources as well as the leveraging of technology for information and knowledge sharing and exchange to not only improve the delivery of health care, but also reduce disparities in care delivery specifically in primary care settings where a large portion of chronic diseases are diagnosed and treated. By looking at the role of information technology in addressing disparities, we focus on a priority of the Office of the National Coordinator for Health Information Technology (ONC) in striving for everyone to have access to quality health care including the benefits conferred by health information technology (ONC 2011).

Second, building on previous work by Kc and Terwiesch (2009; 2011) we provide an illustrative context where by applying the resource dependence theory lens we can explain why health care organizations that operate in lower SES communities and provide care to a greater proportion of those who are marginalized are generally associated with lower quality care. These results can inform policy makers on funding decisions regarding reimbursement and incentives such as federal and state grants for organizations that meet the primary care needs of individuals and families living in low-income communities or the Medicare and Medicaid Electronic Health Records Incentive Programs that provide incentives for the adoption, implementation, upgrading, and meaningful use of electronic health records (Department of Health and Human Services 2010).

Third, by incorporating the concept of 'alignment', this study provides support for a growing concern of whether policy mandated health IT interventions are further increasing the disparities in health care and whether a more targeted approach that emphasizes alignment between need and resources is more appropriate (Chang et al. 2004, Jha et al. 2009). As Wagner and colleagues have long argued, successful care for chronic disease requires a broad array of community resources that can provide ancillary support services as well as non-physician resources that are responsible for routine assessments, key preventive tasks, providing support for patient self-management, and assuring follow-up (Bodenheimer et al. 2002; Wagner et al. 1996; Wagner 1997). Therefore, leveraging IT can complement such resources by improving the effectiveness of community linkages and delegated key care functions resulting in greater care delivery benefits.

This study does have the limitation of being an observational study using a cross section of clinics in a given state, their technology competences, enabling resources that they must contend with, and associated quality of care for a single chronic disease. In order to reduce the potential for model dependence and bias, we employed subsample, matching, and two-stage methodologies. Although the decision to leverage IT may be endogenous, we believe that our sample of primary care clinics operating in a single state controls for federal and state level health care reform mandates. We also attempt to address the concern by means of a two-stage estimation approach. The location decision whether quality organizations might select into better resourced communities may also be endogenous and more tedious to control for. Extensions of this study with longitudinal data, other geographic regions, as well as different disease and clinical delivery contexts would provide robustness and generalizability to the reported findings. Given that we use dichotomous measures for IT leveraging competence, more detailed IT leveraging measures such as IT investment, actual usage and amount information exchange measures would be beneficial. Further, the inclusion of more granular socioeconomic variables such as income, employment, and education would be beneficial. More granular community and clinic resource variables such as community programs and

clinical capacity and staffing would also be beneficial to evaluate complementarities between resources and technology competences in care delivery. In addition, the cost estimates on the delivery of care would provide additional insights as to how affordability impacts access to quality health care.

In closing, to the best of our knowledge, this study is the first to empirically examine the relationship between technology competence and disparities in care delivery due to differences in community and individual enabling resources in primary care settings. In response to Agarwal et al. (2010), we highlight some of the challenges to overcome in order to realize the potential for improving health care. In particular, this study highlights the promise and difficulties that technology has on improving the quality of health care in different primary care settings while at the same time addressing disparities in the delivery of care. The challenge remains to tackle the difficulties in bridging the "digital divide" between those with the ability to benefit from technology, and those without (Walsham et al. 2007). Therefore, we highlight the need for further research in evaluating the extent to which differences in resources and technology affect care delivery. This study lays the foundation for developing a framework to inform how enabling resources and IT can enable the delivery of high quality care for chronic diseases and the need for special consideration in regions with heterogeneous patient populations. As the heterogeneity of the population continues to increase as well as the associated complexity in the delivery of care, we hope that this study will motivate scholars and practitioners to conduct inquiries in this area.

References

Adler, N.E., Boyce, T., Chesney, M.A., Cohen, S., Folkman, S., Kahn, R.L., Syme, S.L. 1994. "Socioeconomic status and health: the challenge of the gradient", American Psychologist, 49(1): 15-24.

