

Health Care Supply Chain Design for Emerging Economies

A DISSERTATION
SUBMITTED TO THE FACULTY OF THE GRADUATE SCHOOL
OF THE UNIVERSITY OF MINNESOTA
BY

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IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

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August 2010

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Acknowledgements

There are many generous individuals who have sacrificed to help me complete this dissertation. The one among them who has worked the hardest is my adviser, Kingshuk K. Sinha. Without his patient, wise guidance and support it would not have been possible to complete this research. His encouragement and feedback challenged me to push myself to achieve more than I thought possible and his support often prevented me from giving up. His dedication to excellence in academic pursuits has inspired me and I hope to eventually achieve the standard that he embodies. Thank you, KK, for all your selfless efforts as my adviser.

I would also like to graciously thank each of my dissertation committee members: Dr. Susan Meyer Goldstein, Dr. Karen Donohue and Dr. Snigdhanu Chatterjee for their generous assistance and support. Their feedback and suggestions greatly improved the quality and clarity of this dissertation. My thanks also go to Dr. Ernest Davenport Jr. who served as a member of my oral defense committee. Additionally, I would like to thank all of the faculty and staff (current and past) of the Operations and Management Science Department for their dedication. It has been a privilege to work with each of you. I also extend my deep gratitude to my friends and colleagues from the OMS doctoral program. Each of you has made this experience more rewarding through your friendship and support.

This dissertation would never have been completed without the generous time and assistance of many individuals who helped, in a multitude of ways, with the data collection. These are Paul Gam of Boston Scientific, Elizabeth Bickel, John Cushing, Andreas Tsakistos, Carissa Johnson, Karen Baumgaertner, Bistra Zheleva, Estelle

Brouwer, Claudia Liebrecht, David Andreas and Frank Watts from Children's HeartLink. My thanks also for the valuable time and insights gained from conversations with Drs. Joseph Dearani, Allison Cabalka, and Roxann Barnes of the Mayo Clinic as well as Dr. Lorry Frankel of the Lucille Packard Children's Hospital at Stanford, Dr. Lee Pyles of the University of Minnesota, Amplatz Children's Hospital, Dr. Jeff Myers of Massachusetts General Hospital, Jeff Paurus of the Minneapolis Community and Technical College and Li Wang of Medtronic Inc.

Also crucial to the completion of this dissertation, was the generous financial support of the Joseph M. Juran Center for Leadership in Quality, the APICS Education and Research Foundation through the George and Marion Plossl Fellowship and the Carlson School Deans' Small Research Grant.

On a more personal level, I would like express my deepest gratitude to my family and to my husband, Tim, for their unwavering support as I navigated this journey. Tim, thank you for your unshakable faith in me and your patience. I also owe a deep debt to my parents, who have always inspired and supported me to fulfill my dreams and have encouraged me in all my endeavors. The time I have dedicated to completing this dissertation has been the most rewarding and challenging of my life. The final result is a credit to the talents and abilities given to me by my Creator, and I thank Almighty God for the blessings He has given.

Any and all errors and omissions in this dissertation are my responsibility. Much of the credit, however, belongs with the creativity and dedication of KK Sinha, whose guidance has shaped the contributions of this research.

Dedication

To my husband, Tim,
&
To my parents, Harry and Sarah McIlvaine

Abstract

This dissertation research is motivated by the global mismatch in the supply and demand of quality health care for underserved communities. To begin addressing the identified need for additional health care services in many communities, this dissertation unfolds a design for the health care supply chain. This design is based on the coordination constructs of access, awareness and affordability and will advance our understanding of how to increase the quality and volume of care in underserved communities by connecting the development of care to the delivery of care. The dissertation is comprised of three studies that are designed to: (i) uncover the nature, measurement and relationships between the three mechanisms (affordability, awareness and access) and propose an integrative framework to inform supply chain design for delivering quality health care to underserved communities; (ii) empirically analyze the relationships in the proposed framework and, (iii) extend the framework by examining inter-organizational relationships and roles between partners in the health care supply chain and how they influence the delivery of care. This research was conducted in collaboration with Children's HeartLink, a medical non-profit organization which partners with health care organizations in developing countries around the globe to provide health care services for individuals suffering from congenital heart conditions. The research setting for this study was the First Hospital of Lanzhou University, located in the Gansu province of China.

Subject Areas: Supply Chain Management, Globalization, Health Care Systems, Service Operations, Quality, Relational Coordination

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Chapter 1

1.1 Problem Statement

The stark reality of the global health care market is that many patients who need quality care in developed, developing and underdeveloped countries are either not receiving care or are receiving poor quality care (e.g., Murray et al. 2002). The commonly accepted wisdom is that health care for many of these underserved communities is simply unaffordable but an argument can be made that the real reason is the unaddressed complexities of the health care supply chain. In a global marketplace, where goods and services are exchanged across country boundaries at a rapid and efficient rate, the undeveloped state of the health care supply chain stands in stark contrast. In the management parlance, there is an extreme level of demand which is currently being met by a paltry supply of quality health care.

While there are numerous reasons for this inequity, one significant contributor is the lack of coordination in health care supply chains. In this dissertation research, health care supply chain will be defined following Schneller and Smeltzer (2006, p. 30): “the information, supplies, and finances involved with the acquisition and movement of goods and services from the supplier to the end user in order to enhance clinical outcomes while controlling costs.” Accordingly, this dissertation will develop a design for health care supply chains that increases the quality and volume of care in underserved communities by connecting the development of care to the delivery of care through the coordination constructs of access, awareness and affordability.

The importance of conducting this research is underpinned by the sheer volumes of non-communicable and chronic diseases in the developing countries of the world. It has been estimated that chronic disease treatment accounts for 75 percent of the global spend on health care (World Health Organization 2005). These chronic diseases are by far the leading cause of death and disability on every continent with the exception of Africa (World Health Organization 2005). In no other disease category is the criticality of the need for ways to expand the reach of global health care supply chains more evident than in cardiovascular disease (CVD). The prevalence of CVD is of large enough proportions to create significant market opportunities for CVD care. According to the World Health Organization (WHO) (Murray et al. 2002), CVD is the most common chronic illness in both developed and developing countries. It has been attributed as the cause of the most deaths worldwide and has also had the greatest impact on morbidity (a state of poor health or a diseased state due to any cause.) Approximately one third of the total deaths worldwide have roots related to CVD in one form or another. To put this more concretely, CVD deaths amounted to 16.6 million worldwide in 2002 compared to 5.7 million from the major infectious diseases (AIDS, tuberculosis, and malaria) (Murray et al. 2002).

A startling fact about many of these deaths is the inequality among the victims of CVD. The WHO (Evans et al. 2003: 70) reports “marked disparities in the quality of treatment can be seen in groups of different race, ethnicity, sex, and socioeconomic status. In essence, many patients who could benefit from treatment remain untreated, or inadequately treated.” In fact, 78% of CVD deaths occur in the middle and lower income countries of the world (Evans et al. 2003). Therefore, much of the world’s population is

suffering from CVD or other chronic diseases but does not have access to existing, effective treatments available commonly in health care centers located in developed nations.

The inequalities present in health care systems do not stop with emerging economies. In fact, the current global economic recession has highlighted the gap in health care access more than ever before, particularly in the developed countries. For example, before the current recession which began in 2007, the number of people without adequate health insurance in the U.S. was estimated to be around 47 million, implying that about 1 in 7 people did not have sufficient means to pay for their health care needs (CIA 2007). With a rising rate of unemployment and an economy in recession, the problem is becoming worse and more complex. For example, there seems to be a growing tendency, particularly among the jobless and uninsured, to postpone the diagnosis and treatment of their health problems as long as they possibly can (Lee 2008; 2009). This increases the likelihood of catastrophic consequences, necessitating emergency care, and, in turn, imposing a significant cost burden on the health care delivery system (O'Neill 2007). Simultaneously, the economic recession is afflicting health care delivery organizations by constraining the available capacity for the delivery of quality care as hospitals and health care systems cut back on expansion plans and staffing (Lee 2008; 2009). These statistics point to the growing underserved community in developed countries, such as the U.S., when it comes to the delivery of quality health care.

As mentioned at the beginning, there is a widely pervasive conventional wisdom that the major barrier to the delivery of quality care to underserved communities is the

affordability of care extended to these populations. However, this does not always appear to be the case. In fact, this project is partially motivated by the failure of an innovation intended to enable the delivery of quality care to underserved communities. It failed despite its effectiveness in making care significantly more affordable. The following is a brief description of the innovation: A few years ago, a medical device manufacturer recognized the need for a low-cost alternative to the typical expensive, high-margin devices required to treat some forms of CVD, whose incidence has been rapidly growing in emerging economies (Gaziano 2006; Mathers et al. 2006; Murray et al. 2002). The company successfully designed a clinically proven and tested device at a low price point. This device was determined to be appropriately designed according to the prevalent disease conditions and patients' economic status in the intended markets.

However, after the product launch, the sales figures for the device remained well below the projected numbers. In fact, net sales for the new device began to decrease after the third year of its presence on the market and the company decided to cancel production and sale of the device six years after its launch. The pattern in the sales figures for the device ran contrary to the expectation of an exponential increase in demand which has been established in the literature on innovation diffusion (Rogers 2003; Rivera and Rogers 2006). Many explanations for the product failure were sought; however, the dismal sales numbers could not be blamed on known medical failures, inadequate design for the product, or a bad reputation for the device. The company concluded that the most likely cause was that the patients who qualified for the implants of this particular device were not diagnosed or referred for an implant. Therefore, although there was a significant market for the device, the price point of the device was adequately low to be

affordable, and the clinical performance of the device was quite satisfactory, the demand was not matched with the supply.

Having described the gap between supply and demand for chronic disease care in underserved communities both in the developed and the emerging markets of the world, this dissertation will strive to provide theoretical and practical insights which positively influence health care supply chain design. While the importance of the affordability of health care cannot be denied, it is but one key to unlocking the complexities of care delivery in underserved communities which requires a solution that has the capacity to address numerous additional factors.

1.2 Study Objectives

The problem area highlighted in the previous section is both large and complex. While recognizing that it is impossible for a single dissertation to provide a comprehensive solution to the existing deficit of supply for quality health care globally, this study begins an exploration of the topic and develops a conceptual model relevant to helping both academics and practitioners understand effective health care supply chain design. These efforts focus on underserved communities in emerging economies because this setting provides opportunities to observe significant variations in the constructs relevant to the supply chains which influence the effective delivery of health care.

Given the volume of the global need for quality health care, evidenced by the data presented earlier for chronic diseases and CVD in particular, we recognize that improving the availability of quality health care is an economic and ethical imperative. This dissertation attempts to understand ways to increase the quantity and quality of health

care by adopting a quality and process-centric perspective toward designing health care supply chains. In the scenarios described so far in this document, it is desirable to increase the quantity of care delivered, however, this is not universally true. There are cases where more health care is not better. An example of this is a study which discovered that 51% of patients diagnosed with a common cold virus were prescribed antibiotics. These unnecessary antibiotics were not only completely ineffective but contribute to an alarming problem of antibiotic resistance which is making some diseases increasingly difficult to cure (O’Kane 2006). This type of unnecessary procedure can both increase cost and decrease the quality of care (O’Kane 2006). Such inefficiencies must be avoided when proposing a design of the health care supply chain that enables the delivery of quality care. In fact, it is imperative that the link between care quality and costs be considered and recommended treatments be based on proven (evidence-based) care processes. This project attempts to narrow the knowledge gap in how health care supply chains can be designed to enable the delivery of quality care in a cost effective way for underserved communities.

One premise of this research is that significant improvement in the quantity of health care delivery in these communities must not be traded-off with the quality of care. Within the field of health care, there has been an emphasis on quality management initiatives and a focus on how quality care can be delivered in order to influence outcomes both with respect to hospital performance and patient satisfaction (Naveh and Stern 2005; Jiang, Friedman and Begun 2006b; Jiang, Friedman and Begun 2006a; Ward, Rolland and Patterson 2005). Despite the obvious benefits of focusing on quality in health care, it has been a difficult field in which to define and measure quality (Ward,

Rolland and Patterson 2005; Peabody et al. 2006; Sage and Kalyan 2006). Current studies of health care quality have shown that poor quality arises from one of two sources; the lack of resources or deficiencies in the knowledge of the resident health professionals (Institute of Medicine 2001). Using this as a starting point, this dissertation defines quality in the health care delivery context as “optimizing material inputs and practitioner skill to produce health.” (Peabody et al. 2006, p. 1293) Because of the importance of quality in the delivery of health care, this dissertation will examine the available measures of care quality in the development of propositions relevant to increasing the volume of care in the health care supply chain.

Given the large global scope, the importance of care quality, and gaps in current relevant theory the central premise of this dissertation is the argument that the coordination mechanisms of the health care supply chain are the most important keys to increasing quality and quantity of care. These supply chain coordination elements are embodied by the information, supplies and finances required to deliver the good or service (Schneller and Smeltzer, 2006). For this project these coordination elements are referred to as *affordability*, *access* and *awareness*. In Sinha and Kohnke (2009) a macro-perspective of the health care supply chain is presented in which the development of care is linked to the delivery of care through the interdependence of industries that span new service and product development to delivery organizations. This chain includes such development industries as medical devices, pharmaceutical, biotechnology firms which are connected both directly and through the health care finance industry to the health care delivery sector. In this dissertation, the three key elements to an effective design of the health care supply chain were identified as affordability, awareness and access. These

are defined briefly as follows and will be further explored by the three studies in this dissertation.

Affordability: The ability of patients to pay for the necessary treatment of adverse health conditions and the parallel ability of the health care provider to offer the necessary services.

Awareness: A dual construct with two specific dimensions - the patient's knowledge of available health services and disease conditions and the physician and allied health workers knowledge and skill relevant to diagnostics and treatment protocols for providing quality care.

Access: The existence of a logistical infrastructure for diagnoses and care delivery, including facilities, equipment and supplies required as well as the public transportation and lodging necessary to support patient transit.

To continue the exploration of these three key constructs, the first study (chapter 3) of this research project develops theoretically sound measurement items for affordability, access and awareness and examines their impact on one another in order to identify the framework of relationships in the health care supply chain. Each of these constructs is both complex and multifaceted and additionally, the innovations involved and the relevant performance outcomes occur at a variety of levels of study. For example, the primary outcome measure of interest is at the level of the individual patient while many of the controls and the constructs are primarily observable at an organizational level. Therefore, an examination of affordability, awareness and access and their influence on the quality and quantity of care produced by the supply chain requires a study with multi-level considerations. The specific research question addressed by the first study is:

How do affordability, access and awareness – the coordination dimensions relevant to health care supply chain design – affect the performance of a supply chain for underserved communities?

Central to an effective design for the health care supply chain is an understanding of the impact that significant changes or innovations in the coordination dimensions of affordability, awareness and access (3-As) have on the ultimate outcome, the volume and quality of care. The second study (chapter 4) provides empirical operationalizations for affordability, awareness and access and tests the strength of the relationships in the proposed framework which link the development to the delivery of care through improved health care supply chain performance. This research explores the role of innovations in the supply chain coordination dimensions on the successful diffusion of a new treatment through the health care supply chain. The premise is that there will need to be innovations in at least one, if not all, of the three coordination elements of the supply chain to substantially increase the volume and quality of care. The second study of this dissertation is driven by the question:

What is the impact of innovations in affordability, access and awareness on the performance of a health care supply chain in underserved communities?

Finally, the third study (chapter 5) explores human roles across organizations in the health care supply chain and their impact on the ability of the supply chain to increase the volume of care for underserved communities. This study utilized relational coordination as a theoretical lens to uncover an additional important layer of complexity in how innovations in the 3-As result in improved supply chain performance. In previous work, relational coordination has been empirically shown to have significant positive impacts on performance and specifically to mediate the performance impact of efforts to increase productivity within the firm. This work will extend that theory to propose and

empirically test the functioning of inter-organizational relationships in a supply chain.

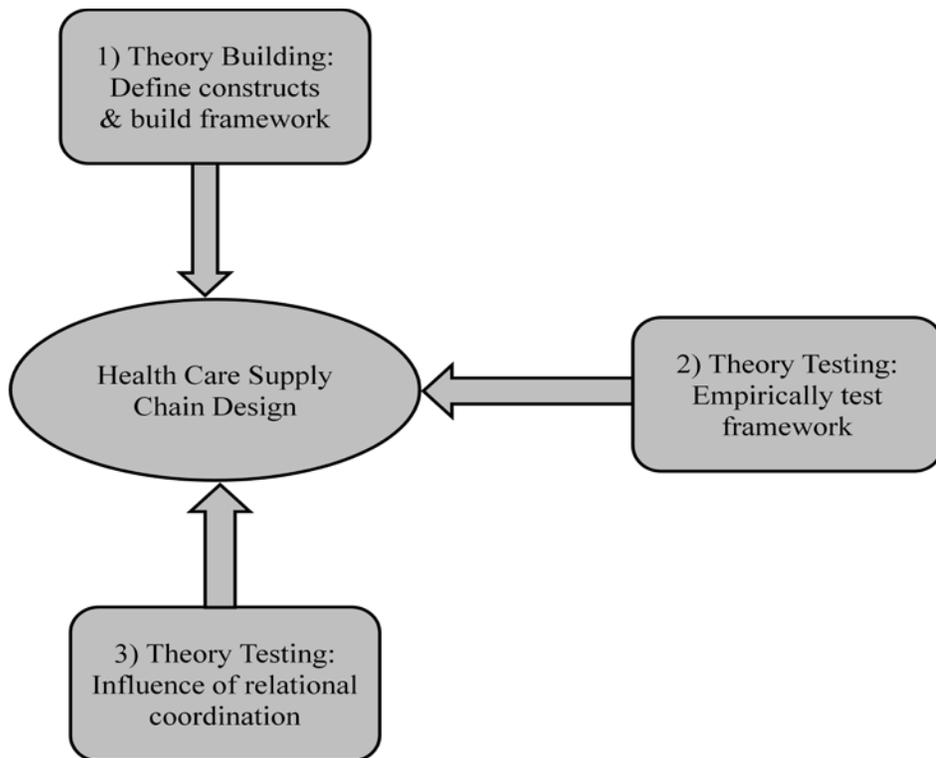
This study is driven by the question:

How does relational coordination (i.e., the relationships between human roles across partnering organizations in a health care supply chain) mediate the relationship between affordability, access and awareness and supply chain performance?

Through these three studies, our aim was to contribute to existing theory on service supply chains for emerging economies and begin filling a gap in the literature at the intersection of the supply chain management, health care operations and innovation management. Figure 1-1 illustrates how these three studies work to individually contribute to our understanding of health care supply chain design. Collectively, the results of this dissertation shed light on how care-centered service innovations diffuse through the health care supply chain globally, specifically to unserved communities. Because this is a research area in which the theory is in a nascent or, at best, an intermediate stage, it requires both qualitative and quantitative data (Edmondson and McManus 2007). For the same reasons, the analysis used for the first study was iterative exploratory content analysis utilizing the techniques of systematic combining (Dubois and Gadde 2002). The first study delved into the development of the constructs over time utilizing both qualitative and quantitative data and utilized the panel data structure to identify patterns and derive relationships between the constructs in the form of propositions. Therefore, an exemplary case was selected that included the creation of a new treatment capability within a hospital in China. An in-depth examination of this inter-organizational context provided the ability to extend and enhance theory related to new service innovations and health care supply chain design (Eisenhardt 1989;

Eisenhardt and Graebner 2007; Pettigrew 1990; Pratt, Rockmann and Kaufmann 2006). This data from the field study was utilized to further develop the relevant constructs and measures for those constructs. It also proposes mid-range theory in the form of an integrative conceptual framework.

Figure 1-1 Organization of Dissertation Studies



The use of a field study is recommended because the current stage of theory development in this area is between nascent and intermediate. Similar studies have used this same approach in their efforts to uncover process and theoretical insights with respect to a phenomenon of interest (Volkoff, Strong and Elmes 2007; Dibbern, Winkler and Heinzl 2008). It is clear from the literature on empirical research methods that the use a field study is appropriate when there is little that can be inferred from the extant

literature and even less empirical validation of a phenomenon of interest (Edmondson and McManus 2007; Eisenhardt 1989). Field studies are frequently used to aid in theory development and are recommended by Yin (2003) in his text on the case study method. In this dissertation, theory building is performed using an inductive field study and model specification and estimation are undertaken using robust regression tools and bootstrapping techniques. Using these methods, a conceptual framework for health care supply chain design is proposed and tested.

The methods utilized in the fourth and fifth chapters allow for an initial testing of the proposed conceptual framework as well as a further exploration of the drivers of health care supply chain performance using an additional theoretical lens. The usefulness of conducting a field study, such as this one, extends beyond the theory building power of qualitative data analysis because the quantitative data that is also collected and generated through this process can be utilized for a preliminary testing of the propositions. Therefore, two and three stage robust regression analysis with bootstrapping techniques is utilized in chapters four and five to specify the constructs in the proposed models and estimate the significance of the relationships. This preliminary testing of the conceptual framework provides a basic foundation for additional research to examine the proposed constructs and the relationships between them in alternative settings.

This dissertation is organized as follows. The second chapter provides an in-depth description of the research setting that was selected to allow the examination of our research questions. It also presents the process of data collection that was undertaken and a summary description of the data that was collected. The third chapter contains an in-

depth, inductive field study aimed at theory development which defines the key coordination dimensions in the design of a health care supply chain for underserved communities. This chapter concludes with the presentation of an integrative conceptual framework of how the dimensions inter-relate and, in turn, influence the performance of a health care supply chain. Chapter four of the dissertation will empirically test this proposed framework of the key coordination dimensions in the design of a health care supply chain and whether changes in the three key elements over time result in improved performance. The fifth chapter extends the proposed framework by delving deeper into how relationships between human roles across partnering organizations in a health care supply chain impact supply chain performance. It does this by extending the theory of relational coordination to the domain of supply chain or inter-organizational relationships. Finally, chapter six concludes the dissertation by presenting an overview of the results and conclusions reached in the previous chapters. It also discusses the contributions made by the dissertation to theory and practice.

Chapter 2

2.1 The Research Setting

This dissertation sets out to develop a design for health care supply chain based on the coordination constructs of access, awareness and affordability that increases the quality and volume of care in underserved communities by connecting the development to the delivery of care. The need for such a study has been argued based on the disconnect between the demand and supply of health care for chronic diseases as well as the significant growth of these diseases as illustrated by CVD incidence rates globally. It has been proposed that the design of service supply chains for complex services like health care is dependent on an understanding of the coordination dimensions of affordability, awareness and access. The purpose of this dissertation research is to further define the measurement for these constructs and develop a conceptual framework that explains the relationships between them and supply chain performance.

The first task was to identify a network of organizations through which it was possible to observe and gather data relevant to each of the identified coordination constructs of the health care supply chain. We found this in Children's HeartLink (CHL), an organization that serves as an intermediary in a health care supply chain with the goal of fostering sustainable treatment options for congenital heart disease (CHD) in underserved communities existing in developing economies around the world. The CVD epidemic as a whole was described in the first chapter of this dissertation. The impact of CHD as a subset of the larger CVD problem is equally compelling. Around the world, it is estimated that one percent of live births annually are children with some form of

congenital heart condition or defect. Of those impacted by CHD ninety percent, more than 1 million children, receive suboptimal or no health care at all (Neirotti 2004; Tchervenkov et al. 2008).

CHL is an international medical nonprofit which has the stated mission of:

“building sustainable programs to help enhance existing pediatric cardiac programs through on-site and off-site training provided by volunteer teams and consultants, technical assistance and resources (funding, equipment and supplies) to support life-saving treatment for needy children.”

The organization started in 1969 and initially functioned by bringing children with CHD from Vietnam back to Minnesota for the necessary treatments. Gradually, they expanded their reach into other developing nations and formed a more formal organization named the Children’s Heart Program in order to serve more children around the world without easy access to care. After many years of operating under the model of bringing children to Minnesota for treatment, the organization realized that to reach more children they should explore the possibility of fostering treatment centers located in the home countries of the children in need of assistance. This new approach was developed to not only treat more children but to increase the number of physicians trained to perform these treatments while reducing the personal & family stress and expense involved in international travel for treatment. By 1988 the first partner institution was created in Honduras and a new paradigm of focused intervention to increase local or regional access of congenital heart patients to care delivery was initiated. This new program was named the Children’s HeartLink (CHL) and is the premier of several successful organizations of its type around the world. In 1999, CHL’s first attempt at partnership in China was initiated with the First Hospital of Lanzhou University (FHLU).

FHLU had an existing cardiac surgery department that treated approximately 100 adult cardiovascular disease cases per year of which forty percent required open heart surgeries. The site had significant challenges in facilities, supplies and staffing but was deemed by CHL to have the vision and leadership to help serve the region's disproportionately large population of children suffering from congenital heart defects. A partnership between CHL and FHLU was birthed. The rest of this chapter will provide a summary of the 10-year evolution of that program and describe the data collection efforts that were undertaken as part of this study. We examine the significant innovations in the health care supply chain design that were implemented at FHLU and what the impact has been on both quality and quantity of care delivered. Through this study we hope to highlight the basic principles of supply chain design that can be applied to the dispersion of similar medical treatment innovations around the world.

Each partnership undertaken by CHL involves a range of assistance that focuses primarily on skill development for the medical staff as well as informational resources for the hospital on how to build the necessary infrastructure and publicity for the program to succeed. The CHL organization focuses almost entirely on increasing the supply of health care for those suffering from CHD in emerging economies. This focus results from the large demand for care in the communities in which they operate which allows them to focus their efforts on training and expanding the capabilities of the health care workers and organizations themselves. The most frequent vehicle used to promote the programs is called a "mission." A mission is a trip wherein a team of medical experts in CHD from a world-class facility in the developed world travel to the partner hospital and work jointly with the resident team for a week. This week is used to teach them new

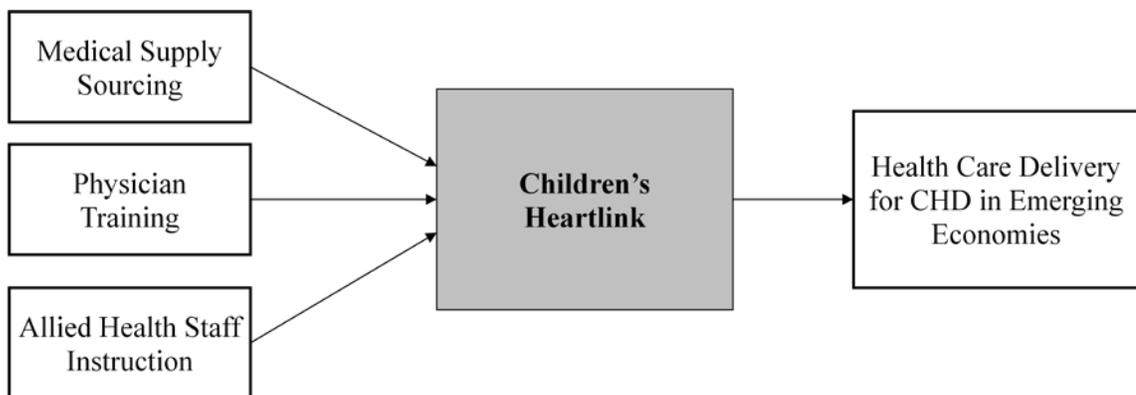
techniques and procedures to enable them to care for more children and more complex cases while reducing mortality and morbidity. It also provides an opportunity for both teams to learn and exchange ideas and to work on the vision and development plan for the program in a cooperative manner. These missions provide the opportunity for significant one-on-one, hands-on training as well as the observation of team interactions and communication to facilitate team growth and development. These trips are also used to conduct some conceptual training through the use of lectures and other group teaching methods.

In addition to these focused week-long missions, CHL provides funds and opportunities for the staff at the partner hospital to travel to other facilities and other countries to learn new techniques on an individual and team basis. CHL arranges for specialists to travel to the site individually throughout the year to provide additional training for longer periods of time. It also provides needed connections to medical product suppliers and help with goal setting and planning for departmental growth. The missions generate significant learning for the visiting western teams through widening their world view and showing the resourcefulness and strength of the local teams' ability to adapt and serve others despite limited resources. CHL commits to providing up to two missions per year in addition to other training opportunities for each site. The missions most commonly occur on an annual basis.

Figure 2-1 depicts CHL's role in the health care supply chain for emerging economies. Specifically, CHL plays a key role as an intermediary in the health care supply chain, encouraging the introduction of new treatment services. This project

therefore, is a study of an inter-organizational partnership context designed to introduce new services for the treatment of CHD in underserved communities. As part of this project we are dissecting one specific partnership between CHL and a site in China called the First Hospital of Lanzhou University (FHLU), effectively examining one network of relationships forming a single health care supply chain for a particular type of care delivery.

Figure 2-1 CHL’s position in the health care supply chain for emerging economies



2.2 Site Selection

The site being investigated, FHLU, is a regional care center in Gansu province which is one of the poorest provinces in China. Their cardiac surgery department was established in 1955 and currently has a 48 bed ward, 10 ICU beds and 2 operating rooms. The hospital established a relationship with CHL in 1999 and at that point the cardiac surgery department was primarily performing adult surgeries. The hospital’s desire to move from adult surgeries to pediatric surgeries led to the partnership with CHL and required a significant investment in facilities, skills and organization. Through this partnership they have progressed from performing 150 total cardiac surgeries per year to

over 505 in 2007 and their mortality rates decreased from 5.33% in 1999 to 1.68% in 2003. In 2007, they performed 264 pediatric cases, up from 1 in 1999 at the beginning of the partnership. They currently have 11 surgeons along with dedicated anesthesiology, perfusion and intensive care unit (ICU) teams. This partnership between CHL and FHLU in Lanzhou (China) is not only an inspiring story, but an appropriate inter-organizational context in which to examine the impact of the health care supply chain coordination dimensions on the quality and quantity of care.

2.3 Qualitative Data Collection

This dissertation has three main stages of data collection followed by extensive qualitative and quantitative analysis. The *first* stage of data collection involved a detailed review of all historical documents that were related to the development of the CHL partnership with the FHLU site in Lanzhou, China. This was the primary method of data collection for the research and covered all of the historical documents that were kept during the evolution of the partnership. Each of these documents was reviewed and references to incidents related to the constructs in our project were recorded, identified and marked as relevant to a specific construct. This process of identifying material relevant to specific constructs will be referred to as “coding” the data for the remainder of this dissertation.

To supplement this document-based view of the partnership and to help establish the validity and reliability of the data the second and third stages of data collection involved primary data collection which included interviews of key informants and travel to the partner site for observation. Specifically, the *second* stage involved interviews of key

individuals from the CHL organization and the FHLU facility, as well as the medical and logistical personnel that volunteered their time to travel to the site for developmental and educational visits over the ten-year duration of the partnership. In the interviews we asked questions to reveal more about the knowledge systems used to advance the pediatric cardiac program at Lanzhou and its effectiveness as well as the infrastructure, finances, and supplies necessary for treatment. The *third* stage was a trip to the FHLU site in China that allowed for both the observation of interactions between the teams and the conducting of short interviews with the staff and administration at the hospital in Lanzhou. This series of three stages of data collection allowed for the triangulation of the data in order to establish the reliability and validity of the constructs and afforded the opportunity to consider many different perspectives on the health care supply chain for CHD care that was initiated by the partnership between CHL and FHLU.

2.3.1 Historical Documentation

The first phase of data collection covered the entirety of the historical data available on the partnership. It was primarily focused on the binders that were kept for each mission as well as other supplemental materials that were relevant to soliciting necessary funding for the missions, the evolution of the site selection and evaluation process, as well as background materials for both CHL and FHLU. Each document provided by CHL, both physical and electronic, was reviewed and incidents which related to the development of the site were recorded and coded. The coding process involved reviewing and attempting to categorize each phrase or paragraph according to its relevance to one of the major constructs identified in the literature review. The items that

did not fit into one of these pre-identified constructs, but that seemed key to the progress at the site, were also recorded and coded as emergent constructs during the data collection process. In chapter 3, further details of how this iterative coding process was conducted and utilized to identify items relevant to constructs of interest, new constructs, and relationships between the constructs will be presented.

2.3.2 Site Visit

Once the historical data collection was complete, we traveled to the FHLU site with a mission team in September of 2008. Once there we were able to observe the formal and informal interactions of the team and we were introduced to the site staff as researchers who had interests in understanding the nature of site development at FHLU and the partnership characteristics. Each formal meeting between the team members and the administration of the CHL and FHLU partnership was observed and notes taken. These notes were later coded according to the relevant constructs. The result of these observations are documents containing the transcribed notes from each official meeting that took place, a summary of the general daily interactions between the teams, and a copy of the presentation given by the FHLU senior staff at the beginning of the trip.

While visiting at FHLU, we began the third stage of data collection by interviewing site staff and leadership. This ensured that the interview data would be representative of both sides of the partnership and thereby increased its reliability and validity. The interviews that took place were conducted with a vice-president of the hospital, the former head of the cardiac surgical unit, and one of the head nurses for the cardiac surgical intensive care unit. These interviews were semi-structured in nature and the

interview questionnaire was generated based on current knowledge of the constructs of interest. The protocol included a section of questions about the usefulness of the partnership, the relevance and usefulness of the training given by the CHL teams and the hindrances to learn the new skills being taught. Another important question covered asked the interviewees to identify the largest obstacle to providing pediatric cardiac care in Lanzhou and whether it was related to general descriptions of affordability, awareness or access. Finally, the protocol included specific questions for the interviewees based on their role in the organization. The physicians and allied health professionals were asked about changes in the daily work routine, diagnostic capabilities and effectiveness of administration. The administrators were asked about their goals, overall treatment costs and how performance is measured. See Appendix 2-1 for the interview protocol used and Appendix 2-2 for more details on the interviewees.

2.3.3 Interviews

The third stage of data collection was completed by conducting additional semi-structured interviews with individuals who had been involved with the partnership in a variety of capacities, both as volunteers and as CHL staff. The CHL staff interviewed had been involved either during the entire partnership or had held key positions during significant events, such as the formation of the partnership. We also attempted to get multiple viewpoints on key positions within the team such as the cardiac surgeon, who fills the role of team leader, as well as pediatric cardiologist since a lack of staffing in this particular role has been a source of difficulty for the FHLU site. Appendix 2-2 contains a more detailed list of the interviewees and their years of experience, position, other

countries visited, and the number of missions conducted at the FHLU site. The interviews were conducted in a semi-structured format and most of the interviews were taped and transcribed. When audio recording was not possible copious notes were taken and typed up later for coding and analysis. Each interview lasted between thirty and sixty minutes and covered general background for the interviewee, aspects related to learning and knowledge transfer, perceptions of logistics in terms of facilities and supplies along with perceptions of barriers and enabling factors related to finances, culture, leadership and quality of care.

The interviews attempted to further understand the effectiveness of the practices used by CHL and were designed to build on the analysis of the historical data described in stage one of the data collection. The general interview protocol for each of the interviewees is included in Appendix 2-3. All of the participants were asked the questions in the protocol and sometimes specific questions were added as they were relevant to the specialty or experience of that interviewee. These additional questions are not included in the appendix. The protocol covered basic demographics, specialty, years of practice and experience with similar outreach programs. It then asked questions relevant to the training effectiveness and learning that occurred on missions, the logistics of the site and the supplies that were available during their interactions with the site and the observed barriers and enablers that would influence the development of this particular health care service in Lanzhou, China. The questions include observations of site leadership, cultural barriers, the design of health care delivery, and which of the constructs (affordability, awareness or access) is the primary obstacle to increased quality and quantity of care at FHLU.

2.4 Quantitative Data

In addition to the qualitative data collection that has been described above, we were also given access to some quantitative data. CHL tracked the patient data for as many of the patients treated at the FHLU site as possible, often getting details only on those patients for whom they had some role in funding treatment. As part of this study, they provided a sample of patient information covers patients from 1999-2007. The sample consists of 152 individual patients treated in the partner facility over the course of a nine-year period which was encompassed by the partnership program. These individual patients are not a comprehensive set of all patients treated during these nine years but rather a sub-set which includes those patients for which the FHLU organization reported more detailed information back to the partner organization, CHL. This set of patients contains approximately 8% of the patients treated during this time. However, the characteristics of these patients are such as age, gender, diagnosis type and difficulty of treatment are similar to those of the information provided on the population of treated patients. One important factor, the mortality rate, is actually statistically higher at 5.3% in the sample used than in the population at 1.7%. In addition to this patient level data, the quantitative data collected included detailed annual reports from the site on numbers of particular surgeries, diagnoses, staffing levels and mortality rates for the population of cardiac surgery unit patients treated during the time frame.

Of these patients in the detailed data set, the average age is 8.8 years and 98.7% are male. There were 14 unique types of surgery performed and over 80% were the three most common treatments; ventricular septal defect repair (VSD), atrial septal defect repair (ASD), and Tetralogy of Fallot (TOF). The in-hospital mortality rate was 5.3% in

this sample of patients which, though higher than the normal for this facility, is still estimated to be quite low according to the volunteers familiar with the site. In studies of CHD procedures, in-hospital mortality rates are generally close to 0.4% in RACHS 1, 3.8% in RACHS 2, 8.5% in RACHS 3, and 19.4% in RACHS 4 (Jenkins et al. 2002). A comparison of these in-hospital mortality rates ensure that we can be certain that high service quality was maintained even with the increase in volumes that were observed over the time frame of the study. Though we do not have specific data for each patient, we also know anecdotally that the length of stay in the intensive care unit after surgery has decreased from about 4 days in the early years of the partnership to 1-2 days with current patients. The patients are also divided into a surgical difficulty scoring model called the RACHS system. This system is used for the pediatric cardiac surgery field and helps us to understand the progression in difficulty of the surgeries over the years as well as the general skill level of the staff. The scoring system rates from 1 as the easiest surgeries and 5 as the most difficult. The entire sample is 16% score 1, 74% score 2 and 9% score 3 with the remaining 1% as score 4.

2.5 Data Summary

The total volume of qualitative data collected included innumerable documents, 1,119 coded references, and 6 constructs over more than 10 years of time. Table 2-1 provides a summary of the total codes in the data broken out by the relevant year and the data collection phase. An extensive tree structure of items relevant to each construct was also generated and will be utilized to identify the dimensions of each construct that should be measured. In addition to this qualitative data, the detailed quantitative data contained 152

individual patients and their characteristics and outcomes. This data was supplemented by detailed annual reports from FHLU containing numbers of particular surgeries, diagnoses, staffing levels and mortality rates.

Table 2-1 Summary Coding References in Qualitative Data by Year and Source

	Historical Documents	Interviews	Observations
Before 1998	14	5	0
1998	37	4	0
1999	185	5	0
2000	138	6	1
2001	66	2	0
2002	54	1	1
2003	73	7	0
2004	132	8	0
2005	139	20	0
2006	29	6	0
2007	91	6	4
2008	16	44	25
Totals	974	114	31
%	87%	10%	3%

Appendix 2-1: FHLU Field Study Interview Questions

- 1) General
 - a. How useful is the relationship and the training received during the presence of a mission team from CHL?
 - i. Very
 - ii. Some
 - iii. Very little
 - iv. Not at all
 - b. What is the percent of mission related training that is used by your staff after the mission leaves?
 - i. All
 - ii. Most
 - iii. Some
 - iv. Very Little
 - v. None
 - c. What type of training is most useful for your program
 - i. team demonstration of techniques (surgery)
 - ii. pre and post surgery discussions
 - iii. lectures (presentations)
 - iv. international training opportunities (one person)
 - v. training as group in other china pediatric cardiac program
 - d. What are the obstacles to providing pediatric cardiac care in Gansu Province? (rank order)
 - i. facilities (infrastructure: buildings, equipment)
 - ii. financing (hospital infrastructure improvements, patient payment)
 - iii. training (physician skills)
 - iv. public awareness/perception
 - v. supplies availability (local disposables etc.)
 - e. How do you track quality of care (mortality and morbidity) for your patients?
 - f. What has CHL done that was very useful?
 - g. What has CHL done that was not very useful?
 - h. What can work better with some changes?
 - i. What things could CHL do (or continue to do) to help your program grow and be successful?
 - j. Have lessons learned about team dynamics in Cardiac Surgery been transferred into any other hospital departments?
 - k. What, other than communication, hinders your ability to learn new skills during the mission?

- 2) Physician Related
 - a. How significantly does the daily work routine change after a mission is completed?
 - i. Completely
 - ii. Some
 - iii. Small Amount
 - iv. None
 - b. Are the diagnoses changing over time? i.e. More complex cases, more of a particular type of defect, more or less acquired heart disease.
 - c. Why have you chosen to focus on similar types of surgeries this year as last year? Are these the types of cases you see in the most volume?
 - d. Has the administration of the program changed since the relationship with CHL started? What are the significant changes you have noticed.
- 3) Allied Health Professional related:
 - a. How significantly does the daily work routine change after a mission is completed?
 - i. Completely
 - ii. Some
 - iii. Small Amount
 - iv. None
 - b. Are the diagnoses changing over time? i.e. More complex cases, more of a particular type of defect, more or less acquired heart disease.
 - c. Has the administration of the program changed since the relationship with CHL started? What are the significant changes you have noticed?
- 4) Administration Specific:
 - a. Is CHL meeting your goals and objective for advancing your cardiac program?
 - b. Do you have more complete data on patients served during the time of the partnership with CHL? Can I have access to that data?
 - c. Are more patients seeking care throughout the year as your program continues to grow?
 - d. Has the cost of the procedures changed substantially over time? Are more patients able to afford treatment in the past few years?
 - e. Does your department have any unit (dept) level performance measures that are used to help you understand how your program and individual surgeons are progressing?

Appendix 2-2 Interviewee Background Information

	FHLU Missions	Other Mission Locations	Total Missions	Citizen	Specialty	Years Practice
John Cushing				US	Administrator (CHL)	21-25
Children's HeartLink, Director of International Programs (Retired June 2009)						
Dr. Lorry Frankel	1	India	5	US	Pediatric Intensivist	26-30
Lucille Packard Children's Hospital at Stanford						
Dr. Allison Cabalka	6	China (Beijing)	8	US	Pediatric Cardiology	16-20
Mayo Clinic, Rochester MN – Cardiovascular Diseases & Pediatrics						
Dr. Joe Dearani	5	India, China	10	US	Pediatric Cardiac Surgery	11-15
Mayo Clinic, Rochester MN – Cardiovascular Surgery, Pediatrics, Transplant Center						
Dr. Roxann Barnes	3	India	5	US	Anesthesiology	11-15
Mayo Clinic, Rochester MN – Anesthesiology & Pediatrics						
Dr. Jeff Myers	1	Kenya	3	US	Pediatric Cardiac Surgery	6-10
Massachusetts General Hospital, Vascular Center						
Claudia Liebrecht				US	Administrator (CHL)	
Children's HeartLink, Former President						
David Andreas	1		1	US	Board Member (CHL)	21-25
Children's HeartLink, Board Member since 1992						
Frank Watts	5	China (Beijing)	7	US	Biomedical Engineering	21-25
St. Jude Children's Research Hospital, Memphis TN (Retired)						
Jeff Paurus	7	China (Chengdu)	8	US	Nurse Educator	31-35
Minneapolis Community and Technical College						
Dr. Lee Pyles	1		1	US	Pediatric Cardiology	16-20
University of Minnesota, Amplatz Children's Hospital						
Li Wang	5		5	China	Biomedical Engineering	16-20
Medtronic, Inc. (Volunteer Interpreter)						
Fang Yumei	10		10	China	ICU Nurse	21-25
First Hospital of Lanzhou University, Head ICU Nursing						
Dr. Gao	10		10	China	Pediatric Cardiac Surgery	36-40
First Hospital of Lanzhou University, Former Head Cardiac Surgery						
Dr. Yu	10		10	China	Hospital Vice President	
First Hospital of Lanzhou University						

Appendix 2-3: CHL Volunteer Interview Questions

General

- 1) Along with these questions we will need to gather demographics. Home country (practicing), number of missions, specialty, locations of missions, years practicing, experience in developing economies, etc.
- 2) What drives you to go on the missions? The ability to help children that otherwise might not get surgeries, the chance to train others to continue work after you are gone or other?

Learning/Training

- 3) From your own (volunteer's) perspective, what is the part of the mission that adds the most value to the site? One-on-one training interactions, seminars, group post-op debriefings, others?
- 4) How receptive do you feel the local teams are to learning from you as you work with them during the week? Are they eager to learn and understand the reasoning behind the technique so they can change after you leave? What is your perception of their ability to implement what they see you demonstrate? How strong is the conceptual base (or foundational knowledge) of the teams? How easy is it to determine what level of knowledge you are working with in your colleagues?
- 5) How different is the culture of teamwork among the Chinese at this site compared to what you are accustomed to in other team members. Do they understand the necessity of inter and intra team communication for surgical team and diagnosis teams?

Logistics

- 6) Did you experience any frustrations with the infrastructure of the hospital during the mission? Was there a lack of equipment that would prevent care from being delivered in an effective or efficient manner?
- 7) Where there supplies that you would normally use that weren't available? If so, what types and how did this affect the treatment of the patient?
- 8) Where there supplies that were simply used differently by the local team than what you are accustomed to in your practice?

Barriers/Enablers

- 9) If you were to identify one of three factors as the biggest barrier to progress in the pediatric cardiac surgery department for the mission hospital would it be financial inadequacy (patient or hospital), lack of logistical development (hospital facility, local supplies, etc), or knowledge gaps (physicians unaware of techniques, teamwork etc, local parents unaware of symptoms)
- 10) Do you feel that stronger leadership in any area would improve the outcomes at the Lanzhou facility? How so and in what area?
- 11) Do you perceive that there is enough commitment to achieving excellence in care that there will be follow through on correcting errors as they occur?
- 12) Do you feel that progress in advancing the cardiac surgery program is strongly influenced by local factors in the city where care is delivered? Could you describe any of the local barriers to health care that you have observed?
- 13) What do you think is shaping the design of health care as it is delivered in rural China? Would you say that the design of available care influences the way that the care is delivered or conversely that the way care is delivered, due to lack of available resources, shapes the design of care?
- 14) Given these two models (appendix) that attempt to depict what influences the treatment of diseases in underserved communities like Gansu Province, which seems more appropriate?

Chapter 3

3.1 Introduction

The overall research agenda of this dissertation is to develop a design for health care supply chain based on the coordination constructs of access, awareness and affordability that increases the quality and volume of care in underserved communities by connecting the development to the delivery of care. The objective of this chapter, in particular, is to identify, define, and clarify the role of each of these coordination elements in the design of the health care supply chain and to uncover the basic relationships underlying their interactions both with each other and to the outcomes, namely, volume and quality of care. In light of the highlighted gap between the supply and demand for medical care around the world and the current debate as to how to redesign our health care systems to accommodate this growing demand, it is essential that we understand fundamentals of health care supply chain design. The research question addressed in this study is:

How do affordability, access and awareness – the coordination dimensions relevant to health care supply chain design – affect the performance of a supply chain for underserved communities?

To address this question, this chapter examines the evolution of one hospital in the Gansu Province of China and their efforts to expand the services offered by their cardiac surgery department by adding the capability to treat CHD. Prior to initiating any partnership, CHL conducts research into the level of need for CHD care in a particular region where the potential site is located. By contacting local experts and care centers they are able to determine if there is a high incidence of genetic and environmentally

caused heart defects in young children. This was determined to be the case for the population in Gansu province. Therefore, CHL decided it was appropriate to dedicate resources toward creating a new service to treat CHD through pediatric cardiac surgery or interventional cardiology in the FHLU partner site. While introducing this new service, the hospital encountered a series of significant challenges around the development of the necessary supply chain mechanisms to enable care. These specific challenges included facilitating additional training for the staff, hiring of new specialists, stronger demands on existing resources such as the blood bank and pharmacy, and new and expensive supplies to be held in inventory. How they overcame these challenges in redesigning their supply chain to handle this new service while achieving and maintaining the quality of care will be the focus of this chapter. From their evolution, we learn both how they overcame each of these challenges and we are able develop some theory that contributes to our understanding of how to design supply chains for knowledge intensive services.

For most of the world's population, the gap between the supply of quality health care and the demand for that care is large and rapidly increasing. The 3-A framework – representing *affordability*, *access* and *awareness* – has been proposed to contain the fundamental elements for the design of a health care supply chain capable of closing this gap (Sinha and Kohnke 2009). This framework seeks to make it possible to evaluate and improve health care supply chain innovation initiatives and improve the ability of global health care supply chains to deliver high volume, quality care to unserved and underserved communities. The 3-A framework is based on the definition of the health care supply chain as stated by Schneller and Smeltzer (2006, p.30) which defines the health care supply chain as “the information, supplies, and finances involved with the

acquisition and movement of goods and services from the supplier to the end user in order to enhance clinical outcomes while controlling costs.” This definition identifies three critical aspects of the supply chain as finances, supplies and information and these aspects are embodied by the three health care supply chain constructs of: affordability, access and awareness (Sinha and Kohnke 2009). These three constructs are defined as follows:

Affordability: The ability of patients to pay for the necessary treatment of adverse health conditions and the parallel ability of the health care provider to offer the necessary services.

Awareness: A dual construct with two specific dimensions - the patient’s knowledge of available health services and disease conditions and the physician and allied health workers knowledge and skill relevant to diagnostics and treatment protocols for providing quality care.

Access: The existence of a logistical infrastructure for diagnoses and care delivery, including facilities, equipment and supplies required as well as the public transportation and lodging necessary to support patient transit.

While supply chain management (SCM) has become a very important concept in the business literature (Slone 2004; Walker 2005; Ketchen and Hult 2007), there has been some debate as to the definition and scope of the term (Mentzer et al. 2001; Mentzer, Stank and Esper 2008; Stock and Boyer 2009). In spite of this lack of consensus, there have been many studies that have linked various supply chain practices to improved performance (Yeung 2008; Foster 2008; Kaynak and Hartley 2008). At the same time as this upsurge in the popularity of SCM, there has also been a well documented shift of the global economy toward services instead of manufacturing (Sampson 2000; Ellram, Tate and Billington 2004; Sengupta, Heiser and Cook 2006). However, much less attention has been given to developing supply chain theories that are specific to this growing

service sector (Johnston 2005; Roth and Menor 2003a; Roth and Menor 2003b). Although a number of studies have attempted to apply principles and frameworks from the manufacturing sector to the service sector (Sengupta, Heiser and Cook 2006; Akkermans and Vos 2003; Vandaele and Gemmel 2007), a significant volume of other research has emphasized the uniqueness of the service supply chain and called for more studies which account for these factors (Sampson 2000; Youngdahl and Loomba 2000; Cook, DeBree and Feroletto 2001). At the same time, other scholars have called for research on supply chain management with specific considerations of industry and operating environment (Beckman and Sinha 2005; Diniz and Fabbe-Costes 2007; Babbar et al. 2008; Baltacioglu et al. 2007). This study will address both the need for more research in the service sector as well as develop a supply chain framework that is specific to the health care industry and an underserved community context.

The organizational learning literature, in particular the knowledge development and information dissemination dimensions, have been shown to play an important role in organizational and supply chain performance (Linderman et al. 2004; Hult, Ketchen and Arrfelt 2007; Hult et al. 2006; Hult, Ketchen Jr. and Slater 2004; Hult, Ketchen Jr. and Nichols Jr. 2003) Similarly, the quality management literature has delved into the role and impact of quality improvement initiative in improving both processes and products which in return has a positive impact on financial performance (Benner and Tushman 2003; Benner and Tushman 2002; Douglas and Judge Jr. 2001). These quality management tools have been extended to applications in the supply chain which have been shown to have significant impact (Yeung 2008; Foster 2008; Kaynak and Hartley 2008; Flynn and Flynn 2005), but the theory in this area is still at a nascent level of

development. In the same spirit, quality management principles have been adopted in the health care industry and have been shown to positively influence outcomes for patients and hospitals (Sage and Kalyan 2006; Jiang, Friedman and Begun 2006; Ward, Rolland and Patterson 2005; Naveh and Stern 2005; Peabody et al. 2006, 1293-1308). Finally, the literature on the diffusion of innovations provides a well developed theoretical lens for the examination of how rapidly a new service or product should be adopted in a particular market (Rivera and Rogers 2006; Rogers 2003; Lazarsfeld, Berelson and Gaudet 1949). This dissertation research will contribute a service supply chain framework by drawing upon key insights derived from the organizational learning, quality management and innovation diffusion literature.

The basis for this study is a field investigation involving the collection of panel data on outcomes and interventions over a ten-year time frame for a set of organizations that are a part of a global health care supply chain. The data were collected from historical documents, interviews in multiple organizations and direct observation. The investigation utilizes a method of research that relies on the simultaneous consideration of theoretic frameworks and the empirical evidence that is being uncovered through an in depth examination of a phenomena in an existing empirical setting (Dubois and Gadde 2002). This method is called systematic combining and is a subset of case research. In this particular study, this research method is appropriate because the extant literatures on supply chain management, quality management and health care management, as indicated earlier, do not provide adequate insights to bridge the growing gap between the development and the delivery of quality care in unserved communities.