Adler, N.E., Ostrove, J.M. 1999. "Socioeconomic status and health: what we know and what we don't", Annals of the New York Academy of Sciences, 896: 3-15.

Agarwal, R., Gao, G., DesRoches, C., Jha, A.K. 2010. "The digital transformation of healthcare: current status and the road ahead", Information Systems Research, 21(4): 796-809.

Allison, P.D. 1999. "Comparing logit and probit coefficients across groups", Sociological Methods & Research, 28(2): 186-208.

AHRQ 2010. "Reducing disparities in health care quality in underresourced settings using health IT strategies: expert meeting summary", Agency for Healthcare Research and Quality, http://www.ahrq.gov/research/dispmtgsum09.html.

Andersen, R.M., McCutcheon, Al., Aday, L.A., Chiu, G.Y., Bell, R. 1983. "Exploring dimensions of access to medical care", Health Services Research, 18(1): 49-74.

Andersen, R. M., Yu, H., Wyn, R., Davidson, P.L., Brown, E.R., Teleki, S. 2002. "Access to medical care for low-income persons: how do communities make a difference?", Medical Care Research and Review, 59(4): 384-411.

Argote, L. 1982. "Input uncertainty and organizational coordination in hospital emergency units", Administrative Science Quarterly, 27: 420-434.

Balsa, A.I., Seiler, N., McGuire, T.G., Bloche, M.G. 2003. "Clinical uncertainty and healthcare disparities", American Journal of Law & Medicine, 29(2&3): 203-219.

Barua, A., Konana, P., Whinston, A.B., Yin, F. 2004. "An empirical investigation of Net-enabled business value", MIS Quarterly, 28(4): 585-620.

Bates, D.W., Gawande, A.A. 2003. "Improving safety with information technology", The New England Journal of Medicine, 348(25): 2526-2534.

Bharadwaj, A.S. 2000. "A resource-based perspective on information technology capability and firm performance: an empirical investigation", MIS Quarterly, 24(1): 169-196.

Blumenthal, D. 1996. "Quality of care – what is it?", The New England Journal of Medicine, 335(12): 891-893.

Blumenthal, D., Epstein, A.M. 1996. "The role of physicians in the future of quality management", The New England Journal of Medicine, 335(17): 1328-1331.

Bode, C., Wagner, S.M., Petersen, K.J., Ellram, L.M. 2011. "Understanding responses to supply chain disruptions: insights from information processing and resource dependence perspectives", Academy of Management Journal, 54(4): 833-856.

Bodenheimer, T., Wagner, E.H., Grumbach, K. 2002. "Improving primary care for patients with chronic illness", Journal of the American Medical Association, 288(14): 1775-1779.

Brook, R.H., McGlynn, E.A., Cleary, P.D. 1996. "Measuring quality of care", The New England Journal of Medicine, 335(13): 966-970.

Byrd, T.A., Turner, D.E. 2000. "Measuring the flexibility of information technology infrastructure: exploratory analysis of a construct", Journal of Management Information Systems, 17(1): 167-208.

Cabana, M.D., Rand, C.S., Powe, N.R., Wu, A.W., Wilson, M.H., Abboud, P.C., Rubin, H.R. 1999. "Why don't physicians follow clinical practice guidelines?", Journal of the American Medical Association, 282(15): 1458-1465.

Chang, B.L., Bakken, S., Brown, S.S., Houston, T.K., Kreps, G.L., Kukafka, R., Safran, C., Stavri, Z. 2004. "Bridging the digital divide: reaching vulnerable populations", Journal of the American Medical Informatics Association, 11:448-457.

Chassin, M.R., Galvin, R.W. 1998. "The urgent need to improve health care quality", Journal of the American Medical Association, 280(11): 1000-1005.

Chwelos, P., Benbasat, I., Dexter, A.S. 2001. "Research report: empirical test of an EDI adoption model", Information Systems Research, 12(3): 304-321.

Clancy, C. 2008. "Improving care quality and reducing disparities", Arch Intern Med, 168(11): 1135-1136.

Daft, R.L., Lengel, R.H., Trevino, L.K. 1987. "Message equivocality, media selection, and manager performance: implications for information systems", MIS Quarterly, September: 355-366.