This study will develop a mid-range theory of health care supply chain design in the form of an integrative 3-A framework comprised of propositions relating the three health care supply chain coordination elements – affordability, awareness and access – to the volume and quality of care delivered. We choose to focus on the development of middle-range theory because of the nascent nature of the theory in this particular area and therefore the necessity of utilizing an inductive study to propose a conceptual model that explains a limited set of phenomena within a specific setting (Bourgeois III 1979; Rungtusanatham and Salvador 2008; Volkoff, Strong and Elmes 2007). Based on the nature of the theory building undertaken, we begin by an in-depth study of one specific supply chain or inter-organizational context within the health care industry, which has interesting and important applications for similar supply chains in underserved communities around the globe.

The remainder of the chapter is organized as follows. In section 3.2, we review and synthesize a number of literature streams relevant to the topic of this study and in section 3.3 we explore what is known about the constructs of interest as a guide for our field investigations. Section 3.4 contains a brief discussion of the relevant data collection and a description of the types of qualitative data analysis which were used in this study. In section 3.5, we discuss the development of the propositions from the ten years of historical qualitative data and interviews. And finally, we present resulting conceptual model in the form of an integrative 3-A framework for health care supply chain design. Section 3.6 contains a discussion of the results and conclusions of the study. Finally, section 3.7 presents the contributions to literature and practice as well as discussing the limitations of the study and future research agenda.

3.2 Literature Review

This research focuses on the design of supply chains for the introduction of new knowledge-based services in the setting of the health care industry in developing countries. In our investigation, we will examine the supply chain literature along with the literature on knowledge management, quality management and innovation diffusion. Specifically, we identify the relevant streams of literature that would help us understand the importance of supply chain coordination mechanisms in a knowledge-intensive service supply chain, specifically the health care supply chain. Examining the state of this literature will show the importance of this dissertation in contributing a conceptual framework that incorporates considerations of new service innovation diffusion, knowledge management in the supply chain, and health care quality to the current theoretical base for knowledge-based service supply chain. The developed conceptual framework is particularly relevant to knowledge-intensive services such as healthcare, financial services, technology support and consulting services (Shah 2007).

3.2.1 Supply Chain Management

Supply chain management (SCM) has become an important concept in the business literature and a key tool in synchronizing demand and supply in the global marketplace. It has even been argued that current competition in the marketplace is better defined as supply chain versus supply chain than firm against firm (Walker 2005; Ketchen and Hult 2007b; Slone 2004). Beginning in the early 1990s, there has been an increasing interest in the idea of supply chains and their role within firm strategy. There have been many definitions of supply chains, supply chain management, supply chain orientation, as well

as many varying opinions on what disciplines and functions within a firm should be considered part of the supply chain domain (Cooper and Ellram 1993; Cooper et al. 1997; Mentzer et al. 2001; Mentzer, Stank and Esper 2008; Stock and Boyer 2009; Lambert, Cooper and Pagh 1998). While there has been no consensus on the definition of supply chain management in the literature, Stock and Boyer (2009) have proposed that researchers adopt the below definition to allow for the coherent development of theory in the area.

“The management of a network of relationships within a firm and between interdependent organizations and business units consisting of material suppliers, purchasing, production facilities, logistics, marketing, and related systems that facilitate the forward and reverse flow of materials, services, finances and information from the original producer to final customer with the benefits of adding value, maximizing profitability through efficiencies, and achieving customer satisfaction.” (Stock and Boyer 2009, p. 706)

This definition was developed using qualitative data analysis methods to examine and identify the core themes that have been identified to date in the SCM literature. There still remain many research questions to be answered within the SCM literature including the identification of an overarching theory, the factors relevant to formation and maintenance of relationships, the coordination of entities, and the identification of correct measurement for outputs and performance (Stock and Boyer 2009).

One particular area of interest is the design of supply chains. Supply chains are inherently complex because of the number of organizations involved. This is exacerbated by the fact that many of these organizations are involved in multiple supply chains and interactions, they are geographical dispersed, and there are many different levels of suppliers. These complexities make it difficult to adequately match supply with demand

(Mentzer et al. 2001; Stock and Boyer 2009; Blackhurst, Wu and O'Grady 2005; Baltacioglu et al. 2007). There is a need to include the design of the product and relevant processes in the design of the supply chain (Blackhurst, Wu and O'Grady 2005). To accomplish this Blackhurst et al. 2009 propose the "Product Chain Decision Model" (PCDM) which provides a network based model for supply chain design that accounts for the product and process design. Other studies have approached the study of supply chains with a strategic, conceptual and empirical position (Lambert, Cooper and Pagh 1998; Ketchen and Hult 2007a; Armistead and Clark 1993; Roy, Sivakumar and Wilkinson 2004). One such study showed that inter-organizational coordination supported by information technology in a design and development organization increased competitive advantage and performance (Argyres 1999). An additional important factor in the supply chain is the extent of the integration that is undertaken between the focal firm and the suppliers and customers. One empirical study of manufacturing supply chains in a variety of industries showed that the more "widely facing" or inclusive of upstream and downstream supply chain members the supply chain was there was a resulting association to better performance (Frohlich and Westbrook 2002; Frohlich and Westbrook 2001).

Much of the research on supply chain management has links to various organizational theories. In different ways, these studies have used theories such as transaction cost economics (TCE) (Ireland and Webb 2007; Holcomb and Hitt 2007), social capital theory (Ireland and Webb 2007; Krause, Handfield and Tyler 2007), agency theory (McCarter and Northcraft 2007; Morgan, Kaleka and Gooner 2007), resource dependence theory (Ireland and Webb 2007; Crook and Combs 2007), institutional theory (Rogers et al.

2007), network theory (McCarter and Northcraft 2007; Morgan, Kaleka and Gooner 2007), game theory (McCarter, Fawcett and Magnan 2005), social capital theory (Ireland and Webb 2007; Krause, Handfield and Tyler 2007), strategic choice (Miles and Snow 2007), and the resource based view and knowledge based view of the firm (Holcomb and Hitt 2007; Miles and Snow 2007) to shed light on how to appropriately design and manage supply chains (Ketchen and Hult 2007a; Ketchen and Hult 2007b). One study uses a synthesis of the relevant organizational literature to propose, what the authors call the best value supply chain. Best value supply chains are defined as those that use strategic supply chain management in an effort to excel in terms of speed, quality, cost and flexibility (Ketchen and Hult 2007a). In the health care context, it is postulated that to improve the delivery of care, both in volume and quality, it is also necessary to change the schemas, rules, norms and routines that are the guidelines for the behavior of the medical professionals. Institutional theory may provide an understanding of how these elements are created and how new ones are adopted and diffused in order to reveal the efficacy or weaknesses of the organizational training programs (Scott 2001; Oliver 1991). Institutional theory would seem to be particularly relevant to understanding the relationship between the awareness mechanism of supply chain coordination and outcomes in terms of care delivery, especially in the evolving health care supply chains of underserved communities. In conclusion, though the organizational theory literature gives some guidance for supply chains, there is still much to be learned about how to accomplish improved outcomes utilizing supply chain management concepts both in product and service industries.

Several studies have leveraged RBV theory to explore the level of innovation and learning as a specific resource in managing supply chains and determined that it does contribute an element of competitiveness and improved performance (Hult, Ketchen Jr. and Nichols Jr. 2002; Craighead, Hult and Ketchen 2009). Absorptive capacity has also been shown to be a key theory for explaining the level of innovation, learning and knowledge building in a supply chain partnership to create greater value and long-term competitiveness (Malhotra, Gosain and El Sawy 2005; Shih-Wei Chou 2005; Lane and Lubatkin 1998; Eisenhardt and Schoonhoven 1996; Malhotra et al. 2001). Supply chain innovation and learning have also been identified in studies as key tools to help in anticipating and responding to changing customer requirements and business environment (Flint, Larsson and Gammelgaard 2008; Kale and Singh 2007). A conceptual model for how the interactions in a supply chain can lead to both radical and incremental innovation was developed and proposed to have applications to both product and service supply chains (Roy, Sivakumar and Wilkinson 2004). This model posits that the interactions between organizations will generate innovations because of internal factors related to technology use, trust and commitment or external factors like the tacitness of technology, stability of demand and existing network connections.

Logically, the goal of much of the SCM literature is to explain what factors will increase the performance of the supply chain in terms of financial and quality measures. A recurring theme in the literature is the key role of information flow and its contribution to both quality and financial supply chain performance. This impact has been shown in several studies both in traditional manufacturing settings as well as services (Vaidyanathan and Devaraj 2008; Boyer and Hult 2005; Bigné, Aldás and Andreu 2008).

Other studies have shown the importance of supply chain management to organizational performance and link the key quality management practices to good supply chain management (Yeung 2008; Foster 2008; Flynn and Flynn 2005; Kaynak and Hartley 2008). In addition, one study links the SCM practices of strategic supply partnership, customer relationship, level of information sharing, quality of information sharing and postponement as a second order construct which both directly impacts the performance of the organization as well as indirectly impacts it through a positive impact on competitive advantage (Li et al. 2006).

3.2.2 Service Supply Chain Management

There has been a shift on a global scale, that is particularly salient in Western economies, from manufacturing and agricultural production to that of service production (Shah 2007; Ellram, Tate and Billington 2004; Sengupta, Heiser and Cook 2006; Sampson 2000). The shift in the literature has been much slower to occur. The majority of research on SCM is from the traditional manufacturing sector but there have been several attempts to examine its applicability in the services sector (Ellram, Tate and Billington 2004; Sengupta, Heiser and Cook 2006). While it is not assured that the application of manufacturing principles to service industries is very well advised, it is quite necessary to conduct more research to extend our understanding of service operations and supply chain management (Sampson 2000).

The roots of the study of service management in the operations management discipline began in the 1980s (Johnston 2005a). Service operations management is a very interdisciplinary field and spans the functions of operations management, marketing and

human resource management (Johnston 2005b; Roth and Menor 2003a; Roth and Menor 2003b). The work in these areas has defined the distinction of services and goods, developed and tested frameworks of service management and linked these service operations drivers to organizational outcomes (Johnston 2005b). However, much of this literature has focused on satisfying the ultimate consumer with very little emphasis on B2B services and the concept of inter-organizational customer satisfaction and coordination (Johnston 2005a). Boyer and Hult (2005) show that there are important operations, marketing and information technology components to a service supply chain and that these components are critical to whether or not the customer will intent to do more business with the firm. They identify the keys to customer intent to repurchase as product quality, service quality and eBusiness quality (Boyer and Hult 2005).

An initial attempt to extend the manufacturing model of supply chain to the service arena applied the factory-based services concept to global supply chain and generated conclusions highlighting the need for additional investigation of the real structure of a service supply chain (Youngdahl and Loomba 2000). In fact, Cook, DeBree and Feroletto (2001) urge caution to those operating in service industries that the SCM concept is undeveloped in the services context and much more research is necessary into the impact of applying the current versions of SCM from manufacturing to services. The uniqueness of the service supply chain is illustrated in the idea of customer-supplier duality. In all services supply chains, the customer acts at some point in the supply chain to provide some inputs to the transformation process that is conducted to produce the service, thereby playing the role of both customer and supplier (Sampson 2000). One early attempt to define and build a unique framework for service supply chain emphasized the

concepts of responsiveness, efficiency and control among the units or organizations in the multinational professional services firm (Kathawala and Abdou 2003).

In a study that specifically compared supply chain strategies across the two sectors, some similarities across important functions such as customer relationship management, supplier relationships management and demand management were identified (Sengupta, Heiser and Cook 2006). Although acknowledging that the development of the service supply chain literature was at its infancy, Sengupta et al. 2006 specified that service supply chains should focus on management of capacity, resource flexibility, information flow, service performance and cash flow management in order to impact both operational and financial performance positively. The differences between the service supply chain and a product supply chain are sufficient enough that a strategy for testing the existence of amplification in the service supply chain has been developed. This is presented as a simulation game of a mortgage application process which shows students the complexities of managing capacity and order fulfillment in a customer driven make-to-order environment (Jr. and Morrice 2000). Akkermans and Vos (2003) explored this concept empirically in the telecommunication industry to see of amplification effects occurred and what causes and mitigation factors would be applicable. They concluded that there was a significant amplification effect in a pure service supply chain but that only some of the same causes were present as in product supply chains and that there was a need for much different mitigation tactics, warranting more study on the design and management of service supply chains (Akkermans and Vos 2003). Another study investigated how customer satisfaction elements differ in a service supply chain dependent on whether the service provider was one or two steps upstream in the supply

chain. This study showed that in a service setting, the customer one firm downstream measured performance based on reliability, complaint handling and expertise, whereas the end customer (two steps down the supply chain) measured that service on more tangible dimensions such as the visibility of the service and direct contact with the providers (Vandaele and Gemmel 2007). These insights emphasize the complexity of the service supply chain and the importance of understanding the interactions in the entire network in more than a product environment.

Two more recent studies have proposed definitions and specific models for a service supply chain (Baltacioglu et al. 2007; Ellram, Tate and Billington 2004). We will adopt the definition from Ellram, Tate and Billington (2004, p. 25) which states that service “supply chain management is the management of information, processes, capacity, service performance and funds from the earliest supplier to the ultimate customer.” Their study compared manufacturing and services applications of the traditional SCM models to determine their applicability in the service sector (Ellram, Tate and Billington 2004). Their research identified seven key service process or flows which must be addressed by the service supply chain. These are capacity, demand customer relationship, supplier relationship, service delivery and cash flow management along with information flow. Another study, which furthered the work by Ellram and colleagues, is a conceptual paper that proposes a new model for SCM in the services industry by focusing on the unique characteristics of services such as intangibility, simultaneity, heterogeneity, perishability and labor intensity (Baltacioglu et al. 2007). Baltacioglu et al. build their IUE-SSC model by starting with the SCOR and Ellram et al. models. Their model is very similar but places the service provider as the focal firm and overlaps the customer and the service

provider in a window called service delivery. According to this IUE-SSC model the important functions which must be managed by the service supply chain are identified as information flow and technology management, demand management, capacity and resources management, supplier relationships management, customer relationship management, service performance management and order process management (Baltacioglu et al. 2007). Although, they discuss the applicability of their model do the health care industry, they do not provide any empirical tests of the model.

Many empirical studies of service supply chain have investigated the performance impact of different mechanisms within the supply chain. Building on earlier work that more widely integrated manufacturing companies see greater performance impacts in the supply chain, an additional study of integration in both manufacturing and service industries indicated that the service firms are not as integrated as their manufacturing counterparts, however, similar performance improvements are still associated with integration in the service supply chain (Frohlich and Westbrook 2002; Frohlich and Westbrook 2001). One study examined the global delivery of goods to cruise ships and focused on whether the application of RFID technology at a variety of levels in the supply chain would be beneficial. The conclusion was that while it could reduce costs by improving visibility and accuracy as well as decreasing labor cost, it was still only marginally viable (Véronneau and Roy 2009). Another recent study in the financial services industry examined whether supplier relationships and satisfaction at the service process level would influence supply chain performance. This study utilized a five dimension measure of supplier relations and found that the relational aspect of cooperation and long-term commitment were significantly correlated with performance

however, coordination, information sharing and feedback were not (Field and Meile 2008).

As a subset of service supply chain, the knowledge-based service industries have also been identified as having particular importance and complexities (Shah 2007). These knowledge-based services include consulting, health care, technology management and human resource management. Research on information technologies in the service supply chain has examined the antecedents and consequences of integrating information technology with suppliers in a travel agency supply chain (Bigné, Aldás and Andreu 2008). Their results show that technology adoptions and integration in service industries can increase performance and efficiencies. Additionally, IT adoption has relational consequences including positively impacting the intention of supply chain partners to continue their relationship (Bigné, Aldás and Andreu 2008).

3.2.3 Industry and Environment

In addition to the importance of having supply chain models that are specific to the service sector, an argument can be made that to design the most efficient and appropriate supply chains, considerations of operating environment and industry must be accounted for in the strategy (Baltacioglu et al. 2007; Beckman and Sinha 2005; Diniz and Fabbe-Costes 2007; Babbar et al. 2008; Agwunobi and London 2009). Therefore, we will examine literature on the topics of health care supply chain and supply chain for developing countries. The definition of the health care supply chain as proposed by Schneller and Smeltzer (2006) has previously been presented in this dissertation. In their text on the strategic management of the health care supply chain they build on this

definition and address customer relationship management, inventory and distribution concerns, dealing with group purchasing organizations, managing risk and appropriate organizational design (Schneller and Smeltzer 2006).

The relatively small body of literature on health care supply chain has examined how to leverage lessons from other industries to lower health care costs, increase quality and improve processes and work flows. One conceptual piece argues for the elimination of some of the costs in the health care supply chain by commoditizing as much of the care as possible without sacrificing care quality. It proposed that some treatments and diagnoses which can be “routinized” based on clinical trials can be redesigned to be low cost and spur typical retailer-like price competition (Agwunobi and London 2009). Another study explored the pharmacy industry and proposed the need for service development processes which would create a role for the pharmacy as a service provider involved in the health care delivery process instead of a retail outlet for pharmaceuticals (Gebauer 2008).

Additionally, Shah et al. (2008) used a field study approach to examine how a particular health care supply chain was able to dramatically increase performance both decreasing service time and increasing service quality in a decentralized network of health care providers. They conclude that the use of lean principles to guide process improvement efforts and the emphasis relational based coordination allowed the organizations to dramatically improve the supply chain performance (Shah et al. 2008). In related research Fredenall et al. (2009), investigated an internal supply chain for perioperative surgical services and attempted to understand reasons for operational

failures and productivity loss. They concluded that there are a number of factors including a lack of process standardization, no effective mechanisms for dealing with bottlenecks or quality problems and, finally, that the use of routines improved relational coordination but that even consensus between departments did not sufficiently improve work flows (Fredendall et al. 2009).

Further studies have addressed the unique considerations of understanding supply chains that operate in developing economies. One field study of sustainable Brazil nut production supply chains tries to uncover the impact of supply chain orientation (SCO) and SCM principles in the success or failure of the endeavors. The study concludes that SCO and SCM skills and practices are almost non-existent in these business environments. In fact, the general acceptance and understanding of these principles in developed countries is very different in developing countries. They conclude that logistics and SCM must be adapted to the developing market environment (Diniz and Fabbe-Costes 2007). Other research seeks to provide multi-national companies and other organizations with a framework to help them link organizational factors to supply chain networks effectiveness in developing countries. They argue that globalization provides a wealth of opportunities but also provides an extreme complexity and uncertainty about how to navigate the diversity of environment and culture. They present a conceptual framework that links alignment of goals and priorities, network commitment, and centralization of operational decisions to supply chain effectiveness. In their framework, they define supply chain effectiveness with seven dimensions which are; access to markets, innovations of goods and services, flexibility, delivery, quality, total cost and ROI (Babbar et al. 2008).

This study is designed to contribute to an understanding of the design of a service-oriented supply chain that effectively increases the service quantity and quality delivered to the end-consumer of health care. Specifically, it will address integration and organizational learning questions relevant to the strategic design of service operations as defined by Roth and Menor (2003b) in their proposed agenda of service operations management research.

3.2.4 Organizational Learning and Knowledge Development

The organizational learning literature has shown knowledge development to be an important component of a supply chain as well as an essential capability for the individual organizations that are partners in the supply chain (Craighead, Hult and Ketchen 2009; Hult, Ketchen Jr. and Slater 2004; Hult, Ketchen and Arrfelt 2007; Hult et al. 2006; Paiva, Roth and Fensterseifer 2008). Other studies have determined that information dissemination, which is a key component of organizational learning, is required when attempting to reach the unserved communities around the globe (Rivera and Rogers 2006; Van Wassenhove 2006). Organizational learning theory speaks to the specific transfer of new, relevant knowledge from one entity to another which thereafter changes the range of potential behaviors in the recipient firm (Hult, Ketchen Jr. and Nichols Jr. 2003; Huber 1991) For this dissertation, we will adopt the organizational learning definition proposed by Huber (1991) which specifies the four constituent constructs of knowledge acquisition, information distribution, information interpretation, and organizational memory. The knowledge acquisition (development) construct itself is defined to have five sub-dimensions by Huber (1991) but we will adopt the definition

used by Hult et al. (2006) which specify eight knowledge elements as critical in the supply chain. These are given as: memory, tacitness, accessibility, quality, use, intensity, responsiveness and learning capacity (Hult et al. 2006).

One particular study of supply chain performance (Hult, Ketchen Jr. and Slater 2004), has identified links to knowledge acquisition and information processing in performance improvements. They demonstrated links between organizational memory, information processing and reduced cycle time, indicating a need to better understand the processes by which organizations learn and share knowledge along the supply chain in order to improve performance. Other studies have examined the development and deployment of knowledge capabilities for different types of supply chains. For each type of supply chain, some knowledge elements like learning capacity and knowledge utilization were the key performance enablers (Hult et al. 2006). More recently, a study has shown that knowledge development capacity in the supply chain influences the ability of the supply chain to innovate and cut costs (Craighead, Hult and Ketchen 2009). The clear implication of these studies is that knowledge flows along a supply chain will have substantial performance impacts; however, this has not been examined in detail in the health care supply chain or knowledge-intensive supply chain literature.

The manufacturing literature has also encompassed the influence of quality management efforts on learning and knowledge sharing in firms. One particular study has shown improvements in manufacturing performance when quality management tools are applied in ways that encourage the development and sharing of knowledge in organizations (Linderman et al. 2004). An examination of the methods through which

learning in an organization might be inducted showed that both training and engineering activities can be effective (Adler and Clark 1991). Additionally, further studies show that there are two kinds of learning that are requisite to a positive change in firm performance: conceptual and operational learning (Lapr , Mukherjee and van Wassenhove 2000). The conceptual learning dimension is defined as the “process of acquiring a better understanding of cause-effect relationships” and is also referred to as “know-why” (Lapr , Mukherjee and van Wassenhove 2000, p. 602). On the other hand, operational learning or “know-how” involves the process of connecting specific actions to outcomes. Similar to their conclusions, it will be our argument that both types of learning are essential and that conceptual learning, in particular, is required to see lasting and high impact change in the knowledge-intensive service supply chain. In light of the above discussion, we conclude that organizational learning and knowledge development in a supply chain are essential to linking the development and delivery of care. This study will begin to examine the techniques for knowledge acquisition utilized by organizations in the health care supply chain and their effectiveness at improving care delivery.

3.2.5 Quality Management

As is well known, quality management has relevance to both product and process. This study conceptualized health care as an inseparable bundle of both product and process which allows for the effective delivery of care. In light of this unique integration of product and process in the health care industry, we focus on the improvement of quality specifically at the intersection of process and the use of products to enable that process. Process management examines how the application of quality techniques and

other organizational innovations can affect the quality and outcomes of a given transformation or service delivery. There are two fundamental types of process management: process improvement (exploitation) and process innovation (exploration) (Gupta, Smith and Shalley 2006; Zi-Lin He and Poh-Kam Wong 2004). There is a body of literature that has examined the effects of these two types of initiatives on both organizational performance and organization structure (Benner and Tushman 2002; Benner and Tushman 2003). Both process improvement and innovation are generally considered imperative to the success of organizations over time (Benner and Tushman 2003).

In the case of health care supply chain design, there is a need for the improvement of existing processes to make them more cost effective and efficient, as well as the need for innovative new ways of approaching the process of delivering quality care to underserved communities globally. It has been demonstrated in the quality management literature that the implementation of quality practices in health care delivery has a positive effect on financial performance and that a learning environment has a positive influence on quality implementation outcomes (Douglas and Judge Jr. 2001). To further our understanding of how quality practices can be implemented effectively, this study will explore how the supply chain coordination elements – affordability, access and awareness –taken together provide a holistic approach to continuous improvement and innovation that can overcome the barriers to delivering high volume, quality care to patients.

Quality management also plays a significant role in supply chain success or failure. Supply chain quality management (SCQM) has been defined by Foster (2008, page 461)

as “a systems-based approach to performance improvement that leverages opportunities created by upstream and downstream linkages with suppliers and customers.” One key theme in SCQM is the validation of specific quality management factors that have been previously shown in the supply chain context. Specifically, prior studies have explored the relevance of supplier quality management, management leadership, and the role of customer focus in SCQM (Kaynak and Hartley 2008). Another study has shown that there is a link between quality management and strategic supply management and that these two practices enable continuous improvement in the supply chain (Yeung 2008). It has been shown in the context of manufacturing operations, that the implementation of quality management practices along with effective supply chain management practices improves the performance of the supply chain and contributes to the competitive advantage of the trading partners in the supply chain (Flynn and Flynn 2005). While the study of SCQM is still nascent, we conclude from our review of the relevant literature that it is an important emergent field of study that can help to explain variations in both firm and supply chain performance (Foster 2008). We would argue that similar considerations of quality management principles in the health care supply chain will lead to more productive, cooperative, and enduring relationships between the supply chain partners.

3.2.6 Quality Management in Health Care

Within the field of health care there has been an emphasis on quality management initiatives and a focus on how quality care can be delivered in order to influence outcomes both with respect to hospital performance and patient satisfaction (Naveh and

Stern 2005; Jiang, Friedman and Begun 2006a; Jiang, Friedman and Begun 2006b; Ward, Rolland and Patterson 2005). Despite the obvious benefits of focusing on quality in health care, it has been a difficult field in which to define and measure quality (Ward, Rolland and Patterson 2005; Peabody et al. 2006; Sage and Kalyan 2006). Current studies of health care quality have shown that lack of quality arises from one of two sources; the lack of resources or deficiencies in the knowledge of the resident health professionals (Institute of Medicine 2001). With this in mind we define quality in the health care delivery context as “optimizing material inputs and practitioner skill to produce health.” (Peabody et. al. 2006, p. 1293)

Specifically, we focus on the design of the health care supply chain for the delivery of quality care while controlling for the large number of the socio-technical factors that also influence the quality of care. The emphasis on quality of care in the health services research area continues to heighten because it has been shown to have an impact on macroeconomic factors. For instance, in underserved communities, increases in quality of care and the resultant positive impact on the available workforce has been linked to both higher educational achievement and growth in GDP (Peabody et al. 2006, 1293-1308). Several studies on quality in health care have shown that an increase in the volume of a particular procedure performed will also have a positive impact on the quality of that procedure (Huckman and Pisano 2006; Pisano, Bohmer and Edmondson 2001; Hannan et al. 1991; Hannan et al. 1989). In essence, these studies argue that medicine adheres to the age old adage that “practice makes perfect.” This study will focus on understanding the factors that increase volume of care delivered but will examine the impact of this increase in volume on the quality of care. A key premise of

this dissertation is that quality in health care is as important as the number of people receiving the care and must be central to any study of performance in the health care supply chain.

3.2.7 Innovation Diffusion

Innovation diffusion theory (IDT) is a well developed lens that examines the general nature of the pattern of adoption of a new good and/or service in a market (Lazarsfeld, Berelson and Gaudet 1949; Rogers 2003). The most common research applications of innovation diffusion theory have generally been in the context of a physical good (innovative such as computer or cellular devices). In these particular contexts, studies demonstrate that the innovative good is adopted by the marketplace at a rate that resembles a normal distribution and identifies different categories of adopters across time periods. This traditional S-curve of adoption rates is a familiar figure in the IDT literature. However, it has also been theorized that IDT does not only concern the consumer targeted innovation but also the surrounding supply chain elements of how the good is delivered (Rogers 2003). Given the fact that in health services, such as implantable medical devices offered to unserved communities, it is often necessary not only to engage in a process of innovating new products (medical device and surgical procedure required) but also to innovate the supply chain coordination mechanisms there are usually three to four simultaneous innovations that must be considered. In light of this complexity, it is important to consider how the volumes of interrelated innovations necessary for a successful medical service influence this rate of adoption.

Within the health care context, the linking of the development of care to the delivery of care requires a great deal of innovation on the part of the involved companies. What we will argue in this chapter is that a simple good or service innovation does not suffice when it comes to delivering new goods and services to these unserved or underserved markets. In fact, we know from the innovation literature that the diffusion of innovation concerns much more than the innovation that is being offered to the consumer (Rogers 2003). This implies that, in the case of a new product or service innovation, success would require innovations in additional functions such as supply chain, financing or marketing in order to allow a new product to diffuse into a market. In fact, we will argue that for a successful new treatment to diffuse through the health care system of any unserved or underserved community there will need to be innovation in at least one if not all of the three coordination elements of the supply chain. These supply chain coordination elements are the identified 3-As which enable the information, supplies and finances required to deliver the good or service (Schneller and Smeltzer 2006).

In the case of Aravind Eye Clinic in India, the access mechanism was approached in an innovative way by establishing and running mobile diagnostic clinics and bus services to and from the surgical site. Because of these additional areas where innovation is required, companies who desire to reach these new markets are engaged in a process of radical innovation. The literature defines radical innovation as one which involves the simultaneous implementation of three or more innovations and specifies that they are difficult to implement (Stieglitz and Heine 2007). So why would companies feel the need to engage in this process of radical innovation wherein they tackle both the product innovation and the supply chain innovations? We argue that they will need to do this

because the standard approaches to the supply chain coordination elements used in western economies are likely to fail when implemented in the radically different cultural context of many emerging economies (Swaminathan 2007, p.137). The standard supply chain mechanisms in place in developed communities, though they were considered innovations in their home context at the point of their implementation, will not work universally. In addition, there are many instances where companies have attempted to innovate only along the good or service dimension and have found that their efforts have miserably failed, highlighting the need for non-standard approaches to developing supply chains through innovations in other dimensions of the 3-A framework.

3.3 Significance of the 3-As in the Supply Chain

The aim of this chapter is to fill the gaps in the existing theory of how the constructs in the 3-A framework -- awareness, affordability and access – can be measured and the nature of their inter-relationships in the health care supply chain. A review of the literature indicates that these constructs relate to each other and to the performance of the supply chain. The affordability construct is defined as the ability of the patient to pay for the health services needed and is enabled by financial services when appropriate. Affordability is observed in the framework through financial services systems. Financial services systems include tools that make the outlay of money for necessary services more feasible. Financial services systems are an integral part of the bundle of services that make up the development of care for unserved and underserved communities. It might include offerings like loans, payment plans, health insurance, and micro financing opportunities. In his study of how to open up the markets represented by the least

affluent segment of the world's population, C.K. Prahalad asserts that while the world's poor have the least access to financial assistance they are the ones who need it the most. While the poor are generally considered the worst credit risk, this characterization has often been shown to be a false (Prahalad 2005; Farrell 2006; Taylor 2006). We would expect that the affordability construct will have a strong influence on the framework when observed in the health care system but nature of that influence is not determined. While we expect that the affordability of a health service and the level of development of the financial services systems in a market will have a significant impact on the patients that receive care, the existence of sophisticated mechanisms in this area is not presumed to exist.

The access construct represents the physical infrastructure necessary for care embodied by facilities, equipment, supplies and transportation infrastructure. When we examine the access construct we find that the literature clearly establishes the importance of developing a distribution network in the success or failure of a product. Good supply chains have the characteristics of what Narasimhan and Kim (2001) call a Stage 4 or the externally integrated supply chain. They define this supply chain as one that is fully integrated from supplier to customers, including both internal integration of functions and external integration of partners (Narasimhan and Soo Wook Kim 2001; Narasimhan, Swink and Kim 2006). This external integration is closely tied to effective network development within a health care supply chain. An effectively developed network is one that contains trust among the members and creates flexibility and adaptability in dealing with uncertainty in the environment (Rivera and Rogers 2006). It is our contention, therefore, that the existence of a logistics system, which includes the capability of

delivering the health service along with the requisite supplies to the patients at which it is targeted, is critical to the success of a new health care service in any market.

The resource-based view of the firm supports this point of view. It asserts that there are specific resources that are required for an organization to be able to compete in a market and ultimately to gain competitive advantage (Wernerfelt 1984; Barney 1991). For hospitals these resources might include infrastructure as well as cultural, administrative and staffing considerations. In this context, they are not only foundational to the delivery of care but they have a significant influence in the volume of quality care delivered. It is the inimitable and non-transferable elements of these resources that hospitals must develop internally in order to not only deliver superior quality of care in high volumes but also to be able to learn and implement new innovations. This leads to the conclusion that the access construct will play a central role in the framework.

The awareness construct is depicted as both the knowledge of the patient of the disease symptoms and accessibility of care and the knowledge of the physicians and allied health worker's regarding the health service protocols necessary to treat or prevent diseases. The examination of the awareness construct is essential because just having a patient population who is able to afford the chronic disease care is not sufficient, the health care workers in the area must be equipped with the skills and knowledge necessary to provide effective treatments. And at the same time, the patients in these underserved communities must also be aware of the availability of treatment. Therefore, knowledge development and information sharing systems are essential. Knowledge development systems are systems that provide information, awareness or cognition about the available

options and skills necessary to implement those options. It is not the distribution of the product or the availability of the product or financing options. Knowledge development systems are an integral part of the bundle of services that make up the development of care for unserved and underserved communities. They are composed of patient awareness of symptoms, physician awareness of treatment options, and availability of training for physicians.

In the particular context of underserved communities, we must be aware of the fact that many of them significantly less access to information about new products and ideas than other communities, and will require innovative and extensive information campaigns different from those used in western economies. This is especially true in the more rural markets but extends into the urban segment of the unserved community (Prahalad 2005). It has been seen through the example of successful products launched in these markets that it is necessary to develop cost-effective but innovative tools that can be used to promote the new product to local entrepreneurs. These tools include live demonstrations, radio and newspaper advertisements, and mobile truck mounted demos in villages among other methods (Chesbrough et al. 2006). It has been stated that these efforts to launch new products are slower because there is a necessity to train and educate the consumers as well as local entrepreneurs who serve to help develop the distribution networks (Chesbrough et al. 2006). This lack of knowledge on the part of the patient population in underserved communities highlights the fact that awareness must be increased on the demand side of the supply chain. On the other hand, the need to increase the knowledge of the providers in the supply chain emphasizes a need for change in awareness on the supply side of health care. For the health care supply chain in particular, this

dissemination of knowledge needs to include significant training for the allied health professionals throughout these unserved communities on simple diagnosis procedures for chronic diseases. In addition to training, we would argue that some type of public awareness campaign through mobile diagnosis clinics or information laden advertising will be necessary. Finally, contact with physicians throughout the healthcare network in the communities will need to be established and training on the availability of devices and implant procedure for these devices must be provided. These efforts would thereby increase awareness both on the supply and demand side of the health care service.

Institutional theory is particularly relevant to the relationship between awareness or knowledge development and care delivery, especially in the case of the partner hospitals associated with the NGO, Children's HeartLink (CHL), which we are studying. In many cases the training and demonstration that is either given on missions or through bringing the staff to other western hospitals to learn is focused on changing the social structure as reflected in elements of teamwork and norms. As described earlier, to improve the health care delivery process it is usually necessary to change the schemas, rules, norms and routines that are the guidelines for the behavior of the medical professionals administering these processes. An understanding of how these rules and norms are created and how new ones are adopted and diffused might reveal the efficacy or weaknesses of the CHL partner training programs (Scott 2001; Oliver 1991).

Understanding what types of learning are occurring and what institutional mechanisms are in place will help give insight into what types of training or teaching methods are most effective for transfer of knowledge from one individual or group. As

we have discussed earlier, there is significant evidence that organizational learning and knowledge development in the supply chain are essential to the development and delivery of care. Therefore, we expect a central role for awareness in the framework. While the impact of the level of awareness in the system is likely to be important, sophisticated levels of training or public awareness campaigns are not presumed to be a prerequisite to delivering care in any market.

3.4 Analysis

The analysis in this study will assist in furthering our understanding of the definition, measurement and roles of the 3-A constructs that we have been exploring in the previous section. It is evident that these constructs will play an important role in the success of the health care supply chain but the nature of their definition and interconnections remain to be uncovered. The study of the partnership between CHL and FHLU over the ten year period between 1999 and 2008 served as the setting for this in-depth field study. As was presented in detail in Chapter 2 the data were collected through an extensive three stage process that involved reviewing and coding ten years of historical data, interviewing fifteen representatives from CHL, FHLU and the network of volunteers who traveled to this site over the ten years of the partnership, and one visit to FHLU during a mission to observe, interview and provide better cultural background and experiences. The following sections describe the analysis process that was used to develop the construct measures and the conceptual framework that is developed and presented in this chapter.

3.4.1 Data Coding

The data analysis began during the historical data collection, as is core to the grounded theory approach. As historical documents were reviewed and interview notes were transcribed, they were coded (Locke 2001; Suddaby 2006; Strauss 1998). The coding process involved three main stages of open, axial and selective coding for all the data, as is recommended by Strauss and Corbin (1998). The coding process was conducted with the larger constructs of awareness, access and affordability as a preexisting conceptual framework. The open coding process was employed to identify the relevant sub-categories for each of these three constructs as well as to identify any additional concepts or constructs that were not identified in the initial literature review. This open coding process was conducted by examining all of the documents generated throughout the data collection process and identifying text passages that contained relevant information about the constructs.

The entire coding process was facilitated by the use of the software NVivo 8 by QSR International. This software package enables the researcher to consolidate, track and code all the qualitative and quantitative data collected in the research study. While all of the data analysis is still performed exclusively by the researcher, the software enables fast and accurate storage, coding and retrieval of the qualitative data collected. NVivo is a tool which has been used by many other researchers to aid in their qualitative research efforts (Volkoff, Strong and Elmes 2007; Dibbern, Winkler and Heinzl 2008).

Table 3-1 Coding Statistics for Key Constructs

Construct	Sub-Dimension	Number of passages with this code	Number of sources with passages having this code
Affordability	Cost Savings	35	23
	Foundation	110	37
	Government Grant	42	25
	Hospital Discounting	25	16
	Loans	3	3
	Payment plan	6	4
	Lack of Funds	45	20
Awareness (Patient)	Disease Prevention	10	7
	Patient Education	6	6
	Publicity	59	27
Awareness (Provider)	Fellowship	30	19
	In-country collaboration	118	44
	Conceptual	138	47
	Practical	214	49
Access	Facilities & Capacity	90	42
	Equipment	244	56
	Staffing	80	34
	Supplies & Devices	228	45
Outcomes	Training Effectiveness	21	15
	Cases Treated	130	43
	Difficulty Score	52	27
	Mortality	31	21
	Quality of Care	104	39
	Sustainability	84	39

During the open coding process the coders actively searched for additional constructs and dimensions that would be relevant to health care supply chains which were not identified in the initial literature review. This process identified some important concepts and categories that had not been initially posited by the authors. These included administration, care design, leadership, teamwork and culture. These concepts and their

implications were discussed by the researchers and additional literature was reviewed. After discussion and consideration the theoretical lens of relational coordination was deemed to shed light on these emergent concepts in the data and an additional round of coding was conducted to examine the data from the perspective of the seven dimension of the relational coordination theory (Gittell et al. 2000; Gittell 2002; Gittell and Weiss 2004; Weinberg et al. 2007b; Weinberg et al. 2007a). Additional explanation of the relevance of this theory is provided in chapter 5 of this dissertation.

The coding process then continued with axial coding process (Strauss 1998; Glaser 1967). This process is used once the major phenomena or constructs of interest have been identified. The axial coding process is designed to uncover more detail relevant to the relationships between the elements in the data (Volkoff, Strong and Elmes 2007; Glaser 1967). Straus and Corbin (1998) recommend the use of axial coding to identify conditions (causal, intervening and contextual) as well as actions or interactions, and consequences in the data. Similarly, Glaser identifies the six C's of axial coding: conditions, causes, covariances, contingencies, context and consequences. Other researchers have recommended that these rules of axial coding be followed with active interpretation and examination of the data and not an overly restrictive set of rules (Locke 2001; Suddaby 2006; Volkoff, Strong and Elmes 2007).

With these guidelines in mind, we proceeded to code the data by identifying what we will refer to as relationships between the core constructs. The querying capabilities of the NVivo 8 software were utilized to enable this process and the significant relationships between constructs in the data were examined. These relationships were coded by

querying the data for overlapping and closely positioned references to multiple constructs. The results of each query were then examined and when a connection between the concepts was evident in the qualitative data then an instance of that particular relationship was coded. Additionally, we reread the data with the intent of identifying any text that made statement that might indicate causal linkages in the data (Dibbern, Winkler and Heinzl 2008; Miles 1994). This process included all of the data collected from documents, interviews and observations and allowed the researchers to narrow down their understanding of how the constructs were influencing one another during the evolution of the partnership. The coding of the data was completed by two trained researchers and any discrepancies were resolved successfully through discussion (Holsti 1969; Dibbern 2008). The reasons for the mismatches were always apparent and consensus on the appropriate coding was reached quickly. The average inter-rater reliability was 0.941 which satisfies recommendations of previous qualitative research and is well over the recommended threshold of 85 percent (Holsti 1969; Morse 1997; Dibbern 2008).

3.4.2 Relationships between the Constructs

The third stage of the coding and analysis involved a process of selective coding which is undertaken with the goal of generating theoretical insights into the phenomena being examined (Strauss 1998). This stage involved an examination of all the qualitative data that had been identified as relevant to the development of this particular phenomenon, a health care supply chain partnership. The selective coding process then seeks to consolidate and refine the codes identified in the data down to particular

theoretical concepts (Strauss 1998; Volkoff, Strong and Elmes 2007; Glaser 1967). This process is central to the goals of our research and will allow us to identify the contributions we can make to existing knowledge of how to design effective health care supply chains. This selective coding process specifically involves querying the data to produce reports of all the text coded as particular constructs or relationships during the previous two stages of coding. These reports are then reviewed carefully by the researchers and the passages are compared to each other and to the relevant literature.

The first task of the selective coding process was to identify the main categories or constructs in the data and their sub-categories. Concurrently, categories that were similar to each other were consolidated. The resulting coding structure consisted of five major constructs (affordability, awareness, access, outcomes and relational coordination) with each construct having numerous significant sub-dimensions. As expected, each of the 3-As of the health care supply chain had substantial representation and between four and six relevant sub-dimensions was identified for each. See Table 3-1 for a listing of the major constructs, relevant sub-dimensions and the number of references found for each in the source documents.

As mentioned previously, the coding of the relationships between the constructs was crucial to identifying insights for supply chain design. The second stage of the selective coding process was to examine the volume and content of the text related to these relationships. The detail of how the framework of relationships was developed out of this coding process is presented in section 3.5 which contains the details of the development of the conceptual framework. This process will examine both the volume of the

references to the specific relationship as well as the content of how the constructs are relating to one another in the text. The results presented in section 3.5 will draw upon the data from archival documents, observations and interviews but will most frequently illustrate the relationships using quotes from the interviews, as these are the most descriptive of the dynamics in the partnership.

While the aggregate view of how the constructs related to one another is important, the authors felt it was also critical to understand how these relationships developed over the length of the partnership. For that reason, in addition to an aggregate view of the relationships between the constructs, the data was sub-divided into historical phases that were initiated by the occurrence of a significant change or innovation in a relevant major construct. To ensure that the conclusions of this research were not biased or unduly influenced through the length of time since the events occurred or the selection of interviewees, the data was analyzed in two sub-sets. The first included only the historical documentation or archival documents. The second sub-set was inclusive of the archival documents as well as the interview and observation data. In almost all cases, the results of the analysis were the same whether just archival data was used or the interview and observations were included. For the purposes of this chapter, the figures and tables utilize numbers for the entire data set but similar figures and evidence can be provided for the archival data only.

The identification of these historical phases occurred while the initial coding and review of the archival data was occurring. Within the progression of the partnership between CHL and FHLU, the authors identified shifts in the way that the partnership

functioned which we are identifying as innovations in health care supply chain design. The affordability construct changed between Phase 1 and Phase 2. Therefore, Phase 1 includes the years prior to the partnership as well as the first year of the partnership and Phase 2 includes the following three years. Awareness changed from Phase 2 to Phase 3 and access changed between Phase 3 and Phase 4. The events or innovations that were identified and used to distinguish the four phases will be discussed in detail in the following sections. The years included and relevant innovations for the historical phases are summarized in Table 3-2, along with key outcome metrics, such as volume of patients, the reduction of mortality and an increase in case complexity. The following analysis is designed to uncover the reasons that these innovations resulted in such significant performance gains. The existence of different phases in the history of the partnership is evident not only to the authors and the CHL staff but also to the FHLU staff and administration, as is illustrated in the following quote:

“During different period of time, things have different importance. Now the surgical operations are become less important than before. And the training (conference) and communication is become more important. Because we have a different system sometimes we have different ways to see things. So we need communication more to understand more.” – *Vice President Yu, FHLU*

3.5 Theory Development: Propositions and the Integrative 3-A Framework

Prior to and coinciding with the inception of the partnership we were able to identify some existing relationships between the constructs. There were several initial interactions between CHL and FHLU and the cardiac surgery department did already exist at FHLU in 1999, which we consider the inception of the partnership, so there is some existing capability in the FHLU site and connection with CHL. In most cases,

these relationships were evident in the data but only with very weak supporting evidence. The key relationships that form the propositions proposed later in the chapter are those that were seen to strengthen or appear over the course of the partnership. These initial relationships between the constructs of interest are depicted in Figure 3-1 with thin, solid, black lines. One interesting fact is that the relationship between access and awareness is the strongest relationship evident in the initial data. Also, the initial connection to the outcome of volume and quality of care exists through a relationship to access. This relationship is initially weak and the evolution of the partnership will show that the largest impact on outcomes does not occur until the final phase when innovations in all three of the key constructs have been undertaken.

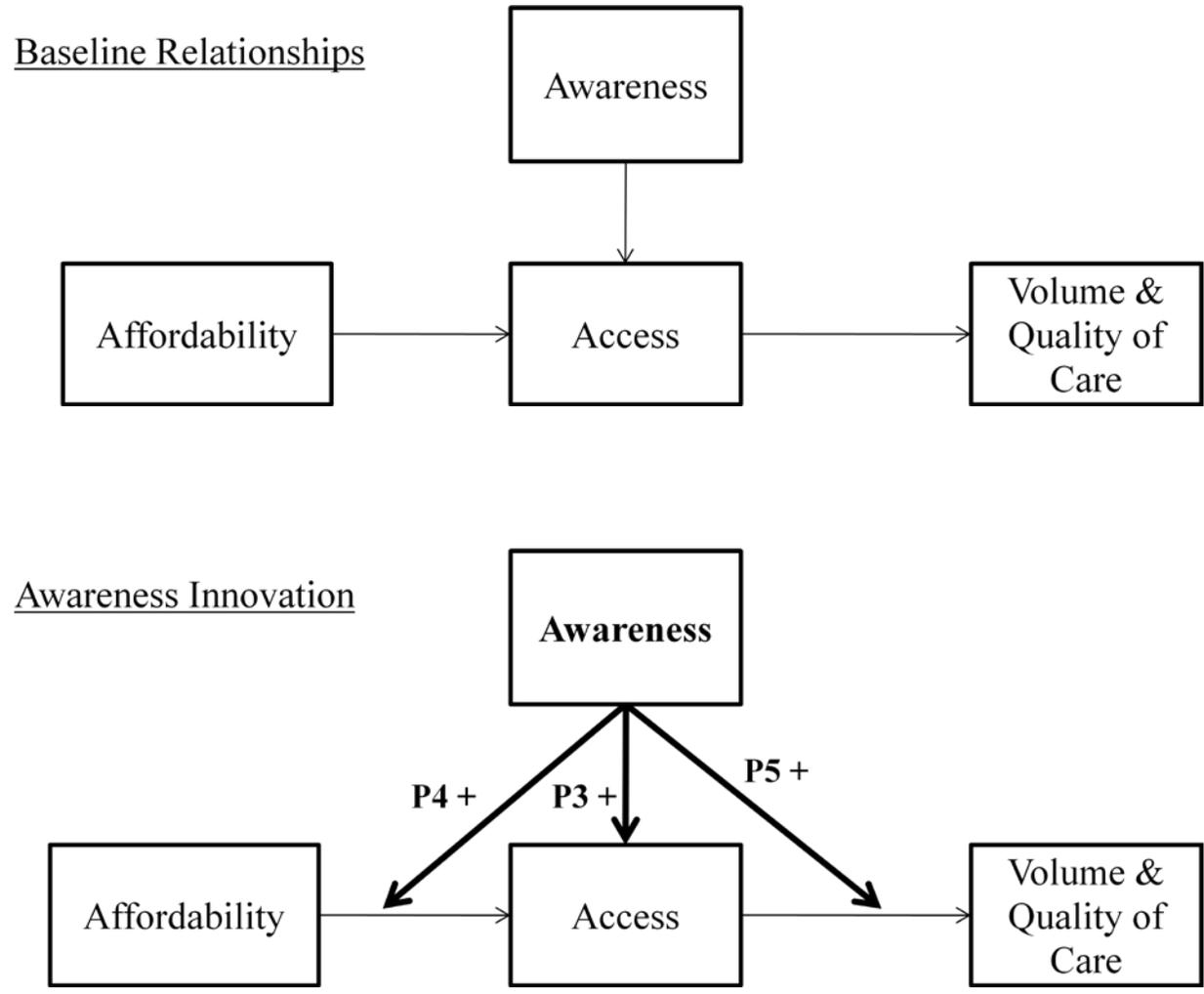
3.5.1 Innovation in Affordability

In 2000, shortly after the inception of the partnership, both CHL and FHLU realized that the financial status of the patients in the region was limiting the ability of the program to grow. The FHLU department staff simply could not learn and practice new techniques if the patients could not afford to pay for the surgery, hospital stay, blood products needed and other expenses. Therefore, the CHL Foundation was formed. The Foundation is an allocation of money provided by CHL from charitable sources which is administered and distributed to children coming to FHLU for treatment. The children selected to receive assistance from the Foundation must be shown to be too poor to pay for the needed surgery on their own. The years subsequent to the enhancement of the payment system for patients in Gansu Province facilitated by the CHL Foundation, through the next innovation to occur are included in Phase 2.

Table 3-2 Time Line of Partnership Development

Year	Other events	Intervention	Cases Treated*	Mortality**	Complexity***
< 1998			80	6.25%	0.00%
1999	start of partnership		184	4.35%	0.99%
2000		<i>Affordability (Inception of Foundation, 11-99 agreement; \$500 initial funding)</i>	200	4.00%	0.84%
2001			250	1.60%	1.45%
2002			253	3.95%	1.83%
2003	increased Gov't support	Awareness (Change focus to simple procedures)	298	1.68%	2.82%
2004	focus on collaboration		295	2.03%	3.49%
2005			430	2.33%	3.21%
2006	<i>QA introduced</i>	<i>Access (fully functional new facility)</i>	550	1.82%	9.52%
2007	<i>team training in SCMC</i>		505	1.98%	6.71%
2008			616	1.95%	17.42%
	*	Cases Treated = total patients treated in cardiac surgery department for that particular year			
	**	Mortality = percentage of total patients who died while in the hospital			
	***	Complexity = percentage of cardiac surgery department cases that were infants (<12 months) for that year			

Figure 3-1 Baseline Framework and 3-A Framework after Innovation in Affordability



The evidence in the data indicates a simple direct link between the affordability of the service to the patients who need it and the ability of the hospital to make enough money to further invest in the infrastructure, staff and equipment needed to improve their service offerings. This relationship is explained concisely by the former head of the cardiac surgery department, Dr. Gao.

“For many in this area, it is a financial problem. For the patients, they have no money, so we cannot make a treatment. For the hospital, they have not enough money to buy supplies and equipment, to buy very good equipment. This also hinders the development. But these two financial problems also influence each other you know. Because they treat less patients because they have no money, they don't have money to come to the hospital. The hospital cannot make enough money [to invest in needed supplies and equipment].” – *Dr. Gao, Cardiac Surgeon & Former Department Head of Cardiovascular Surgery*

An important factor which relates to affordability is the strong focus on the part of the FHLU site to keep costs as low as possible for each patient. This is not a factor often considered by care providers in the U.S., but remains a huge consideration for physicians and nurses in countries like China, as is evidenced by the following quotes:

“... I would say is that the main difference between the, if I could exaggerate a little bit, is from the US side it is pretty much the philosophy of ‘we will do this at all costs’ meaning that resources, the blood, all that, nothing would be spared to save a life, so they would do anything they can to save a life. On the other hand the China side, they take, if you will, cost benefit ratio, ..., they spend a little more time looking at is it worthwhile to spend another ‘x’ amount of money to, for example to get another bag of red blood cells, or platelets or something like that, having spent a lot of time and money already. There is more of that discussion, I would say on the patient mission than we would be having that conversation on the US side.” – *Li Wang, Interpreter and Medtronic Device Representative*

“And they have got to be under a lot of pressure to not waste anything ... I think it was the 3rd trip. Because I got really angry and then didn't want to go back. The perfusionist and I had come up with, because on previous trips we would occasionally run out of oxygen because they just roll these

big tanks in. So we came up with this little 'Y' device so you could 'Y' two of them together, you know and have one closed off and then when the other one ran out you just switch over to the other one and you never go without. Because what they were doing before was then they ran out the whistle would blow and someone would run and get a tank and someone would run and get a wrench and by that time the patient could be dead if they were unstable. (They are really in need of the oxygen.) And so it was a very simple device and then right as we were leaving from that trip. Literally as we were saying our goodbyes we were watching them dismantle this.” – *Roxann Barnes, Anesthesiologist*

The above quotes that show the necessity of constantly considering costs related to the delivery of care at FHLU. Another frequent volunteer at the FHLU site also mentioned that the staff at FHLU continuously considers the cost of the supplies they use and even the drugs that are administered to the patients because of the expense to the families.