Danaei, G., Finucane, M.m., Lu, Y., Singh, G.M., Cowan, M.J., Paciorek, C.J., Lin, J.K., Farzadfar, F., Khang, Y.H., Stevens, G.A., Rao, M., Ali, M.K., Riley, L.M., Robinson, C.A., Ezzati, M. 2011. "National, regional, and global trends in fasting plasma glucose and diabetes prevalence since 1980: systematic analysis of health examination surveys and epidemiological studies with 370 country-years and 2.7 million participats", The Lancet, 378: 31-40.

Davenport, T.H., Short, J.E. 1990. "The new industrial engineering: information technology and business process redesign", Sloan Management Review, Summer: 11-27.

Davidson, P.L., Andersen, R.M., Wyn, R., Brown, E.R. 2004. "A framework for evaluating safety-net and other community-level factors on access for low-income populations", Inquiry, 41(Spring): 21-38.

Department of Health and Human Services 2010. "Medicare and Medicaid programs; electronic health record incentive program; final rule", Federal Register, 75(144): 44314-44588.

Devaraj, S. and Kohli, R. 2003. "Performance impacts of information technology: is actual usage the missing link?", Management Science, 49(3): 273-289.

Fiscella, K., Epstein, R.M. 2008. "So much to do, so little time", Arch Intern Med, 168(17): 1843-1852.

Galbraith, J.R. 1977. *Organization Design*, Reading, Mass: Addison-Wesley.

Gittell, J. H. 2002. "Coordinating mechanisms in care provider groups: Relational coordination as a mediator and input uncertainty as a moderator of performance effects", Management Science 48(11), p. 1408-1426.

Gittell, J.H., Fairfield, K.M., Bierbaum, B., Head, W., Jackson, R., Kelly, M., Laskin, R., Lipson, S., Siliski, J., Thornhill, T., Zuckerman, J. 2000. "Impact of relational coordination on quality of care, postoperative pain and functioning, and length of stay", Medical Care, 38(8): 807-819.

Goodman, D.C., Mick, S.S., Bott, D., Stukel, T., Chang, C., Marth, N., Poage, J., Carretta, H.J. 2003. "Primary care service areas: a new tool for the evaluation of primary care services", Health Services Research, 38(1): 287-309.

Ho, D., Imai, K., King, G., and Stuart, E. 2007, "Matching as nonparametric preprocessing for reducing model dependence in parametric causal inference," Political Analysis, 15: 199-236.

Hult, G.T., Ketchen, D.J, Arrfelt, M. 2007. "Strategic supply chain management: improving performance through a culture of competitiveness and knowledge development", Strategic Management Journal, 28(10): 1035-1052.

Jha, A.K., DesRoches, C.M., Shields, A.E., Miralles, P.D., Zheng, J., Rosenbaum, S., Campbell, E.G. 2009. "Evidence of an emerging digital divide among hospitals that care for the poor", Health Affairs, 28(6): w1160-w1170.

Kc, D.S., Terwiesch, C. 2009. "Impact of workload on service time and patient safety: an econometric analysis of hospital operations", Management Science, 55(9): 1486-1498.

Kc, D.S., Terwiesch, C. 2011. "An econometric analysis of patient flows in the cardiac intensive care unit", Manufacturing & Service Operations Management, Articles in Advance, Sep 2: 1-16.

Kirby, J.B., Kaneda, T. 2005. "Neighborhood socioeconomic disadvantage and access to health care", Journal of Health and Social Behavior, 46(March): 15-31.

MDH 2010. "2010 Health Care Quality Report", Minnesota Department of Health.

Melville, N., Kraemer, K., Gurbaxani, V. 2004. "Review: information technology and organizational performance: an integrative model of IT business value", MIS Quarterly, 28(2): 283-322.

McFadden, D.L. 1974. "Conditional logit analysis of qualitative choice analysis", in Frontiers in Econometrics, ed. P. Zarembka. New York: Academic Press, 105-142.

Millery, M., Kukafka, R. 2010. "Health information technology and quality of health care: strategies for reducing disparities in underresourced settings", Medical Care Research and Review (not yet in print).

MNCM 2010a. "2010 Health Care Quality Report", MN Community Measurement.

MNCM 2010b. "Minnesota HealthScores", MN Community Measurement, http://www.mnhealthscores.org.