“And so some drugs but not major, most drugs it seemed like they have. (Why are the ones not available that you mentioned?) I think it is expense, for the most part. Yeah, what they have available in the pharmacy is what they are willing to charge the patients for. (So the hospital might not put a certain drug in the pharmacy because they don't want to charge the patients the amount they would need to for that drug?) Yeah, it might be. And interestingly, and I think some things [drugs] are more pricy in China than here.” - *Jeff Paurus, Nurse Educator – Minneapolis Community and Technical College*

These considerations of the cost of care by the FHLU staff show the link between the affordability and access construct to the outcomes of the department and the accessibility of care through drugs, equipment, and basic supplies. Consequently, as the affordability of care is increased the availability of supplies, drugs, and a multitude of other concerns is also improved.

Proposition 1 (P1): Affordability is positively related to access.

The previously described innovation in the affordability construct enabled not only additional volumes of surgeries to be performed but facilitated an increase in access through better equipment and supply availability. The innovation in affordability was identified as the key to an initial improvement in outcomes by most of the involved individuals. However, affordability continues to present significant hurdles, as is evidenced by the following quotes:

“And also the foundation from CHL is very useful. If there is no foundation, for some poor children it is impossible for them to have the operation. When they come it is cheaper or they get some discount, and without the foundation this is impossible...So when Children's HeartLink came agree to support for this, they gives foundation and free operation, so the cost becomes lower. Much lower than other province in this case...and you also give support to the hospital, you take some equipment...all this supports are very important for the children in this poor province.” – *Dr. Gao, Cardiac Surgeon & Former Department Head of Cardiovascular Surgery*

“Because you offer the financial support that can solve a lot of poor children's problems so that they can afford the operation, which helps a lot. So that more patients come for operation. CHL also provides some equipment for them and also solves problems (with the equipment?)” – *Fang YuMei, FHLU Head ICU Nurse*

“I think from that perspective the limiting factors are the nursing staff and the patients’ ability to pay might be the two biggest limitations right now” – *Jeff Paurus, Nurse Educator – Minneapolis Community and Technical College*

In light of the above quotes from both medical volunteers who traveled to the site as well as the cardiac surgeon who was the head of the department during the first years of the partnership and one of the head nurses in the ICU, it is easy to see the impact that an increase in affordability through the foundation had on the ability to treat patients.

Therefore, we posit the following proposition:

Proposition 2 (P2): The relationship between awareness and access is moderated by affordability, such that awareness has a greater positive impact on access as affordability is increased.

3.5.2 Innovation in Awareness

Phase 3 is delineated as the years 2003 to 2005. After the May 2002 mission there was a phone conference that resulted in a watershed decision to change the focus of the missions by limiting the number and complexity of cases. This change was undertaken in order to respect local supply availability, prevent unnecessary deaths due to complications, and encourage actionable learning among the FHLU staff. Therefore, in 2003, there was a significant change of the tone and conduct of the mission teams that traveled to the FHLU site. This change involved a shift away from focusing the efforts of the visiting team on the more complex and challenging cases. Instead, the visiting team conducted the cases from which the FHLU team could learn the most and perform similar surgeries after the visiting team left. This shift brought a greater focus on collaboration and teamwork and was designed to allow the FHLU team to learn what they could do within the constraints of their local facilities, supplies, staffing and experience.

“teaching/training set as primary goal of missions instead of number of children treated, need more direction and focuses participation of local physicians” – *Final Mission Report 2002*

This resulted in less complex cases receiving surgery during the mission but was designed to increase the number of cases performed during the year when no mission team was present. As a result, the main goal of the missions became the transfer of knowledge for medical best practices through improved communication about how to deliver daily care as can be seen in the quote below:

“One of the main stated goals for this mission was to improve communication between the CHL team and the Lanzhou staff. Under Dr. Dearani’s leadership, an initial staff meeting was held at the beginning of the week, and daily grand rounds and pre- and post-operative meetings were held with both teams to improve communication.” – *Evaluation Report 2004*

These team visits create learning on both sides of the table with impacts on the visiting team that include a widened world view and exposure to the resourcefulness and strength exhibited in the ability of the partner site to adapt and serve patients despite limited resources. The most striking example of this is the difference in the approach to the lack of staff in the pediatric cardiology role at FHLU. The FHLU site has never been able to employ a physician trained in this role for a variety of reasons. The initial reaction of CHL and the volunteers was to encourage FHLU to fill this staff position as quickly as possible. One of many requests each year was for the hospital to hire a trained pediatric cardiologist to perform diagnosis and coordinate overall care. One of these requests from a Mayo volunteer and pediatric cardiologist is below:

“noted that echo tech is not an MD and did not show interest in training, stressed need for pediatric cardiologist on staff” - *Dr. Allison Cabalka, 2004 mission debriefing report.*

This same need for a trained physician in pediatric cardiology had been expressed every year since the partnership began in 1999 and would be repeated each year over the next several years. Over time, the CHL staff and volunteers realized that they should take page from the book of their site partners and just adapt to the local constraints on the availability of a cardiologist. The new philosophy they are applying, as a stop gap measure to address this deficiency and assist FHLU to continue growing, is to teach the existing FHLU physicians the skills and duties of a cardiologist. Once these skills are

learned, the CHL team then leaves the distribution and execution of the tasks related to the cardiology role to the judgment and teamwork of the local staff. According to Dr. Lee Pyles, a pediatric cardiologist from the University of Minnesota Medical School:

“If you don't have the person that comes with that label, you better figure out how to replicate what is important about what I've done and what a cardiologist does and assign those important functions to different members of the team that can accomplish some of them.”

In addition to the learning experienced by the visiting team, the innovation in awareness triggered significant changes in three other relationships in the 3-A framework. The first relationship that experienced significant strengthening was that between access and awareness directly. As the FHLU team was shown the importance of some key elements of the treatment of congenital heart disease they began to realize the critical new roles of staff members as well as the importance of continuously learning by having the technology and equipment to review cases. To that end, Dr. Lee Pyles suggests:

“ stresses the need for pediatric cardiologist. Since it seems that it is so hard to find one, I will explain the role in the department...important for surgeons to see the echo in motion and not just still images, suggests the need for new equipment that allows for video capture, storage and retrieval of images”

Similarly, the partners both realized that awareness needs to extend beyond the FHLU facility to the entire physician network in the province. This can then help to facilitate the early identification of patients so that they can be treated while they are still young and further complications of their disease have not progressed. According to Li Wang, who traveled to FHLU five times to serve as an interpreter in the operating room while working for Medtronic Inc. (a major medical device manufacturing company):

“One of the things is that the physicians are fully educated on their indications and then that the surgeons are fully capable of operating on the complicated procedures, may become another layer of issues. (So you think that the referring physician network is probably somewhat lacking?) Yeah, I don't know that everybody is up to speed on all the new guidelines and new procedures. (Or even in the development at the department in Lanzhou, that a lot of the physicians in Gansu province don't know what the hospital is capable of.) Yes, that is what I mean by that. If they don't believe in surgery, the patient might not even get that far.”

Specifically, the link between access and awareness is illustrated by changes which enable the teams to teach more concretely the principles that would help improve care and allowing the FHLU team to practice their newfound knowledge more frequently. Even with these improvements, however, significant additional areas to be addressed in the future are also identified. According to Jeff Paurus, a nurse educator from Minnesota who has traveled to FHLU numerous times, including seven CHL missions starting in 2001:

“It used to be that there was one sink in the room next to the ICU sometimes with soap, sometimes with no soap and no place to dry the hands and so you would actually have to leave the ICU just to be able to wash your hands. And it was very inconvenient and now they have waterless hand cleanser at each bedside and the entrance and they have a sink and an automatic sink. Still paper is in short supply you have to shake your hands and dry them on your lab coat or uniform or something. But still there is the waterless hand cleanser which is proven to be very effective”

One of these areas for improvement could result in huge patient care improvements if additional equipment and training were provided but must start with equipment. The cardiac surgery group needs a particular type of echo machine which would allow them to assess the patient immediately after surgery and could possibly save lives. An example of how this additional equipment is utilized at Mayo is below:

“Right I mean, if you take an example of what happens here the probe is down they get the pre-op and the post-up so as soon as they come off pump they get the echo. The canulas aren't even taken out; the pump is in the room it is ready to go. So if you say, there is a problem. Done, they are on pump, one second. And so that can make a big difference.” – *Dr. Allison Cabalka, Pediatric Cardiologist – Mayo Clinic*

Finally, with the additional facilities and equipment the issue of equipment maintenance arises yet again as a big weakness. They are clearly aware of the potentially serious consequences of continuing to ignore this area but still need to implement significant change. Because their equipment does not receive standard maintenance or calibration, the medical staff may not be able to trust the indicators on those machines. The FHLU staff has learned the importance of looking for these potentially deadly errors before they occur:

“I mean they can listen to the heart with a stethoscope and then when they hook up the patient and see the machine and the stethoscope don't match. They are beginning to see that. You know, they just, when I first started going over there, I mean they would hook the patient up to the machine without even thinking. Assuming that the machine is right, well the machine isn't always right and if you listen to the patient's heart and it doesn't agree with the monitor then you say, hey! And either you make a mental correction when you look at the dials or the readout on the patient monitor or you don't use the piece of equipment.” – *Frank Watts, biomedical engineer*

So with these innovations in the awareness dimension more growth in access is accomplished and future areas for growth are exposed. Therefore, we posit below in Proposition 3 that the link between access and awareness is significantly influenced by this change. The result of an innovation in awareness is an increase in the understanding of the needs of the larger system of referring physicians, as well as utilization of existing equipment, compliance with infection control standards and staffing decisions.

Proposition 3 (P3): Awareness is positively related to access.

The next significant influence of the innovation in awareness on the 3-A framework is a strengthening of the relationship between affordability and access. This relationship is enhanced as more of the actors in the supply chain recognize the importance of funding for these types of treatments and the conditions and facilities necessary to execute them. The below quotes, from some of the volunteers who traveled on the earlier missions, illustrate the depth at which the FHLU facilities needed investment in infrastructure and equipment. The success of the efforts of the CHL teams relied on the ability of the FHLU cardiac surgery department to convince the hospital administration and provincial government of the need for investments in equipment and facility updates.

“I mean, they had no running water to speak of ...So even by way of basic things, they didn't even have waste baskets in the room or in the OR, they didn't have sharps buckets in the OR and really no easy way to keep your hands clean. I mean, we brought hand sanitizer but that is not a concept that they were obviously into. So, they didn't often, they didn't use universal precautions, you know gowns, gloves, things like that. They weren't using hand sanitizer and there was no way to clean up because there was no safe water” – *Dr. Roxann Barnes, Anesthesiology – Mayo Clinic*

“Like even getting the equipment that they could use to expand their program growing they have to have buy in from the administration in the government and the money to do that, so all the education and the training in the world might not do them any good if they don't have the hardware so to speak.” – *Dr. Allison Cabalka, Pediatric Cardiologist – Mayo Clinic*

In the first case above these access improvements were as basic as access to clean running water and reliable electricity in the operating room but in the second case it was an issue of investment in diagnostic or surgical equipment that is essential to patient care for complex cases. Further examples of this intertwining of the affordability, awareness

and access aspects include the donation of some equipment and supplies which the local team is now capable of utilizing.

“Children's HeartLink gave this department, this hospital support and technology and also information...and you also give support to the hospital, you take some equipment...all this supports are very important for the children in this poor province.”

“Last time, CHL, send/give machine for perfusion to hospital, which was a second hand machine. That one is very useful because before they had only one machine. So they could only make one operation each time. Now they can make two operations together because they have one more machine. This second hand machine is still in use.” – *Dr. Gao, Former Head of Cardiac Surgery Department, FHLU*

These examples of basic improvements in facilities, commitment to invest in new equipment and the integration of donated equipment into the department highlight the ways in which these constructs have worked in concert to enhance patient outcomes and volumes. This leads us to posit the following proposition:

Proposition 4 (P4): The relationship between affordability and access is moderated by awareness, such that affordability has a greater positive impact on access as awareness is increased.

Finally, an innovation in awareness during this phase revealed another significant strengthening of an existing link directly from access to changes in patient outcomes. Addressing and resolving staff training gaps is tied to specific care delivery elements of OR procedures or ICU recovery care so that the utilization of the available technology by trained staff enhances patient outcomes. The below quotes show the improved application of medical techniques by the FHLU staff that were observed by mission teams as evidence that within the constraints of their current operating environment they were achieving higher quality of care:

“Lanzhou anesthesiologists paid close attention to airway management with children; this continued during transport from OR to ICU” – *Source: site assessment documents 2004*

“Lanzhou team used simplified approach to using antifibrinolytics with smaller amounts of medication in bypass machine...Approach is adequate, but use of larger doses and infusion pump will be necessary with smaller or more complex children” – *Source: site assessment documents 2004*

“We operated on a variety of cases – wide range of difficulty. For the most part, their surgeons are successfully operating on the majority of the diagnoses that we dealt with. They found it helpful to see how I set up the case and how I work my way through difficult intra-operative problems.” – *Dr. Joe Dearani, Pediatric Cardiac Surgeon – Mayo Clinic*

“If they (CHL team) don't think they are very proper or the process doesn't work very well or has some problem then they will say what they think and next year when they come back they will find that the problem has been solved. There has been process improvement. So she thinks because of this kind of exchange, they are the best ward in the provincial hospitals” – *Fang YuMei, Head ICU nurse - FHLU*

While there is significant progress in the quality of patient care, as evidenced by the previous quotes, there are still areas which merit improvement. In some cases these are areas that are deficient because of staffing resources and others are larger issues which require longer time investment for changing cultural viewpoints on patient care. The below quotes show some of the areas that remain for improvement:

“Issues to be addressed at Lanzhou include patient care prior to the surgery. The patients must be healthy and hydrated prior to surgery, issue should be addressed with Chinese team” – *Dr. Roxann Barnes, Anesthesiologist – Mayo Clinic*

“goals for surgical team to improve training in specific skills by evaluating consistently throughout the day including pre and post op as well as in surgery training” – *Source: Evaluation and Observations, 2005*

Finally, the FHLU team is able to learn a lot from simply observing the interactions and actions of the teams brought to the site by CHL as part of the partner process. It

allows them to be exposed to a standard and approach to care which are not inherent in the current Chinese system.

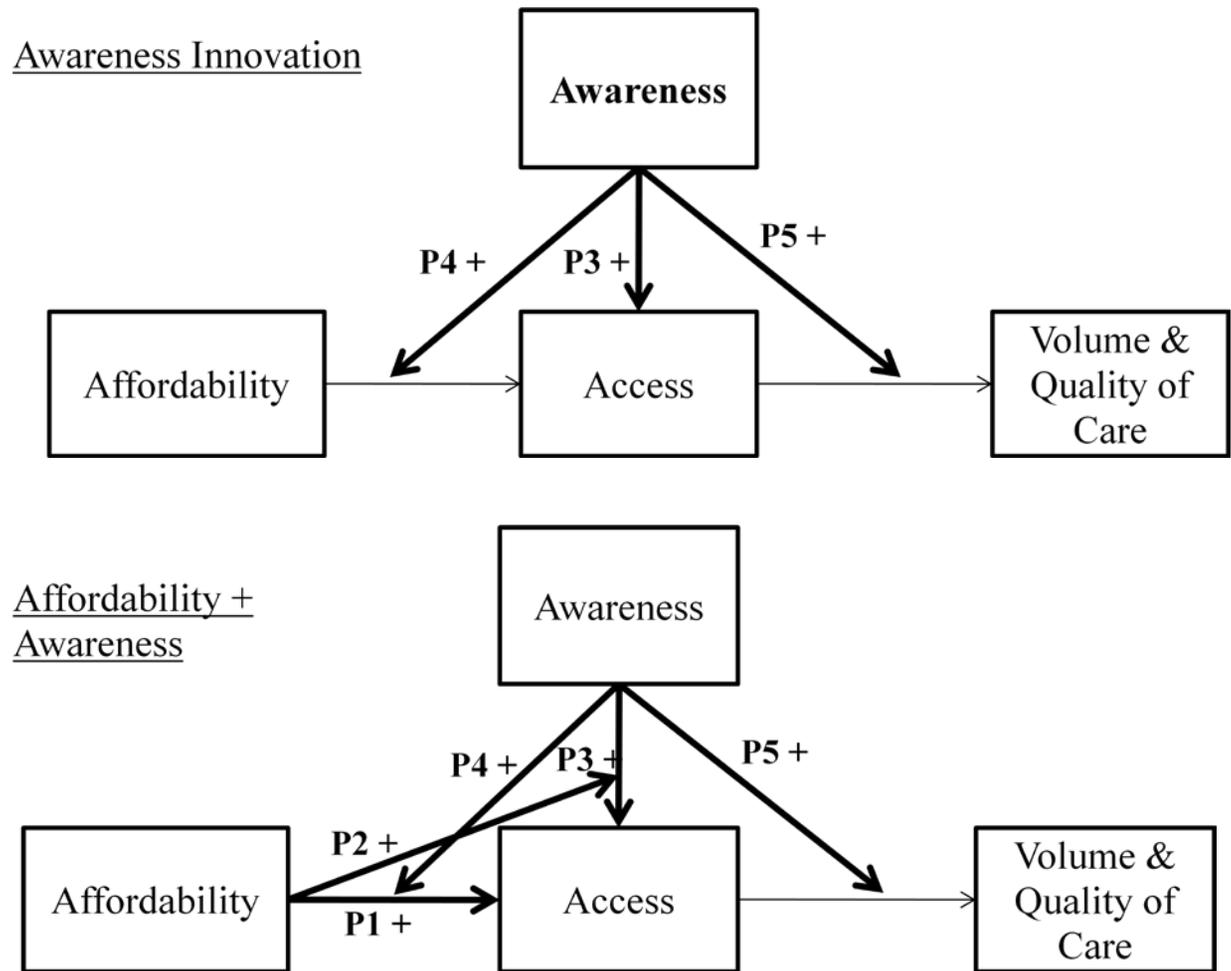
“(The) first time that CHL came to our hospital they supplied a new concept about the treatment. So I think it is very useful because they supplied us new concept and provide opportunity for us to see how American doctors and nurses worked. So, this is very important because the doctors in China have very few opportunities to travel outside China to see how doctors outside China are working. So I think from the tiniest time that our hospital doctors and nurses have contact with your doctors and nurses they learn a lot from your doctors and nurses how to work. Not only in technique but also in how to take care of the patient, how to face the patient, how to treat of the patient, I think that is the important things. It is very important for us, for our hospital. So the medical teams from US they can supply the high level standard of the concept of service and medical care, so that can teach us and show us how we can better treat the patient and have better quality of our work and quality of medical service and nursing.” – *Vice President Yu, FHLU*

These quotes show the direct impact of the learning presented by the interactions of the partner teams on missions. This learning impacted things like intra-operative problem solving, pre-operative care, dosing of medications and a generated a basic concept of service in medical care.

Proposition 5 (P5): The relationship between access and volume and quality of care is moderated by awareness, such that access has a greater positive impact on volume and quality of care as awareness is increased.

Figure 3-2 illustrates the impact of an innovation in awareness on the 3-A framework.

Figure 3-2 Relationships in the 3-A Framework after Innovation in Awareness



3.5.3 Innovation in Access

The final phase was initiated because of two specific innovations relevant to the access construct which involved both facilities and supplies. The first was construction of a new hospital for inpatient care at the FHLU partner site. The completion of the new hospital building significantly increased capacity and the reliability of such essentials as electricity and water. In so doing, it expanded the capacity of the surgical team at FHLU and contributed to the growth over time of the number of patients and the increase of the complexity of the surgeries performed.

A second instance of an innovation in the access construct was a shift by CHL volunteers away from bringing in any significant volume of supplies when coming to the site for a mission. After this point, instead of viewing expensive and specialized supplies that the mission teams used in their home hospital as essential ingredients to the mission, they now attempted to use only those supplies that were available easily and locally to the surgical team in Lanzhou. The reason for this is summarized in the following quote:

“And in the past we brought more of our drugs with us on the mission, but I think now the idea now is that we don't want to do anything that the normal operations couldn't repeat. That they couldn't do when the team left.” – - *Jeff Paurus, Nurse Educator – Minneapolis Community and Technical College*

This shift in the policy of the mission teams on imported supplies was based on both the difficulty and expense of bringing in the supplies, as well as considerations for effectively training the FHLU team to work within local constraints. The CHL teams had realized that the most effective way to assist the FHLU team was to function and provide care under the same conditions as when the mission team is not present. This allows the

FHLU team to see the skills and concepts they should learn without these things being obscured by specialized equipment brought in by the CHL teams. This concept is illustrated succinctly by one of the surgeons leading many mission teams at the site:

“Secondly, we want to work within the parameters that they are functioning. I mean it really doesn't do them a lot of good if we bring all our stuff and fancy things and supplies and fancy gadgets to use there for a week but then they are not going to use them when we are gone. That is not very practical from their standpoint.” – *Dr. Joe Dearani, Pediatric Cardiac Surgeon – Mayo Clinic*

Now, turning to the relationship that is most significantly strengthened in this last phase, the relationship between access and the volume and quality of care, we see significant impacts on the strength of this relationship. In particular, there is an emphasis on better use of resources to improve outcomes. The following two quotes show that changes to the current practices of utilizing the supplies that are available to the department will have significant impact on outcomes.

“Increased attention in the amount of plasma used on a patient after weaning from bypass. The judicious use of plasma on a patient may improve safety and reduce overall costs to the patient and hospital” – *Source: Observations and Recommendations 2007*

“For future practice, avoid reusing cannulas on patients, the concern being that this could lead to the cleaner being absorbed into the plastic and leaching out during the case and also the protein deposits may not be totally removed” – *Source: Observations and Recommendations 2007*

The next several quotes highlight some limitations to the current state of the FHLU program. They point out further investments that can be made in the availability of supplies, diagnostic equipment, and patient treatment equipment that are necessary to make the next step to advancing the volume and quality of patient care.

“Real issue is having the appropriate sized cannulas for small children they are currently using adult sized cannulas. It shows lack of commitment on part of administration to not invest in the inventory that it would take to have appropriate cannulas... as complexity increases then patient care complexity increases 10 fold. Need more intensivists and ICU nurses and much better cardiology program.” – Dr. Jeff Myers, Pediatric Cardiac Surgeon – Massachusetts General Hospital

“See that is where we used our borrowed loaner machine ...we could use it in a larger patient but not in a small patient. So we used some of our own stuff that we brought in ... their equipment wasn't great and so (so even if they did bring in a cardiologist there would still be limitation?) Yeah and if they did get a new machine in the outpatients then maybe that would help with better diagnostic studies in the pre-op as well as the post-op. I mean that is one of the big limitations to enlarging a cardiac program is the involvement with cardiology post-op too and getting echoes done in the hospital at the bedside or someone is having a problem in the ICU, what's going on. I think they are used to going without technology so they don't miss it per say.” – Dr. Allison Cabalka, Pediatric Cardiologist – Mayo Clinic

“Before attempting to carry out more complex procedures (such as Fontan) it is critical that the program carry out continuous gas monitoring, in particular, having end tidal CO₂ available; an increase in CO₂ gas monitoring in the OR will also lead to further training and expertise in the management of pulmonary artery pressure. In order to carry out more complex procedures the program will need to acquire triple lines CVP kits versus the current double lines” – Source: *Observations and Recommendations 2007*

All of the preceding quotes show the importance of the somewhat self-evident link between the level of access and the volume and quality of care in a system. In particular, they emphasize the influence that the availability and condition of supplies has on the way in which care is delivered to the individual patients. Additionally, the improved conditions and capacity in the operating rooms in the new hospital simplifies the process of delivering care consistently with high quality.

Proposition 6 (P6): Access is positively related to volume and quality of care.

The previous proposition deals with the direct impact of the access innovations in the supply chain on the outcome measures. Figure 3-3 illustrates the impact of an innovation in access on the 3-A framework. As illustrated by the quotes below, these innovations have a strong influence on outcomes as well as a significant system-wide effect due to the cumulative or complementary effects of all three of the innovations that took place in the supply chain design at FHLU. In fact, at this stage there emerges evidence of marked improvements in outcomes associated with the efforts of both teams. The efforts of both partners through the CHL program have resulted in increased skills, confidence, program sustainability and patient outcomes as illustrated by the following quotes:

“In the years CHL has been working with the site, this visit was the most successful in terms of site preparation, organization, interaction by members of both teams, and encouraging developments in program leadership, volume and outcomes. Review of cases was held after surgery and selection of cases for the next two days. Again we were impressed with Dr. Song’s directness in asking to indicate which cases his team would like to operate on with our team’s concordance. Everyone agreed with their recommendations and it was decided to try and perform surgery on four cases Tuesday and two on Wednesday if surgery could start at 7:30.” – *Mission Summary 2007*

“So after that, gradually they can do younger and younger children. Now they still cannot do newborn babies, but they believe after time, each time the team comes, each time the children's age becomes younger, you know the operation age. So now, uh, the younger people get treated after you have gone; they still have the skills to treat them.” – *Dr. Gao, Former Cardiac Surgery Head - FHLU*

“But for other operations, they stay only a very short time, just one day. (Is this an improvement?) At that time, they would stay 2 or 3 days for an operation but now often only 1 day. Usually the patients when they come from the operating room are in very stable condition. For the very young patients, like 3 months they stay longer, because the caring is more difficult for the parents if not in the hospital. ” – *Fang YuMei, Head ICU nurse – FHLU*

Figure 3-3 Relationships in the 3-A Framework after Innovation in Access

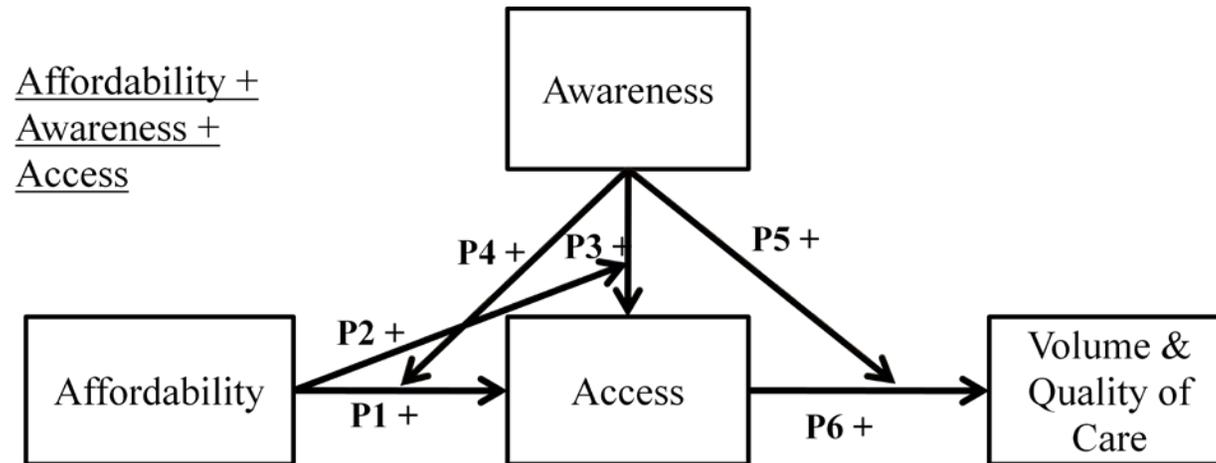
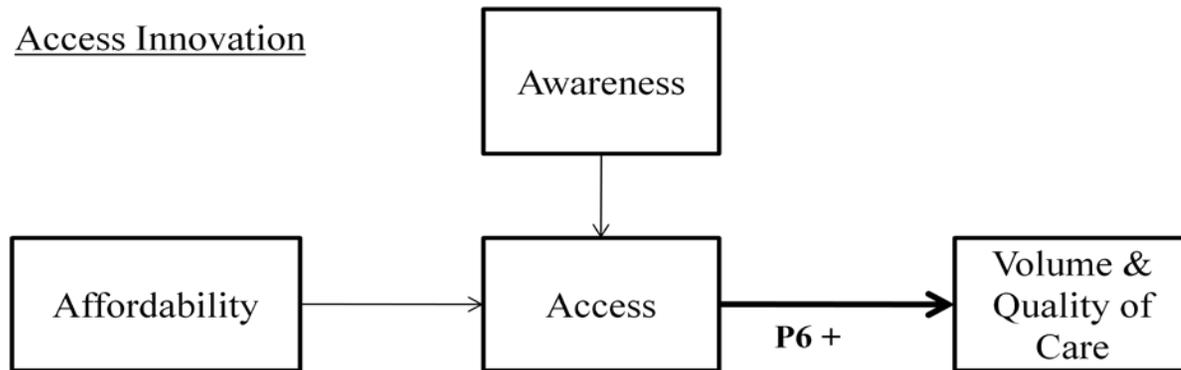
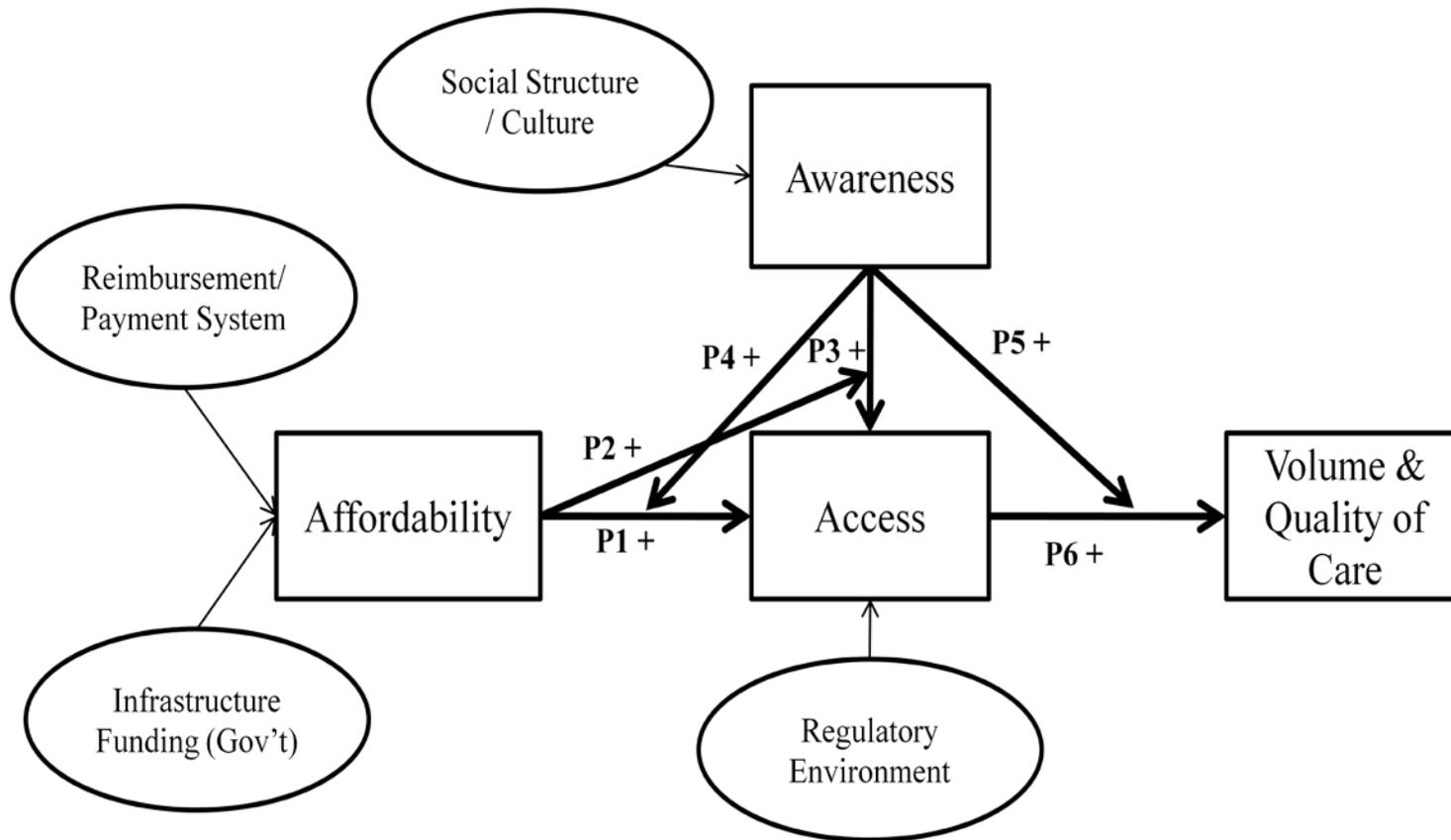


Figure 3-4 An Integrative 3-A Framework for Health Care Supply Chain Design

Integrative Framework



3.5.4 An Integrative 3-A Framework for Health Care Supply Chain Design

The previous section outlines in detail the evolution of the 3-A framework over time and the propositions related to how the relationships in the framework will strengthen based on the innovations that are implemented in the supply chain. The 3-A framework also has the ability to model the behavior of the supply chain at a single point in time. From a cross-sectional viewpoint, the propositions are slightly different so the aggregated framework and behavior of the constructs is presented in this section. This integrative 3-A framework presented in Figure 3-4, with the propositions numbered according to the previous section. These propositions have been developed based on patient-level considerations in the data and supported using evidence presented in the time-related analysis from the previous section.

The preceding analysis has not addressed the significant influence of other factors which should be controlled in studies which span more than one country such as Governmental support, regulatory environment, and culture (social structure). In future studies, which are designed to test the proposed 3-A framework, these factors must be controlled for and considered seriously. In fact, there is some evidence in the data collected from this partnership of the influence of culture on outcomes. Some of the important influences revolve around communication between the FHLU staff and the families, communication between teams on the FHLU staff about patient status, and the allocation of available resources to patients, as illustrated by the following quotes.

“Change is always difficult, a little more cautious in Lanzhou but very open to change. Lanzhou was a time warp back to 1980 in the coastal cities after the Cultural Revolution, most people were hesitant to speak up

and suspicious of foreigners. They prescribe the health care priorities for the entire country and they have a much lower value on an individual life than here. The design of health care system has a focus on working adults or more pervasive diseases than congenital heart disease. “– *Claudia Liebrecht, Former President of CHL*

“Well, I think culturally they are not as concerned with it, because I think there is this big different in terms of valuing a life versus having enough resources to treat a population. Here in the US, it is clearly understood that every life is ultimately priceless, ... it is more important for them to do what is good for the common good for everyone as opposed to any one individual.” – *Dr. Roxann Barnes, Anesthesiologist – Mayo Clinic*

“There was a tendency for a lack of communication between the surgical team and the ICU team. They need to develop a new model for keeping everyone on the same page. There was an especially big breakdown between surgery and ICU that could be either tradition or culture. There also appeared to be a divide between the male surgeons and the female MD in the ICU. ”- *Jeff Myers, Pediatric Cardiac Surgeon – Massachusetts General Hospital*

With proper measures for the previously listed control factors, the 3-A framework presented above should reveal significant insights about how to design innovations for health care supply chains as well as how to account for the timing of these innovations. At the FHLU site, there was an existing program and the innovations in affordability and awareness preceded the innovations in access because the resources to innovate along the access dimension were not available at the beginning of the partnership. The FHLU program needed to prove that it could optimize the outcomes with its existing resources prior to asking for additional resources. However, in a scenario where the required treatment facility does not yet exist then the ordering of the innovations would, of necessity, be quite different. In that scenario, an innovation in the access dimension would have to occur first in order to facilitate the delivery of care. Further study of the 3-A framework and its constituent constructs will provide more insight into the nature, order and timing of important innovations in other and different circumstances.

3.6 Discussion

“Across the board when I look at what it was like when I first started going there to what it is like now, I mean it is hands down 100% better. I mean, from the personnel to the facility and all that stuff. I mean, things have really escalated to pretty respectable levels” – *Dr. Joe Dearani, pediatric cardiac surgeon from Mayo Clinic*

The above quote from Dr. Dearani attests to the significant achievements of the FHLU team in concert with support from their CHL partners. To summarize with only statistics the outcomes and accomplishments over the life of the partnership with FHLU would not do justice to the impact of the partnership. These partnership accomplishments include \$424,000 worth of equipment & supplies donated, 260 children screened with 111 surgeries during the CHL missions, and 600 on-site training opportunities provided with 16 off-site training opportunities in addition. The relationships specified in the developed 3-A framework assist us in understanding how CHL and FHLU have accomplished so much over the past ten years. The examination by phases of the partnership gives us a glimpse into both the importance of the innovations in each of the 3-As, as well as insights into the process by which knowledge dissemination and organizational learning occurred in the supply chain.

We set out to investigate the important dimensions of each of these elements and to propose a 3-A framework that ties the three coordination dimensions to the achievement of quality health care in high volumes for underserved communities. To that end, this study has shown that not only are the 3-As (affordability, access and awareness) important factors in the health care supply chain but that innovation in these factors will result in significantly better outcomes. The field study and systematic combining method utilized here allowed for a very detailed study of one inter-organizational setting and the

transformation that occurred over a ten year time period. This in-depth examination was critical to gaining a full and multifaceted picture of how innovations in the design of the health care supply chain impacts performance over time. The following paragraphs will discuss the insights gained with respect to the important measurement items for each of the 3-A constructs and their interrelationships with each other and the outcomes of the supply chain.

The analysis of the affordability construct shows that there are several key dimensions that range from the necessity of cost saving and discounting on the part of the hospital to the essential nature of government funding through grant or public insurance options and additionally through charitable giving from outside sources. The most interesting finding about affordability is that while it is not enough by itself to create large volumes of quality care, an increase in the level of affordability will create key links within the framework that allow for an increase in access to health care as well as a positive effect on outcomes.

Awareness, while representing primarily the knowledge of the physicians and allied health workers in the care system, as well as the level and availability of training for these individuals, also has aspects related to the patient. These patient aspects are relevant to disease prevention and publicity as well as level of knowledge about disease symptoms and treatment options. Most importantly, innovations in the provider awareness dimension result in the strengthening of an important direct link between the level of system awareness and access. This construct is also tightly interconnected with the other elements of the 3-A framework and has a moderating impact on the link

between affordability and access as well as the link between access and the volume and quality of care.

While these other two constructs are essential to creating the vital connections in the framework, innovations in the access construct are vital to strengthening them. An innovation or significant investment in one of the key areas related to access results in strengthening the direct link from access to the volume and quality of care delivered. The access construct has dimensions that have been identified as specific to facilities, staffing and equipment as well as supply and medical devices available. Since this is the third of the innovations to take place in our study, there appears to be a significant complementarity effect of not only improved outcomes but a strengthening of all the links in the 3-A framework with this innovation.

3.7 Conclusion

In conclusion, this study has demonstrated that the elements of the 3-A framework are interrelated and that an innovation in one of them will result in changes to the overall system. These insights into the connections between the elements of the 3-A framework taken together provide a new perspective on the way in which we can influence the outcomes of health care systems in underserved communities. There has been significant debate in the literature on the benefits and drawbacks of a single field study from which significant conclusions are drawn. In this case, we feel that a single inter-organizational context was the appropriate setting because the nascent theory in this area requires the in-depth examination of both qualitative and quantitative data (Edmondson and McManus 2007). Additionally, the use of similar field study techniques has effectively uncovered

both process and theoretical insights in other contexts (Volkoff, Strong and Elmes 2007; Dibbern, Winkler and Heinzl 2008). We believe that the presented conceptual framework will have a much greater scope of generalizability including other knowledge-intensive service supply chains for emerging economies.

This chapter contributes to theory in the areas of global supply chain management, service supply chain management as well as innovation diffusion, new service introduction in health care and construct measurement. This study develops a conceptual framework for understanding the dynamics of a global supply chain in emerging economies and provides a framework of constructs essential to the distribution of goods and services in these settings. Additionally, the study details a framework for designing health care supply chains to deliver cost-effective quality care for underserved communities, whether they exist in emerging economies or fully developed nations. This research also creates a substantive and effective way to measure innovations related to affordability, awareness and access in a health care supply chain. In specific, the conceptual framework developed in this study begins to address the need for more research which is specific to the service sector supply chain and identifies and builds constructs to help measure the important coordination dimensions relevant to services.

It is the aim of the 3-A framework to provide guidance for health care providers in how to direct their innovation initiatives to grow their ability to provide health care in underserved communities. In particular, this study highlights the importance of considering access and awareness constructs in addition to affordability when implementing efforts to improve care delivery in emerging economies. The results of this

study are encapsulated in an intuitively appealing framework which presents a clear connection between the 3-A constructs and the volume of quality care delivered. These insights provide a practically relevant framework for medical professionals to apply in their medical volunteerism and humanitarian outreach efforts. This framework can provide some compensation for the lack of formal training in business tactics or health administration that might slow or disrupt these efforts when undertaken by individuals trained only in medical practices.

The panel data utilized in this study were limited by the timing of the interviews involved. Ideally, we would have conducted interviews over the course of the ten year partnership and thereby have been able to examine the responses of the hospital and the volunteers over time. Since this was not possible, we have mitigated this weakness by conducting the analysis both with only the archival documents, as well as, by including all data; archival documents, interview data, and observational data. In both cases, the conclusions drawn from the analysis were identical. The interview and observational data were valuable in that they provided a more human connection to the evidence about the changes in the health care supply chain for this particular hospital.

This research can be used as a springboard for a series of broader studies that determine the generalizability of the proposed 3-A framework for guiding the design of supply chains for health care and other relevant knowledge intensive services. In additional work, we will attempt to learn more about the phenomena observed and to broaden the applicability of the 3-A framework by examining it in more diverse settings. In other studies, it will be interesting to further explore these linkages in the 3-A

framework over multiple supply chains that function in additional countries. Another interesting question for further investigation is whether there are significant sequential effects of implementing innovations in the 3-As of the framework. And, finally, it would be enlightening to examine how to apply the 3-A framework to other sectors of the emerging economies which utilize similar knowledge intensive services, such as technology providers, consultancies, and research and development organizations.

Chapter 4

4.1 Introduction

The objective of this chapter is to empirically test the integrated framework developed in the previous chapter. This empirical examination of the framework is the next step in achieving the overarching goal of this dissertation to develop a design for the health care supply chain based on the coordination constructs of access, awareness and affordability that increases the quality and volume of care in underserved communities by connecting the development to the delivery of care. Specifically, we test the proposed relationships among the coordination dimensions of affordability, awareness, and access in the health care supply chain, and their relationship to the quality and quantity of care delivery. The second study is motivated by the following question:

What is the impact of innovations in affordability, access and awareness on the performance of a health care supply chain in underserved communities?

The need for greater efficiency and increased treatment volume while stabilizing costs in the health care industry is more evident than ever. The 3-A framework has been proposed to help in our understanding of the design of the health care supply chain as well as to show how innovations in the health care supply chain impact the outcomes in terms of the number of patients served and the quality of the care that they receive. In this study, we examine relationships in one particular supply chain from a patient perspective and show empirical evidence of the impact of changes in the coordination elements of the health care supply chain.

The premise of the 3-A framework is that the delivery of a service hinges on the three coordination constructs of awareness, access and affordability in the supply chain. These constructs appear and have applicability at various levels in the supply chain from the organization or hospital level, to the operational unit or department level, as well as the individual or patient level. The delivery of a particular service offering is a complicated undertaking requiring that attention is given to both the service itself as well as the requisite goods in the form of supplies, devices or equipment which are required to deliver that service. In this particular study, we examine the introduction of a new service to a specific hospital. We study this new service introduction and the development of the service delivery process over a ten year period and examine the changes in the supply chain design and how those changes increase the service volume and therefore the total treatment volume available to the community population.

The connections between the elements of the 3-A framework have been proposed in the conceptual model which was developed and presented in chapter 3. See Figure 3-4 for the final integrated framework. This study will operationalize these constructs and examine the hypothesized relationships between them utilizing the available empirical evidence. The proposed relationships in the supply chain have been described in chapter 3, and ultimately each of these constructs exerts an influence on care delivery at the level where patients contact the system. Therefore, the service delivery process results in the delivery of a particular health care service from diagnosis through treatment and determines the capacity of the system.

In reviewing the literature relevant to bridging the gap between the demand and supply of high quality and cost effective care, we found that proven treatments exist for many of the chronic disease conditions in question (World Health Organization 2005; Murray et al. 2002). In spite of this, many patients who could benefit from these proven treatments remain untreated or inadequately treated (Evans et al. 2003; CIA 2007). The disparities across patients with disease conditions for which there is a proven treatment are now so significant that the World Health Organization (WHO) has issued a call for action asking that increased emphasis be placed on the appropriate use of proven treatments for everyone with treatable disease conditions (Mackay and Mensah 2004).

From the standpoint of health care supply chain design, we posit that one effective way to answer such a call for action is found in further examining the role of the three critical coordination dimensions of the service supply chain: *affordability*, *access*, and *awareness*. The rest of this chapter is organized as follows; in section 4.2 we present an overview of the conceptual foundation for the 3-A framework of health care supply chain design. It then presents the hypothesis to be tested in this study and introduces the data which will be utilized. This data is from the CHL-FHLU partnership which was described in chapter 2. In section 4.3 we describe the research design including the operationalization of the constructs in the empirical analysis. Section 4.4 presents the results of the analysis. At the end of the study, section 4.5 summarizes the conclusions and section 4.6 discusses the contribution of the results to theory and practice.

4.2 Conceptual Foundation

This dissertation research builds upon the conceptual foundation laid in Sinha and Kohnke (2009) which outlines the significance of the supply and demand gap between the development of care and the delivery of care. The idea that health care services are an integrated bundle of service, good and experience that must be carefully managed around a disease-centric care plan is foundational to the work in this dissertation. This study will continue to build an end-to-end, supply chain-centric view of the health sector as we posit ways to connect care development to delivery in underserved communities around the world. Sinha and Kohnke (2009) also introduced the constructs of affordability, awareness and access with respect to a device centric health care supply chain and began to conceptualize a framework of how they interrelate. This dissertation has reviewed these constructs and undertaken the task of developing definitions and measurement items for them based on empirical evidence from one particular health care supply chain. This chapter will empirically examine the proposed 3-A framework using the definitions and measurement items from chapter 3. This will help us to understand the validity and strength of the proposed relationships in the 3-A framework of the health care supply chain.

In the existing literature, there have been only a few studies that have attempted to develop supply chain theories that are specific to the growing service sector (Johnston 2005; Roth and Menor 2003a; Roth and Menor 2003b). Although a number of studies have attempted to apply principles and frameworks from the manufacturing sector to the service sector (Sengupta, Heiser and Cook 2006; Akkermans and Vos 2003; Vandaele and Gemmel 2007), in contrast other research has emphasized the uniqueness of the

service supply chain and called for more studies which account for these unique factors (Sampson 2000; Youngdahl and Loomba 2000; Cook, DeBree and Feroletto 2001). At the same time other scholars have called for research on supply chain management with specific considerations of industry and operating environment (Beckman and Sinha 2005; Diniz and Fabbe-Costes 2007; Babbar et al. 2008; Baltacioglu et al. 2007). This study builds on this nascent field of service supply chain management by providing an empirical test of a proposed new conceptual model, called the 3-A framework, which is applicable to health care supply chain management.

In developing this framework, the authors leveraged insights from the lenses of quality management, organizational learning and innovation diffusion. The organizational learning literature, in particular the knowledge development and information dissemination dimensions have been shown to play an important role in organizational and supply chain performance (Linderman et al. 2004; Hult, Ketchen and Arrfelt 2007; Hult et al. 2006; Hult, Ketchen Jr. and Slater 2004; Hult, Ketchen Jr. and Nichols Jr. 2003) Similarly, the quality management literature has delved into the role and impact of quality improvement initiatives in improving both processes and products which in return has a positive impact on financial performance (Benner and Tushman 2003; Benner and Tushman 2002; Douglas and Judge Jr. 2001). These quality management tools have been extended to applications in the supply chain which have been shown to have significant impact (Yeung 2008; Foster 2008; Kaynak and Hartley 2008; Flynn and Flynn 2005), but the theory in this area is still at a nascent level of development. Finally, the literature on the diffusion of innovations provides a well developed theoretical lens for the examination of how rapidly a new service or product

should be adopted in a particular market (Rivera and Rogers 2006; Rogers 2003; Lazarsfeld, Berelson and Gaudet 1949). This study will contribute to the literature on service supply chain management by empirically testing a framework of the key coordination mechanisms in the supply chain which was generated by drawing upon insights derived from the organizational learning, quality management and innovation diffusion literature.

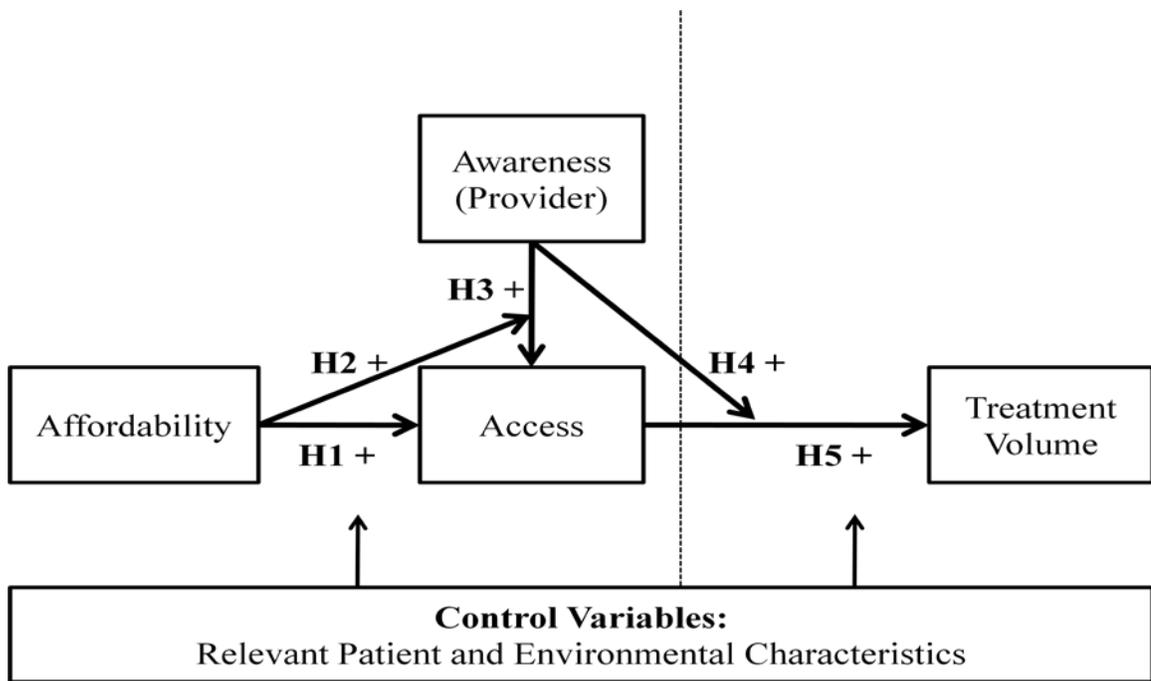
This new conceptual model, the 3-A framework, proposes a way to understand and view efforts to improve the design of the health care supply chain and consequently the health care delivery network for underserved communities around the globe. This study is an empirical examination of how changes to each of the dimensions of affordability, awareness and access cumulatively affect the volume of care provided by the health care service delivery system. Specifically, we will describe innovations in the affordability, awareness and access constructs and hypothesize how those changes will ultimately affect the patient's ability to receive quality care. This study will allow us to begin to establish some validity for this model and provide insights into how we can influence the number of patients receiving care through the health care supply chain. Figure 4-1 depicts the proposed relationships in the health care supply chain and the rest of section 4.2 will present the specific hypotheses depicted in the framework.

4.2.1 Affordability

A patient's interaction with the health care delivery system begins with their interest in seeking care. In many cases, the propensity of a patient to seek care will be a function of that patient's financial ability to pay for care, their knowledge of the symptoms and

indications of their disease condition, as well as their proximity to facilities that are capable of delivering the care needed (Braine 2006; Farrell 2006; Ofoi-Adjei 2007). In many cases, and especially in the emerging market setting of this study, the financial considerations are dominant in the patient's decision to seek care (Braine 2006; Ofoi-Adjei 2007; Gaziano et al. 2006, 645-662).