ONC 2011. "Federal health information technology strategic plan: 2011-2015", Office of the National Coordinator for Health Information Technology, Washington, DC, FINAL-Federal-Health-IT-Strategic-Plan-0911.pdf.

Pagan, J.A., Pauly, M.V. 2006. "Community-level uninsurance and the unmet medical needs of insured and uninsured adults", Health Services Research, 41(3): 788-803.

Pavlou, P.A., El Sawy, O.A. 2006. "From IT leveraging competence to competitive advantage in turbulent environments: the case of new product development", Information Systems Research, 17(3): 198-227.

Pfeffer, J., Salancik, G.R. 2003 (reissued). *External Control of Organizations*, Stanford University Press.

Rai, A., Patnayakuni, R., Seth, N. 2006. "Firm performance impacts of digitally enabled supply chain integration capabilities", MIS Quarterly, 30(2): 225-246.

Ray, G., Barney, J.B., Muhanna, W.A. 2004. "Capabilities, business processes, and competitive advantage: choosing the dependent variable in empirical tests of the resource-based view", Strategic Management Journal, 25: 23-37.

Ray, G., Muhanna, W.A., Barney, J.B. 2005. "Information technology and the performance of the customer service process: a resource-based analysis", MIS Quarterly, 29(4): 625-652.

Ross, C.E., Mirowsky, J. 2008. "Neighborhood socioeconomic status and health: context or composition?", City & Community, 7(2): 163-179.

Sampson, R.J., Morenoff, J.D., Gannon-Rowley, T. 2002. "Assessing "neighborhood effects": social processes and new directions in research", Annual Review of Sociology, 28: 443-478.

Sequist, T. D., Fitzmaurice, G. M., Marshall, R., Shaykevich, S., Safran, D. G., and Ayanian, J. Z. 2008. "Physician performance and racial disparities in diabetes mellitus care," Archives of Internal Medicine 168(11), p. 1145-1151.

Sinha, K. K., Kohnke, E.J. 2009. "Health care supply chain design: toward linking the development and delivery of care globally". Decision Sciences, 40(2): 197-212.

Starfield, B., Shi, L., Macinko, J. 2005. "Contribution of primary care to health systems and health", The Milbank Quarterly, 83(3): 457-502.

von Nordenflycht, A. 2010. "What is a professional service firm? Toward a theory and taxonomy of knowledge-intensive firms", Academy of Management Journal, (35) 1: 155-174.

Venkatesh, V. 2006. "Where to go from here? Thoughts on future directions for research on individual-level technology adoption with a focus on decision making", Decision Sciences, 74(4): 497-518.

Wagner, E.H. 1997. "Managed care and chronic illness: health services research needs", Health Services Research, 32(5): 702-714.

Wagner, E.H., Austin, B.T., Von Korff, M. 1996. "Organizing care for patients with chronic illness", The Milbank Quarterly, 74(4): 511-544.

Walsham, G., Robey, D., Sahay, S. 2007. "Foreword: special issue on information systems in developing countries", MIS Quarterly, 31(2): 317-326.

Wennberg, J.E., Barnes, B.A., Zubkoff, M. 1982. "Professional uncertainty and the problem of supplier-induced demand", Social Science Medicine, 16: 824-824.

Wooldridge, J.M. 2002. *Econometric Analysis of Cross Section and Panel Data*, Massachusetts Institute of Technology.

World Health Organization 2005. "Preventing chronic diseases: a vital investment", WHO global report: World Health Organization Press.