Figure 4-1 3-A Framework for Health Care Supply Chains



So, for the sake of this study, we will examine the affordability construct as representative of the payment system which allows the individual patient to gain access to health care and begin to break the cycle of poverty and poor health (Ofoi-Adjei 2007). From the patient's standpoint, if an assumption is made that they possess awareness (knowledge of the existence of a care network with trained staff) and access (physical proximity of the care network), then the final hurdle to receiving health care is whether or

not they have the financial capability to pay for the needed treatment. In most health systems around the world, the patient's ability to pay for care is a prerequisite to receiving the diagnosis and treatment that is necessary (Braine 2006; Ofoi-Adjei 2007). In the 3-A framework, this requirement is depicted by the proposed direct effect of affordability on access. Without an initial and fundamental ability to provide recompense for services rendered most patients are unable to receive any treatment. Thus, we posit:

Hypothesis 1 (H1): Affordability is positively related to access.

Along a similar line of reasoning, once a patient has been physically admitted to a care delivery facility for treatment, then effective treatment is not guaranteed to take place. In fact, in addition to a patient's ability to provide financial remuneration for services rendered, they must have the ability to access a provider with a sufficient level of knowledge and skill in the particular ailment from which the patient suffers. Therefore, the patient's ability to pay in combination with the provider's level of knowledge will influence whether or not the health care system has the ability to produce the correct diagnosis and trigger the appropriate treatment. Based on this argument, we propose the following hypothesis.

Hypothesis 2 (H2): The relationship between awareness and access is moderated by affordability, such that awareness has a greater positive impact on access as affordability is increased.

4.2.2 Awareness

The awareness construct in this study will be operationalized to reflect the provider side of the awareness construct only. The nature of the setting for the study focuses on the supply side of the health care service delivery by attempting to enhance the

capabilities of the providers in the health care system with very little emphasis on enhancing the patient awareness in the community. The previous hypothesis presumes a direct relationship between the level of provider awareness in the health care supply chain and the level of access or the capacity of the supply chain. The level of provider awareness refers to the skill set and knowledge base of the health care providers in a given health care facility. This can be thought of as the system capability, its ability to provide the service that the patient is seeking. Provider awareness in our study will be the only element of the awareness construct that is changing; patient awareness is assumed to be constant. The FHLU site prior to 1999 did not have the capability to provide treatment for congenital heart conditions even when a patient with that specific disease and the ability pay for health care services came to their hospital for treatment. After the partnership with CHL and the increase in the level of provider awareness in the supply chain, the FHLU site did then have some capability to provide care for congenital heart conditions. Stated formally:

Hypothesis 3 (H3): Awareness is positively related to access.

In an important way, the level of access is also linked to the level of provider awareness in the health care system in order to realize the actual delivery of care. In a sense, the provider awareness of specific treatments or interventions must occur in combination with the existence of the physical infrastructure of the necessary supplies and equipment in order to then result in realized capacity, which, in the health care setting, is the effective treatment of patients. This ability for staff to use their new knowledge in ways that capitalize on the existing potential capacity of the health care delivery system is posited in the following hypothesis:

Hypothesis 4 (H4): The relationship between access and treatment volume is moderated by awareness (provider), such that access has a greater positive impact on treatment volume as awareness (provider) is increased.

4.2.3 Access

Finally, the potential capacity of the health care delivery system can be seen through the access dimension of the health care supply chain. In this study, access is viewed as a basic potential capacity which includes such tangible aspects as the size of the building, number of beds, volume of diagnostic and treatment equipment, the supply of blood in the blood bank and the availability of supplies such as clean syringes and IV tubing. The existence of this type of capacity for the system to treat patients is essential to the ability of the health care delivery system to provide care for any patient. For this reason, the access construct is theorized to mediate the relationship between the affordability and awareness constructs and the treatment volume for the system. Put more formally:

Hypothesis 5 (H5): Access is positively related to treatment volume.

4.3 Research Design

To test these hypotheses, the data gathered from the CHL and FHLU partnership was utilized. The research approach and data collection were presented in chapter two of this dissertation. The data for this particular study was extracted from the both the qualitative and quantitative study data for the purposes of an initial measurement and testing of the 3-A framework. As described, one of the purposes of this research was to determine and develop the appropriate measurement items for the constructs in the framework. Therefore, in testing the framework these identified items are used to measure the respective constructs. Part of the data used in the analysis in section 4.4 comes from

coding the extensive qualitative data set. Also used for the analysis is quantitative patient level data provided by CHL to aid in understanding the progression of the difficulty of surgeries over the nine year partnership. This patient level data allowed us to increase the sample size while still examining the unit level constructs of affordability, provider awareness and access. These unit level measures were generated from the qualitative data analysis and then imputed to the individual patient level, thereby gaining a sample size of 152. In the following sections, the sample and the measurement for each of the constructs will be described. Finally, the control variables used in the course of the study are listed and the reason for their importance is given.

4.3.1 Dependent Variable

For this study, the most relevant and available measure of the improved efficiency of the health care supply chain is the volume of surgeries performed by the unit at the FHLU site. Therefore, the dependent variable used in the analysis is the raw volume of surgeries performed by the unit in a given year. This variable was not normally distributed, and, therefore, a log transform of the raw annual volume of surgeries was used for the analysis. Because of the necessity of combining unit and patient level measures in this analysis, for each individual patient in the data set of 154 patients, the outcome is the total surgeries performed during the year of their treatment. The total surgical volume is the only outcome variable examined because the in-hospital mortality rate was too low overall to facilitate an analysis of the quality of care as a dependent variable. However, for all the analyses performed in this dissertation, the mortality rate is

included as a control variable to ensure that a decrease in quality of care (i.e. increasing mortality rate) was not a significant predictor of the increase in treatment volume.

4.3.2 Independent Variables

For the independent variables, the measures were generated from the qualitative data that was collected. The analysis in chapter 3 describes the extensive process of coding and review that was undertaken for the identification of each construct and the items that are used to form these constructs. For the constructs of affordability, awareness and access the measures used in this study are generated from counts of mentions of specific items which represent the identified dimensions of each of these constructs in the qualitative data. Therefore, for each construct there are two or three items for which there is an annual count of references in the data. The items that are included for each of the constructs will be described in detail in the following sections.

In order to combine these items into an aggregate reflective score for the 3-A constructs, it would have been ideal to run a factor analysis to ascertain if the items did indeed load on the respective construct and form reliable and valid measures. Because the sample size for the unit level data was limited to 10, with one score for each year of the partnership, the output of a factor analysis was not considered usable. However, to explore the cohesiveness of the construct items a factor analysis was conducted. Before this could be done, the scores for each of the items were examined for normality, and a transformation was applied if necessary. A detailed list of the items, their descriptions and the transformations used is presented in Appendix 4-1.

With these items identified and descriptive statistics calculated (see Table 4.1), a principal components factor analysis was undertaken and resulted in reasonable construct reliability scores and item loadings. The statistical calculation process for a principal components analysis will work with a sample size of 10 but the reliability of the results is questionable. For this reason, the factor scores generated from this factor analysis were not used in the analysis. As an alternative, that provides more reliable scores, the variables used for each construct were calculated using a mean score of each of the items identified. Therefore, for each of the 3-A constructs, the items scores were summed and then divided by the number of items. Further empirical analysis was performed using these means scores instead of the factor scores. However, as a robustness check, the same analysis was performed with the factor scores and the results obtained were consistent.

Table 4-1 Descriptive Statistics and Correlations

Variable	Mean	s. d.	1	2	3	4	5	6	7
1. Aff. Charity	8.36	7.54							
2. Aff. Government	6.09	5.59	.729*						
3. Aff. Self	2.73	3.26	.652*	.731*					
4. Awa. TrainLT	10.55	8.85	.286	.470	.380				
5. Awa. TrainPrac	12.73	10.86	.427	.252	.673*	.477			
6. Awa. TrainConc	6.18	4.31	.398	.393	.510	.797**	.681*		
7. Acc. SupDevLoc	6.82	5.29	.466	.697*	.786**	.780**	.688*	.805**	
8. Acc. FacCapSt	10.45	13.03	.195	.286	.715*	.575	.860**	.649*	.790**

The affordability dimension of an individual patient's ability to seek care is represented in our data by three unique items that reflect the origin of their payment ability. In the development of the affordability construct, we identified specific items

that reflected innovations in how the payment for care was met. These identified items were charitable sources, government sources and individual funds. These three items capture any significant changes in the way that patients paid for care during this study. The first item included is the government financing. This includes any references to government payment for particular conditions or procedures, cost savings policies implemented within the hospital and discounting for services provided. The hospital involved in the study was a provincially sponsored institution so the discounting of services to poor patients and the use of various cost saving mechanisms to increase the affordability of care are considered government related interventions.

The second aspect is the self-provided financing or the out-of-pocket expenses for the patient. The patients utilized various mechanisms of funding to make sure their family member received the necessary care. These included the negotiation of payment plans with the hospital to spread out payment for the treatment received. It also included borrowing in the form of private loans from family members or friends in their community to help pay for the care received. Finally, another significant element of this affordability dimension for patients is the frequent delay before seeking care until the funds needed could either be saved by the family or borrowed from other sources. Therefore, patients frequently delayed treatment and, in some cases, even diagnosis because of affordability concerns. This delay, for this particular disease category, increases the complications and risks of the treatment.

The third aspect of the affordability measure is the factor of charitable giving. The presence of an international organization like CHL brings with it a certain amount of

funds which are allocated to be used for providing treatment to needy families. The charitable sources were an important infusion of payment in this particular setting and this item includes references to any funds donated to the hospital unit to be used to pay for treatments of patients who were in dire financial need. These funds were typically from sources outside of the country and were available for the majority of the timeframe covered by this study. The Cronbach's $\alpha = 0.823$ for these three items of charitable sources, government sources and individual funds.

The awareness construct is also composed of three items. Because of the setting of this particular research, the awareness construct is focused entirely on the provider dimension and does not reflect patient awareness. The work done by CHL at the FHLU site was primarily directed at increasing provider awareness because of the total absence of the ability to provide this service in the hospital. The demand for this service is so great in this particular province of China that there was a steady stream of patients asking for treatment and therefore an immediate increase in patient awareness was not necessary. The items used to reflect the provider awareness are centered on two categories of training. The first is long-term training, what we define as training endeavors that endure for a length of 6 months or longer. The other is short-term training which encompasses all those training efforts that have a duration shorter than 6 months. These short-term training efforts are further sub-divided into those which concentrate on conceptual learning and those which are more practical skill oriented. These two types of training were often distinguished as important elements of the efforts CHL provides at the partner site. These three items resulted in a scale with a Cronbach's $\alpha = 0.703$.

The access construct has two items and a Cronbach's $\alpha = 0.854$. Similar to the awareness construct, the items used for this measure were split by the elements that have more short-term applicability or are disposable and those that are long-term or concrete. The short-term elements included the supplies used and medical devices necessary for particular treatments. The other dimension included references to the facility itself along with staffing considerations and the capacity of the combined facility and staffing. The descriptive statistics and correlation matrix of the final construct measures for the 3-As calculated with the mean item scores is presented in Table 4-2.

Table 4-2 Descriptive Statistics and Correlation Matrix for Constructs

Variables	Mean	s. d.	1	2	3
1. Affordability	5.73	4.93			
2. Awareness	1.56	0.66	.519		
3. Access	0.67	0.38	.578*	.698**	
4. Volume	5.67	0.59	.288	.265	.537*

4.3.3 Control Variables

The control variables in this study are many of the same which are used in other health care studies. These controls are used because the literature has shown an impact of patient and treatment characteristics on patient outcomes as well as the volume of treatment that can be performed (Cleary et al. 1991; Kane, MacIejewski and Finch 1997; Young, Meterko and Desai 2000; Powers and Bendall 2004; Katz et al. 1996). In our data, the essential control variables for the patient included age and gender (Cleary et al. 1991; Kane, MacIejewski and Finch 1997). The treatment factors deemed important were the frequency of treatment for a particular procedure by the cardiac unit, the difficulty score (RACHS) for that treatment, and whether or not the treatment was

performed while a mission team was present (Kane, MacIejewski and Finch 1997; Young, Meterko and Desai 2000). For each patient in the dataset, the type of treatment was noted and the relative volume of that particular treatment for the unit in that given year was included (Farley and Ozminkowski 1992; Luft et al. 1990). Additionally, the data allowed for the inclusion of an indicator variable for whether the patient was given treatment during a training mission or at some other point in the year. This control was included to account for the possible impact of the missions that occurred almost every year. Finally, we also included considerations for the RACHS difficulty scale categories, 99% of the surgeries fell into categories one through three. Consistent with other studies, for the final analysis we did not include the patient gender because there was a lack of any significant variation in this category. Almost the entire sample of 152 patients was only one gender (Weinberg et al. 2007).

4.3.4 Model Specification

The hypothesized relationships in the 3-A framework represent a system of equations which accounts for the impact of affordability and awareness on access and the subsequent impact of access on the volume of surgeries. Therefore, the empirical analysis is performed in two stages utilizing the 2-stage least squares (2SLS) regression procedure to estimate the models. The described controls were entered into the model in both stages. We chose to use a 2-stage least squares (2SLS) approach to this empirical estimation because the sample size was not large enough to allow for a structural equation model approach. The general form of the 2-stage model specification that will be used to test the hypotheses is represented in equations (1) and (2).

(1) Stage 1:

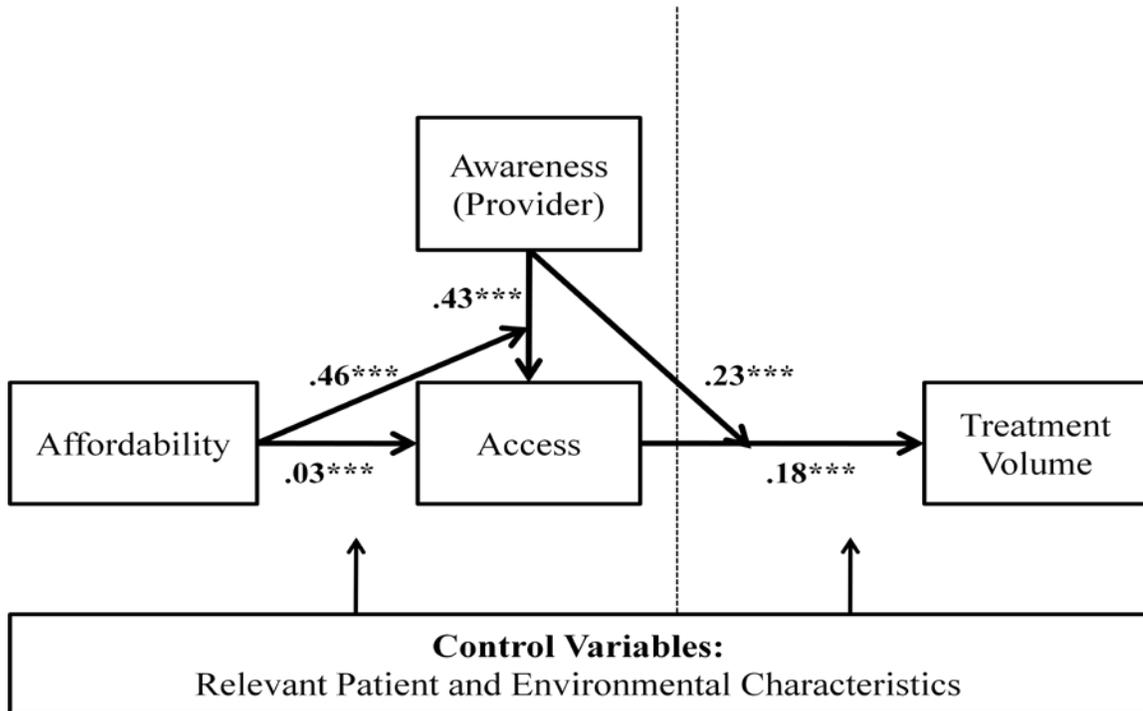
$$\begin{aligned} Access = & \beta_0 + \beta_1 \%Diag_t + \beta_2 Mort_t + \beta_3 Age_t + \beta_4 Mission_t + \beta_5 RACHS2_t + \beta_6 RACHS3_t \\ & + \beta_7 Affordability_t + \beta_8 Awareness_t + \beta_9 Affordability_t * Awareness_t \\ & + \varepsilon_t \end{aligned}$$

(2) Stage 2:

$$\begin{aligned} \ln(Volume_t) = & \beta_0 + \beta_1 \%Diag_t + \beta_2 Mort_t + \beta_3 Age_t + \beta_4 Mission_t + \beta_5 RACHS2_t \\ & + \beta_6 RACHS3_t + \beta_7 PredictedAccess_t + \beta_8 Access_t \cdot Awareness_t + \varepsilon_t \end{aligned}$$

The first stage of the analysis, shown in equation (1) will test hypotheses 1- 3 which involve the influence of affordability and awareness on access. The second stage (equation 2) will examine hypotheses 4 and 5 including the influence of access on the number of pediatric heart surgeries performed. In performing the estimation of these models, a robust OLS command or one that uses Huber-White estimators was used. This empirical estimation procedure is used when it is necessary to relax the assumption that the data are independent and identically distributed and when data may violate the assumptions of normally distributed error terms (Kutner et al. 2005). The use of robust OLS is recommended to be used as a confirmation of the reasonableness of an OLS model and if the results are similar then outliers are deemed not to be a problem in the data. Finally, it is recommended that robust regression be used with bootstrapping to confirm the robustness of the results. Therefore, to confirm the statistical significance of the model coefficients we employed a bootstrapping method with replacement using 250 samples from the dataset. We also ran the bootstrap method with 500 and 1000 samples and found that the significance levels for each of the coefficients were stable across each of the runs (Kutner et al. 2005; Rosenzweig 2009; Efron and Tibshirani 1993).

Figure 4-2 OLS Results for Hypothesized Framework



4.4 Results

The results of the empirical models for both stages of the analysis are presented in Table 4-3. The first stage model shows both the effects of the control variables on the access construct as an outcome but also the main effects of the affordability and awareness constructs. This first OLS model shows that there is a positive direct effect of affordability on access ($\beta = 0.0306$, $p < .01$). Though this direct effect is small, it is significant, providing support for hypothesis 1. Similarly, the model shows a positive direct effect of awareness on access ($\beta = 0.4325$, $p < .01$). This supports hypothesis 3 which proposed that an increase in the capability of the service providers would increase the potential capacity of the system. The final hypothesis tested in stage one was the second, which proposed that there would be a moderating influence of affordability on

the relationship that between awareness and access. This hypothesis was supported with the positive coefficient for the interaction term between the affordability and awareness measures ($\beta = 0.4637$, $p < .01$).

Table 4-3: Empirical Results

<i>Independent Variables</i>	2-Stage Ordinary Least Squares							
	Stage 1: Outcome: Access				Stage 2: Outcome: Treatment Volume			
	No Interactions		Interactions		No Interactions		Interactions	
<i>Constant</i>	0.2447	**	-0.4492	***	2.4448	***	2.3452	***
<i>% Diagnosis Yr</i>	0.1230	*	0.1434	**	-0.1488	***	-0.0902	***
<i>Mortality</i>	0.0642		0.0783		-0.0429		-0.0030	
<i>Age</i>	0.0021		0.0060	***	-0.0059	***	-0.0041	***
<i>Mission Case</i>	0.0617		0.0909	**	-0.1079	***	-0.0799	***
<i>RACHS1</i>	-0.0685		0.0439		-0.0970	***	-0.0662	**
<i>RACHS2</i>	-0.1444	*	-0.0731		0.0040		0.0040	
Affordability	0.0216	***	0.0307	***				
Awareness (Provider)	0.1747	***	0.4301	***				
Affordability x Awareness			0.4614	***				
Access					0.2674	***	0.1835	***
Awareness x Access							0.2321	***
<i>R²</i>	0.4303		0.5528		0.3924		0.6293	
<i>F</i>	19.25	***	25.15	***	15.41	***	38.26	***
<i>N</i>	152		152		152		152	

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Note: Analysis conducted with Huber-White standard errors. Coefficients reported from robust regression results and significance after bootstrap with 250 replications.

Consistent with the first stage model just discussed, the second stage model presented in Table 4-3 was also estimated using OLS and robust standard errors. This model has the treatment volume as the dependent variable and also includes all the same control variables as the first stage model. In this model, we find support for hypothesis 5 in the significant positive effect of access on treatment volume ($\beta = 0.1842$, $p < .01$).

Additionally, we find that the moderating effect of the awareness construct on the relationship between access and treatment volume is also supported. Hypothesis 4 predicted a positive relationship between the interaction term of awareness and access on

volume. This hypothesis is supported by the coefficient for this interaction term in the second stage model ($\beta = 0.2287$ $p < .01$). Figure 4-2 illustrates the results of this analysis.

Table 4-4 Empirical Results: Fixed Effects

<i>Independent Variables</i>	Fixed Effects Models					
	Stage 1: Outcome: Access			Stage 2: Outcome: Treatment Volume		
	No Interactions		Interactions	No Interactions		Interactions
<i>Constant</i>	-0.0814		-0.6209 ***	2.4228 ***		2.3419 ***
<i>% Diagnosis Yr</i>	-0.0322		-0.0550	-0.0343 *		-0.0139
<i>Mortality</i>	0.0256		0.0072	-0.0086		0.0115
<i>Age</i>	-0.0009		-0.0003	-0.0008		0.0000
<i>Mission Case</i>	0.0472		0.0036	-0.0103		-0.0013
<i>RACHS1</i>	-0.1014 *		-0.0766	-0.0145		-0.0001
<i>RACHS2</i>	-0.1149 **		-0.0692	-0.0058		-0.0015
<i>Affordability</i>	0.0188 ***		0.0518 ***			
<i>Awareness (Provider)</i>	0.4785 ***		0.5424 ***			
<i>Affordability x Awareness</i>			0.7585 ***			
<i>Access</i>				0.0465 **		0.0374 *
<i>Awareness x Access</i>						0.1613 ***
<i>R² within</i>	0.6742		0.8533	0.086		0.669
<i>R² between</i>	0.1014		0.335	0.9466		0.9445
<i>R²</i>	0.3854		0.4139	0.3853		0.5446
<i>Groups</i>	4		4	4		4
<i>F</i>	36.21 ***		89.82 ***	1.89 *		35.36 ***
<i>N</i>	152		152	152		152

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Note: Analysis conducted with Huber-White standard errors. Coefficients reported from robust regression results and significance after bootstrap with 250 replications.

4.4.1 Additional Analysis for Model Robustness

In addition to the 2SLS analysis, an additional analysis was run to test the robustness of the results. Since the data on these constructs was collected over a 10 year time-frame, a fixed effects analysis was estimated to account for the time dimension in the data. The data was segmented into phases relevant to when major changes took place in the

constructs of interest. For details on how these phases were identified, see the discussion in Section 3.4.2 and summary in Table 3-2.

A 2-stage fixed effects analysis was then undertaken with four groups, representative of these four phases in the partnership. These models were significant and the majority of the hypotheses were supported as was the case with the 2SLS model in the previous section. Table 4-4 presents results for the fixed effects analysis. The positive direct effect of access on treatment volume is only marginally supported with significance levels just over 0.1 in the bootstrap analysis.

4.5 Discussion

The empirical analysis in this study provides strong evidence that there are important relationships between the constructs in the 3-A framework. However, the results of this work must be understood in the light of the limitations of this research. Given the nascent stage of theory development in this area of health care supply chain, the data for this study was collected from one particular health care delivery system and indeed from one specific unit of that system which specialized in the treatment of a particular disease category. While this is a limitation of the research, this approach has allowed us to understand the phenomenon in much greater detail. For instance, we concluded that the realized capacity of the health care delivery system will be a function of the levels of affordability, awareness and access in the health care supply chain and that these levels of the 3-As are going to change based on the innovation and improvement initiatives undertaken by the organizations that make up the health care supply chain. The FHLU facility partnered with the CHL organization precisely to help them to innovate in the

level of awareness for their own health care delivery system and through the course of the relationship this partnership spurred additional innovations in affordability and access.

In fact, this study reveals the interrelatedness of these three constructs in how they influence patient treatment volume in a health care system.

Hypothesis 1 asserted that the individual patient's ability to pay for treatment would have a significant influence on the access construct. This was strongly supported in all forms of the analysis and although the direct effect of affordability on access did not have a large coefficient (0.03, $p < 0.01$), it did come out statistically significant. In fact, a surprising result of this study was that the most important impact of changes in affordability appeared to be through the moderating influence of these changes on the influence of awareness on the access construct. The coefficient for this effect was not only strongly significant, but also of much greater magnitude at 0.46 with a p-value less than 0.01. This result leads to the conclusion that although affordability in and of itself is a very important piece of the health care supply chain, the impact of changes in affordability will always be closely tied to the level of innovation in the awareness construct.

The premise of Hypothesis 3 stated that there should be a significant direct impact of innovations in the level of provider awareness on the potential capacity or access of the health care delivery system. This hypothesis was strongly supported and bears out the argument that increasing the capability of the provider network will increase the potential capacity of the entire system without any significant physical infrastructure changes. The magnitude of this effect (0.43, $p < 0.01$) is most likely due to the fact that the primary

goal of the CHL partnership with FHLU was to increase the provider awareness in the system. Similarly, support was found for Hypothesis 4 which posited a moderating effect of these increases in provider awareness on the ability of the system to realize the capacity that was generated. The large positive effect (0.23, $p < 0.01$) had a strong influence in all models and in fact, has a stronger influence than the direct impact of access on treatment volume. The direct effect of access on treatment volume as hypothesized was also found to be significant, although not as large as was initially expected (0.18, $p < 0.01$).

4.6 Conclusion

Drawing on the 3-A framework, which was developed based on the literature in supply chain management, quality management and health care management, this study provides evidence of the validity of this conceptual framework in the context of developing new services in emerging economies. By investigating the framework in-depth in a specific inter-organization context, this study has allowed us to show initial evidence of the existence of the links between the constructs. It contributes to supply chain management theory by enhancing our understanding of the applicability and viability of this framework for designing supply chains that facilitate the introduction of new services in emerging economies. In addition, it empirically operationalized measures for provider awareness, access, and affordability that can be used in future studies of a similar nature.

For practitioners, both in the medical professions as well as health care administration, this study gives strong support for the impact of training efforts, both

long-term and short-term, on the improvement of outcomes in a health care system. It also emphasizes the magnitude of the inter-relatedness of the 3-A constructs and provides a strong case for simultaneously considering how to change the knowledge level, financial, and infrastructural elements of the health care supply chain as new services are introduced into an underserved community.