FIGURES AND TABLES

Figure 1. Conceptual Framework: The relationship between enabling resources and IT leveraging competence in delivering high quality health care.
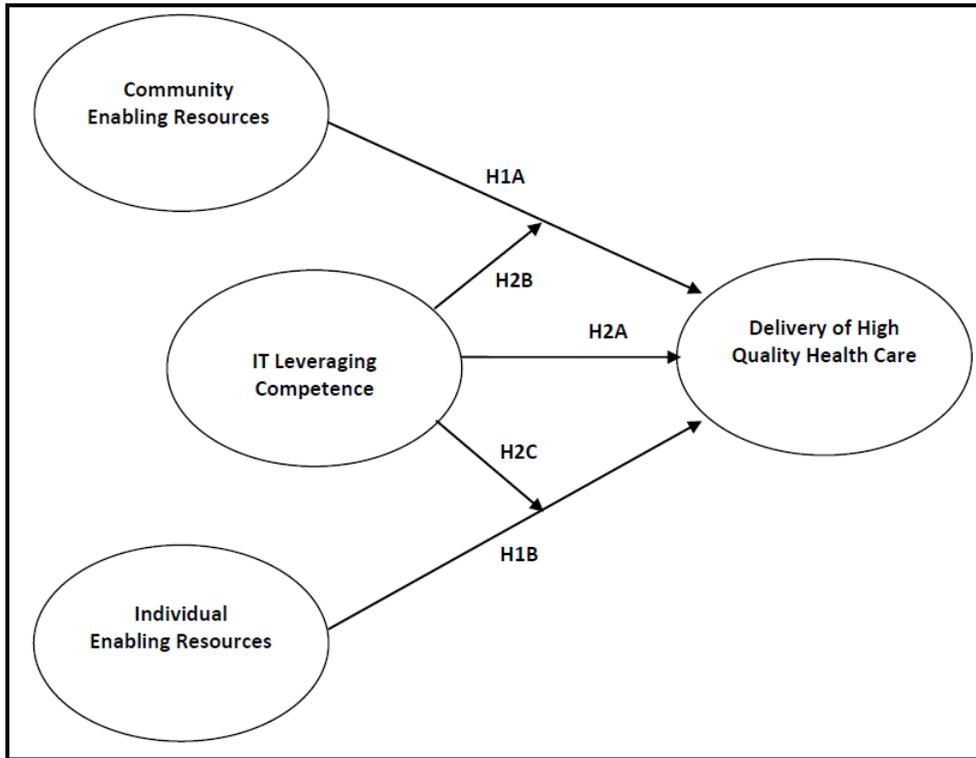
Figure 2. Quality care vs. community and individual enabling resources; line drawn for mean proportion of patients receiving high quality diabetes care; N = 450, PCSAs = 141.
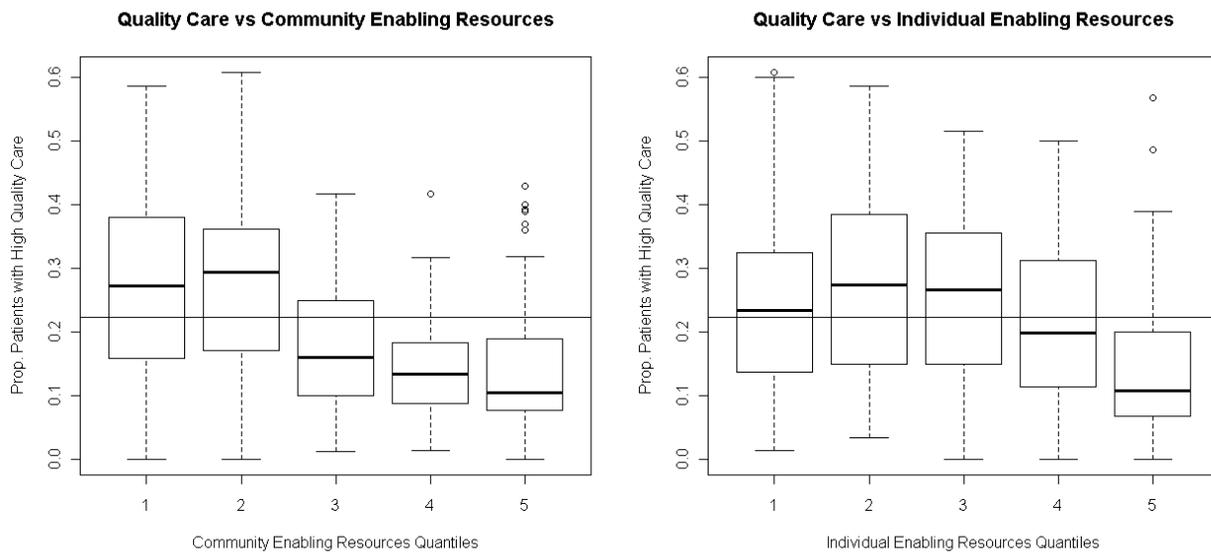
Table 1. Summary and descriptive statistics of variables.

Variable	Description	Mean	SD	Min	Max
Dependent Variable					
D_COMPOSITE	Proportion of patients at clinic level that received D5 care	0.223	0.133	0.000	0.608
D_RISKADJ	Risk adjusted proportion of patients at clinic level that received D5 care	0.223	0.127	0.000	0.572
Independent Variables					
P_POV	Proportion of population in PCSA that is below 200% poverty level (2005 estimate)	0.311	0.105	0.089	0.640
D_GOVNON	Proportion of patients at clinic level that received diabetes care that are on government assistance health insurance or has no insurance	0.163	0.144	0.000	0.870
ITINFRA	Indicator = 1 if clinic reports a fully installed EHR	0.762	0.426	0.000	1.000
ITFUNCT	Indicator = 1 if clinic reports the use of health IT (EHR) for lab and test results, tracking patient health problems, tracking doctors' orders, creating benchmarks, and reminding patients when they are due preventive care	0.420	0.494	0.000	1.000
ITEXCH	Indicator = 1 if clinic reports the use of health IT for electronic prescribing, safely sending data to hospitals in provider's network or outside network	0.533	0.499	0.000	1.000
ITLEVERAGE	Indicator = 1 if clinic reports high IT leveraging competence on all three measures *ITINFR* = 1 and *ITFUNCT* = 1 and *ITEXCH* = 1	0.300	0.459	0.000	1.000
Control Variables					
P_NONWHITE	Proportion of population in PCSA that is nonwhite	0.606	0.041	0.510	0.744
P_AGE18_64	Proportion of population in PCSA that is between ages of 18-64	0.081	0.100	0.009	0.684
log(D_N)	Log of the number of diabetes records reported	5.057	1.038	3.401	7.996
REPORT	Number of quality of care measures reported	2.187	0.722	1.000	3.000
D_MCARE	Proportion of patients at clinic level that received diabetes care that are on Medicare	0.318	0.107	0.000	0.720

Note: N = 450, PCSA = 141

Table 2. Matched sample by propensity for high IT leveraging competence (*ITLEVERAGE* = 1). Binomial logit GLMM results with random intercepts for each PCSA; Dependent variable: proportion of patients receiving high quality diabetes care; Standard errors for coefficients in parentheses; N=270, PCSA=80.

	(1)			(2)			(3)		
Intercept	-1.7705	(0.0738)	***	-2.2609	(0.1082)	***	-1.9164	(0.0880)	***
log(D_N)	0.1479	(0.0128)	***	0.1383	(0.0129)	***	0.1447	(0.0131)	***
REPORT	0.2570	(0.0188)	***	0.2485	(0.0188)	***	0.2538	(0.0188)	***
D_MCARE	-0.0721	(0.0159)	***	-0.0701	(0.0161)	***	-0.0747	(0.0159)	***
P_AGE18_64	0.0718	(0.0674)		0.0289	(0.0687)		0.0681	(0.0683)	
P_NONWHITE	0.0702	(0.0639)		0.0432	(0.0650)		0.0720	(0.0649)	
P_POV	-0.1140	(0.0625)	*	-0.4606	(0.0830)	***	-0.1001	(0.0634)	
D_GOVNON	-0.3546	(0.0129)	***	-0.3493	(0.0130)	***	-0.7553	(0.1211)	***
ITINFRA	0.1374	(0.0515)	***	0.7758	(0.1131)	***	0.2938	(0.0726)	***
ITFUNCT	0.0466	(0.0202)	**	0.0759	(0.0298)	**	0.0383	(0.0205)	*
ITEXCH	0.0584	(0.0228)	**	-0.0150	(0.0378)		0.0654	(0.0234)	***
ITINFRA x P_POV				0.4346	(0.0708)	***			
ITFUNCT x P_POV				0.0264	(0.0238)				
ITEXCH x P_POV				-0.0744	(0.0316)	**			
ITINFRA x D_GOVNON							0.5181	(0.1236)	***
ITFUNCT x D_GOVNON							-0.1302	(0.0273)	***
ITEXCH x D_GOVNON							-0.0155	(0.0319)	
Log-likelihood	-1061.0			-1035.0			-1039.0		
Pseudo R²	0.4419			0.4555			0.4534		

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.