This study is limited by the fact that it is a field study conducted in the context of one inter-organizational setting in an emerging economy. However, the value of the opportunity that this type of study provides for an in-depth examination of a dynamic and evolving relationship over a long time period was deemed to outweigh the drawbacks. Another limitation is the limited operationalization of the awareness construct. Because of the nature of the field study and the resultant availability of data, this study only tests the impact and influence of provider awareness in the framework. Although, patient awareness is defined in the measurement sections of chapter three, there was not enough data on this construct to further pursue the role of patient awareness in the empirical analysis. Therefore, the conclusions drawn with respect to the awareness construct should be carefully interpreted as providing insights for only the influence of an increase in long-term and short-term training opportunities for the care providers in the health care supply chain.

The next step in examining the validity of the 3-A framework is to expand on this work by studying more than one health care supply chain across multiple countries. By utilizing the measurement items and constructs developed in this dissertation, it will be easier to construct a survey instrument which will have a legitimate chance to accurately

measure and allow for the study of service supply chains in diverse geographic and economic settings. Another essential element of further studies will be to operationalize the patient awareness construct and explore the significance and influence of this construct in the 3-A framework.

Appendix 4-1: Variables and Descriptions

<u>Category</u>	<u>Name</u>	<u>Transform</u>	<u>Description</u>
Controls	Gender		Gender
	%Diagnosis mortality		% of active diagnosis for the current year 1 - death, 0 - healthy, 8 deaths in 152 patients (in-hospital)
	Age		influences difficulty
	RACHS Category		Represents difficulty for congenital heart surgery. Scale of 1-5 with 1 being easiest and 5 most difficult.
	Mission Phase		identify effects resulting from presence of foreign medical team, 1 - yes, 0 - no groups years into types of interventions
Affordability	AffGovtFin	Ln	encompasses references to government payment, cost savings, discounting and Represents part of the non-charitable efforts or considerations of affordability
	AffSelfFin	Ln	Payment plans and loans as well as general references to the patient's ability to pay for services. Represents part of the non-charitable efforts or considerations of affordability
	AffFdCd	none	contains references to the use of charitable funds for helping patients pay for services (primarily from outside country sources)
Awareness	AwaTrainLt	Ln	Involvement with in-country programs for improving knowledge and skills of local team, activities like internships or team visits for ≥ 6 months. Also includes other extended overseas training outside of local country
	AwaPracT	SQ	extent of involvement with foreign visiting teams using hands-on techniques for improving knowledge and skills of local team
	AwaConcT	$\ln(x+1)$	extent of involvement with foreign visiting teams using lecture/seminar for improving knowledge and skills of local team
Access	AccSupDevLoc	Ln	Encompasses medical devices and supplies relevant to medical care from local sources. The emphasis of this is on supplies.
	AccFacCapSt	$\ln(x+1)$	References to the state of the facility itself and includes specific references to the capacity and staffing of the facility.
Outcomes	Surgical Volume	Ln	The number of surgeries performed in a year by the cardiac surgery unit. An increase in this "rate of service" is a positive outcome for the hospital

Chapter 5

5.1 Introduction

The goal of this dissertation is to provide insights into the design of the health care supply chain based on the strategic coordination mechanisms of access, awareness and affordability and their relationship to the quality and volume of care in underserved communities by connecting the development to the delivery of care. The previous chapters of this dissertation have discussed the definition and role of affordability, awareness and access in the health care supply chain. The empirical analysis in the previous chapter has provided support for the fact that innovations in these supply chain mechanisms result in increased volume of quality care for individual patients. This chapter is a natural extension of the proposed and empirically tested 3-A framework. Specifically, the chapter will investigate the human roles and relationships across organizations in the health care supply chain and their impact on the ability of the supply chain to increase the volume of care for underserved communities. The question guiding our investigation is:

How does relational coordination (i.e., the relationships between human roles across partnering organizations in a health care supply chain) mediate the relationship between affordability, access and awareness and supply chain performance?

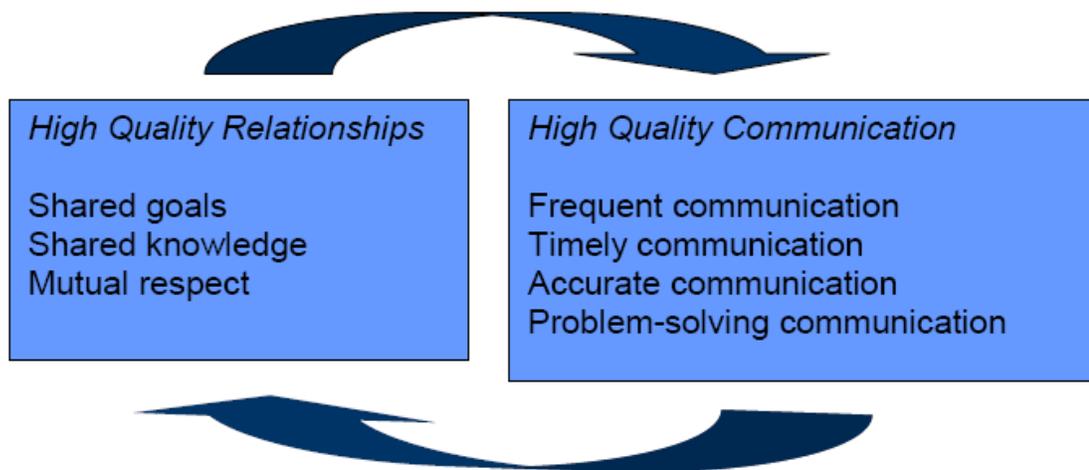
The theoretical lens that has the potential to aid in this endeavor to deepen our understanding of the design of health care supply chain is relational coordination. This theoretical lens will be used to build on the previous chapters by addressing how the supply chain coordination mechanisms of affordability, awareness and access are able to

have such an impact on the performance of the health care supply chain. Relational coordination will help in understanding the nature of the influence of human roles and relationships between partnering organizations in the supply chain. This particular approach was undertaken because the relational aspects of inter-organizational dynamics, which seem to affect supply chain performance and facilitate the delivery of care, are not well understood. In fact, the aim of this chapter is to more fully understand the network of work design issues that spans both multiple organizations and also multiple levels of authority within those organizations (Sinha and Van de Ven 2005). Sinha and Van de Ven (2005) have proposed the need for more grounded theory building efforts to investigate the nature of changing work practices within and between organizations in the increasingly knowledge-intensive industries that span organizational, country and cultural boundaries.

In order to investigate the importance of the relational aspects in the health care supply chain, we will utilize and expand the emergent theoretical perspective on the importance of relationships within organizations of relational coordination (Gittell 2009). Gittell (2002b, p. 300) defines relational coordination as “a mutually reinforcing process of interaction between communication and relationships carried out for the purpose of task integration, is expected to increase performance in settings that require improvisation rather than simple reliance on preprogrammed modes of action.” According to relational coordination theory, the quality and efficiency of the work being done in a fast-paced, demanding environment is dependent on the relationships involved, specifically the shared knowledge, shared goals and mutual respect between the workers along with the volume and characteristics of communication employed (Gittell 2009). As shown in

Figure 5-1, relational coordination theory presents the overall construct as two mutually reinforcing dimensions each of which has specific sub-dimensions, these dimensions are: (i) communication and; (ii) relationship. The relationship sub-dimensions are measures of shared goals, shared knowledge and mutual respect. The communication sub-dimensions examine the frequency, timeliness, accuracy or problem solving aspects of effective coordination. These seven dimensions have been examined within organizations to show the connection between how organizational design mechanisms work to improve organizational performance (Gittell 2002a; Gittell 2000; Gittell, Seidner and Wimbush 2010). Insights gained from this theoretical perspective should advance our understanding of how to improve the effective delivery of care through enhanced inter-organizational human roles and relationships in the supply chain.

Figure 5-1 Reinforcing Dimensions of Relational Coordination Theory



(Source: Gittell 2009, p. 20)

This study will argue that not only is relational coordination relevant within organizations for the improvement of performance, but it is also relevant between

partnering organizations in a health care supply chain. This perspective has been suggested by earlier work in the organizational theory area but has not been empirically tested (Gittell and Weiss 2004). In particular, this study will use relational coordination theory to examine how a medical outreach or assistance organization can enable organizations with which they “partner” to provide greater volumes of quality health care for their communities.

In specific, this research will apply and extend relational coordination theory in two distinct ways. The first will be accomplished by an examination of the evolution of the relational coordination construct in a network of human role and relationships across organizations. This will extend relational coordination theory by proposing how it can be influenced by supply chain coordination mechanisms and how it may impact the performance of a supply chain over time. Secondly, this study will leverage this understanding of the evolution of relational coordination and proceed to empirically examine the previously proposed mediating role of relational coordination in inter-organizational networks.

As a whole, this study will investigate relational coordination in the supply chain context to describe the functioning of relationships in an inter-organizational setting to improve supply chain performance. It is an examination of the development of a work system between the CHL and FHLU organizations which uses relational coordination as a theoretical lens to aid in understanding the dynamics of how work is effectively coordinated in an international and inter-organizational context. We propose that an understanding of the role that relational coordination plays in the health care supply chain

will provide answers to the question – how do the supply chain coordination constructs in the 3-A framework ultimately increase health care delivery for underserved communities?

The rest of this chapter will be organized as follows; section 5.2 will present a review of the current literature on organizational theory, relational coordination and coordination in networks. Section 5.3 and 5.4 will develop theoretical insights into the growth of the relational coordination construct in the supply chain and present insights into to the nature of this evolution. Sections 5.5 and 5.6 will present and empirically test a hypothesis of the role of relational coordination in the 3-A framework based on the insights gained from the examination of the network. Section 5.7 will present the results of the primary and alternative empirical analyses. Section 5.8 discusses the insights that were gained from the study and section 5.9 concludes by presenting the contributions to literature and practice as well as the limitations and future research possibilities.

5.2 Literature Review

The theory of relational coordination has emerged from efforts in many disciplines to define and understand the impacts of coordination between tasks or activities and people or their roles in systems (Malone and Crowston 1994). Coordination is a larger construct and in general terms: “Coordination is managing dependencies between activities” (Malone and Crowston 1994, p. 90). Relational coordination theory makes a deeper examination of the role of effective communication and how communication bolsters important relationship dimensions to create coordination among system roles within organizations (Weinberg et al. 2007b; Gittell 2006, 74-94). Relational coordination

theory is conceptualized as seven dimensions, which are grouped into those related to communication and relationship. Specifically, the theory of relational coordination states that “effective coordination occurs through communication that is frequent and high quality – timely, accurate and problem solving – and supported by high-quality relationships – characterized by shared goals, shared knowledge, and mutual respect.” (Weinberg et al. 2007b, p. 142)

The communication dimension is intended to measure the quality and effectiveness of the interactions between functions or roles in the organization, these communications should ultimately be supported by and contribute to building stronger relationships between these roles. The frequent communication dimension reflects the time that elapses between interactions. In contrast, the timely communication dimension examines whether the interactions took place at a point in time when they were useful in mitigating negative impacts by allowing for the productive application of the information communicated. The accurate communication dimension examines whether the information being communicated is free from errors. Finally, a problem-solving communication is that which is oriented toward finding a way to avoid failures or breakdowns in the future and does not seek to place blame on another party for the occurrence of errors or failures in the system (Gittell 2009; Weinberg et al. 2007b; Gittell 2002a).

The remaining three dimensions are centered on measuring the quality of the relationships. The shared goals dimension examines whether the participants in the roles are able to grasp a similar vision of what the overall work process they are engaged in is

intended to accomplish. Similarly, shared knowledge as a dimension is intended to capture the extent to which the players in one role understand the tasks and requirements of the players in another role. This knowledge allows for the consideration of potential impacts and repercussions of changes in the work process on the outcomes or the ability of the group to reach their shared goals. Finally, the dimension of mutual respect reflects the divisions (or lack thereof) between the roles engaged in a work process which are created and reinforced by status differences, pride or disrespect for others. These seven dimensions can work together positively to reinforce the group's ability work as a team or if they are occurring negatively they can disrupt and negatively influence the work process (Gittell 2009; Weinberg et al. 2007b; Gittell 2006, 74-94).

5.2.1 Organizational Design

Relational coordination theory extends the organizational design literature which has attempted to explain the positive performance impact that can be achieved by improving provider-provider relationships within an organization (Gittell 2002b). The organizational literatures on group effectiveness, social capital and internal service quality have discussed the importance of coordination, information processing and information dissemination to the performance of a both manufacturing and service organizations (Berry and Parasuraman 1991; Hallowell, Schlesinger, and Zornitsky 1996; Zeithaml, Parasuraman, and Berry 1990; Hackman 1987, 315-342; Gully, Devine and Whitney 1995; Seers, Petty and Cashman 1995; Burt 1992, 1997; Nahapiet and Ghoshal 1998; Leana and Van Buren 1999). Relational coordination builds on these foundations

by adding the perspective that relationships are critical to the most efficient functioning of these other mechanisms (Gittell 2002b).

Previous studies on relational coordination have studied the influence of this construct within organizations by examining the roles that must coordinate with each other to accomplish a particular service process. They have also looked at how an increase in the relational coordination between those roles can increase the performance of the service as well as the job satisfaction of the providers (Gittell 2002b; Weinberg et al. 2007b; Gittell et al. 2008a). These studies have focused on the provider-provider relationships that exist within one organization, specifically between direct participants in a particular service process (Gittell 2002b). In some cases, the literature utilizes the high-quality relationships dimension of the relational coordination theory alone, ignoring the communication dimensions. In one such study, high-quality relationships were shown to be an antecedent to psychological safety within work groups which then was shown to allow for more learning from failures in that organization (Carmeli and Gittell 2009). This study did not examine how the relationships and communication dimensions of relational coordination work together to facilitate high-quality relationships. Much of the existing literature has studied services such as the airline industry and the health care industry because they frequently contain work processes which are highly uncertain, time-constrained and interdependent (Gittell 2000). Additional studies have attempted to understand the antecedents to relational coordination as a whole, seeking to understand what work practices and principles could result in increased relational coordination within the the organization. Some of the work practices shown to have an influence are

cross-functional liaisons, cross-functional performance measurement and flexible work roles (Gittell, Seidner and Wimbush 2010).

5.2.2 Health Care Applications

One particular study of relational coordination in the health care setting examines the impact of both an aggregate measure of relational coordination and all seven of its individual dimensions on the quality of care (quality) as well as hospital length of stay (efficiency) and concluded that there is a significant positive impact (Gittell 2000). In previous work, Gittell (2002a) has shown that within an organization, the relational coordination mechanism mediates the effect of other coordinating mechanisms such as routines, boundary spanners and team meetings. Her work shows that these coordinating mechanisms, which had previously been discussed as ways through which organizations could increase performance by encouraging for more effective information flow and processing within the health care organization. These coordinating mechanisms are shown in a patient care context to have a positive effect on relational coordination among the participants in the work process and that subsequently, relational coordination has the greatest impact on the organizational performance outcome (Gittell 2002a). Another study, conducted among nine urban hospitals which provided surgical care for joint replacement patients, shows that relational coordination is a mediator between high-performance work practices and the quality and efficiency of patient outcomes (Gittell, Seidner and Wimbush 2010). These work practices for the intra-organizational context involved teamwork, conflict resolution, performance measurement, rewards, meeting and boundary spanners all at the cross-functional level. Along a different vein, another study

showed that relational coordination can be strengthened by a combination of increased environmental pressures and work stress alongside formal work practices that encourage relational development (Gittell 2008). This insight suggests that relational coordination is important to organizations which are under pressures to decrease costs and increase quality of services as is the case with the health care industry today.

5.2.3 Inter-Organizational Applications

A few studies have also explored the idea of applying relational coordination to some aspects of inter-organizational roles. Work by Weinberg et al. (2007b), extends the applications of relational coordination theory in the health care delivery setting to include not only the relationships between formal providers within the health care organization but also the informal caregivers who attend to the patient after they are discharged. In that study, the results showed that increased coordination between formal providers and informal caregivers did improve outcomes for the patients. Another study has investigated coordination across organizations and included different care settings as well as different care provider types (Weinberg et al. 2007a). Instead of using a formal measure of relational coordination, this study defined and measured coordination as information transfer and processing, however, it did conclude that coordination has a significant impact on patient care quality outcomes and satisfaction.

Similarly, it has been suggested in the literature on organizational theory and specifically on relational coordination that there is a role of inter-organizational coordination between networks of organizations that help to improve quality and efficiency of performance (Gittell and Weiss 2004; Smith, Carroll and Ashford 1995;

Provan and Milward 1995). One study has utilized relational coordination theory to help explain particular phenomena in a supply chain. In that study by Shah et al. 2008, the authors utilized the three relational dimensions of relational coordination to help explain why organizations in a health care supply chain would undertake significant efforts for the coordination of care across organizations when there are no obvious, perceivable, financial incentives to do so. In addition, studies from the information systems discipline have recognized the importance of understanding information flows among the organizational networks that make up supply chains. One such study tests relational antecedents to effective supply chain integration and finds that the use of formal and informal mechanisms to exchange information and knowledge between supply chain partners improves information flow integration. In turn, information flow integration has been shown in other studies to positively impact the performance of the supply chain (Patnayakuni, Rai and Seth 2006).

This study is different from these previous studies in that it examines the influence of the specific relational coordination construct on organizations further up the supply chain which do not have direct patient contact but that nevertheless impact the delivery of care to the patient within the selected care setting (hospital). This dissertation will extend relational coordination theory by examining relationships that span organizations and involve the improvement of the execution of a particular service process. Similar to studies that have investigated the coordinating mechanisms within organizations, we expect that the work between organizations is managed and facilitated by the health care supply chain coordination mechanisms of affordability, provider awareness and access.

In fact, we posit that increases in these three mechanisms over time will result in increases in relational coordination between organizations.

5.3 Existing Theory

As was discussed in the preceding literature review, there is some existing theory on the nature of inter-organizational coordination and the mechanisms which support it. In fact, some studies have suggested that there is a strong need for inter-organizational coordination to achieve effective care quality in the health care system which is composed of many differing organizations (Provan and Milward 1995; Gittell and Weiss 2004). Although the impact of coordination with networks has been illustrated to be beneficial to performance and to health care outcomes, it is also difficult to achieve (Weinberg 2003; Argote 1982; Gittell et al. 2000). Organizational design theory has studied both intra-organizational mechanisms for coordination between units within a firm as well as mechanisms to help achieve inter-organizational coordination (Provan and Milward 1995; Gittell and Weiss 2004; Grandori and Soda 1995; Malone, Yates and Benjamin 1987). These inter-organizational mechanisms have been identified as cross-organizational liaisons (Provan and Milward 1995; Grandori and Soda 1995), shared information systems and staff (Malone, Yates and Benjamin 1987; Phillips 1960), shared supervision, training and systems for accounting (Pilotti and Pozanna 1990). Finally, shared incentives and selection systems have been shown to be effective at coordinating across firms (Grandori and Soda 1995; Williamson 1985). It has been suggested that just as intra-organizational networks are influenced by organizational design mechanisms (Gittell 2000; Gittell 2002a; Gittell, Seidner and Wimbush 2010) so also inter-

organizational networks may be influenced by mechanisms of organizational design as well (Gittell and Weiss 2004).

Studies have shown that the application of these specific work practices, work design and organization design can increase the levels of coordination in a network and that this increased coordination within and between units of a firm will result in improved performance (Gittell 2000; Gittell 2002a; Gittell, Seidner and Wimbush 2010). In essence, these studies demonstrate relational coordination as the mechanism that functions within organizations to mediate the relationship between organizational design mechanisms and performance. The strength of the impact of these mechanisms can vary based on input uncertainty (Gittell 2002a) and some mechanisms are more effective in environments that are more reliant on employee knowledge and skill sets (Gittell, Seidner and Wimbush 2010). However, the connection between work practices, relationships and coordination networks within organizations, and performance have been empirically demonstrated (Gittell 2000; Gittell 2002a; Gittell, Seidner and Wimbush 2010).

5.4 Network Analysis

In this section, we will further develop relational coordination theory to investigate ties between specific human roles across organizations in a supply chain and their evolution over time. This will contribute towards advancing the existing theory of relational coordination by providing analysis into how relational coordination evolves and what impact these changes have on the overall performance outcomes of the supply chain. In the sections to follow, we describe the research setting, discuss the relevant network roles and relationships, and examine the impact of these changing relationships

over time. This examination will serve to generate insights relevant to understanding the nature of the role and influence of relational coordination in a health care supply chain.

5.4.1 Research Setting

This study is conducted in the inter-organizational context of a global health care supply chain which is intended to enable the introduction of a new service into the health care delivery network of a hospital in an emerging economy. As was discussed in chapter 2, the context of our study is the relationship between Children's HearLink (CHL) and the First Hospital of Lanzhou University (FHLU) in the Gansu province of China. Data was collected through an involved process that included historical documentation, interviews and observations. Through this process, the researchers were able to gain a deep understanding of the network of organizations essential to introducing the new health care service of providing care for congenital heart conditions in the more rural regions of an emerging economy.

The qualitative analysis presented in this chapter was conducted following the same careful, iterative coding process as was used in chapter 3. This process was described in detail in section 3.4.1. As with the analysis presented in that chapter, the querying capabilities of the NVivo 8 software were utilized as the researchers analyzed the data. This analysis included all of the data collected from documents, interviews and observations and allowed the researchers to enhance their understanding of the functioning of the relational coordination construct during the evolution of the partnership. The coding process was used to identify the relevant roles in each organization, the relationships between those roles and the types of interactions that

occurred along each link during the course of the relationship. The coding of the data was completed by two trained researchers and any discrepancies were resolved successfully through discussion (Holsti 1969; Dibbern 2008). The reasons for the mismatches were always apparent and consensus on the appropriate coding was reached quickly. The average inter-rater reliability was 0.941 which satisfies recommendations of previous qualitative research and is well over the recommended threshold of 85 percent (Holsti 1969; Morse 1997; Dibbern 2008).

Because the setting is between a non-profit and a hospital situated in an interior city (Lanzhou, the capital of the Gansu Province) of an emerging economy (China), the specific roles and organizations involved in the supply chain are somewhat unique but easily generalizable to other non-profit, NGO or aid organizations working in emerging economies. Being very geographically isolated, Lanzhou is considered a second-tier Chinese city with an industrial presence and some foreign investment but not the national stature or prosperity of the first-tier cities such as Beijing or Shanghai (Fitzgerald et al. 2007). The following discussion will present the important roles in each organization as then the relationships that emerged between those roles. Subsequently, we will present the analysis of the evolution of the relational coordination construct over time in the network of organizations and begin to draw some conclusions as to the evolution and nature of relational coordination as it functions in the supply chain. This analysis will enhance our understanding of the 3-A framework for the health care supply chain by including a human factor into the framework which has previously been focused on process and technologies only. An understanding of the human roles in the supply chain will reveal the mechanisms by which the 3-As affect the volume of care delivered.

Our look at the important roles in this inter-organizational network will begin with the Outreach/Assistance Program (CHL in our particular data set.) Within this organization there are three roles relevant to the efficient functioning of the supply chain. These are the donor relations coordinator, outreach coordinator and administration advisor. The donor relations coordinator manages and ensures the sufficient flow of charitable giving to fund the activities of the outreach/assistance program and their partner site activities. The outreach coordinator provides the majority of the logistical and tactical support for the activities of the organization and the administration advisor takes the lead role in forging and maintaining the progress and direction of the relationship with each individual partner site. See Table 5-1 for a list of the organizations and a more detailed description of each of the roles within them.

The second key organization in the network is the partner site itself. This is usually a hospital or clinic which has agreed to engage with the outreach organization in an effort to introduce a new type of service or treatment or to expand their abilities in a particular service area. The partner site organization has four critical roles that must be functioning. These are site administration, unit leadership, patient care team and a coordination contact. The site administration plays a particularly important role in the strategic direction and goals of the relationship, the unit leadership provide a more concrete implementation of how these goals are reached, and the patient care team itself is the direct recipient of the majority of the substantial interaction and efforts involved in the introduction of the new service. The coordination contact is also a key role that serves to help with translation, distribution of information and overall logistical concerns.

Table 5-1 Description of Inter-Organizational Roles

Outreach/Assistance Program		
1	<u>Administration Advisor</u> (International Programs Director)	Provides advice on how to develop the local program, where to invest money, and volunteer recruitment.
2	<u>Donor Relations Coordinator</u>	Maintains connections to donor base and companies who contribute. Funds used to help defray travel cost and investments necessary to be able to provide the consultation and training given by volunteers and program staff
3	<u>Outreach/Training Coordinator</u>	Performs task level coordination to organize and support training and equipment donation/maintenance activities. Includes coordination of volunteer recruitment, volunteer team orientation, travel and logistics considerations.
Partner Site (Hospital)		
1	<u>Hospital Administration</u>	Decision maker on funding, organization procurement and resource allocation.
2	<u>Hospital Unit Leadership</u>	Heads communication on needs and interests of program, vision and execution of growth and learning plans.
3	<u>Contact Person</u>	Coordinates communication, translation and point person for contact between program and partner site members
4	<u>Patient Care Team</u>	Team of allied health and physicians who perform patient care activities directly at partner site.
Volunteer Network		
1	Medical Advisor	Lead volunteer who works closely with and complements administration advisor in site assessment and development tasks. This includes areas such as what staff to hire, what training is necessary, patient care coordination and evaluation of current skill sets and opportunities for growth at the partner/potential partner site.
2	Medical/Allied Health Staff	Provide primary on-site practical and conceptual training opportunities by working with patients at partner site and providing workshops to present training materials to larger audiences of site staff.
Local/National Government		
Donor Organizations		

In addition, more peripheral but critical, are organizations that include the donor network, local and national governments, and the volunteer network itself. The donor network is important for financial support as well as the provision of goods and services used to make the relationship productive and are primarily leveraged through a link to the outreach/assistance program. The local and national governments involved in the partner site country can have a profound impact through policy and funding decisions. While the primary link with these governmental representatives is through the partner site, there are times when a contact from the outreach/assistance program can be influential. Finally, the volunteer network that is created primarily through the efforts of the outreach/assistance program plays an essential role in the success of the supply chain. These volunteers provide medical expertise and health care administration advice that is fundamental to the success of the new service introduction. There are vital and influential links between this volunteer network and both the outreach/assistance program and the partner site.

5.4.2 Network Evolution

The links between these organizations and roles within the organizations can be seen in Figure 5-2 which illustrates the basic relationships that are important in the supply chain. These relationships were identified, inductively, by mapping the interactions between organizations in the field study data that was collected about the CHL – FHLU partnership during 1999 - 2008. For this chapter, the first step in the analysis was to identify the organizational roles utilizing a formal coding process according to the qualitative data analysis techniques detailed in chapter 3. Once this coding process had

been completed, a subsequent analysis of the qualitative data identified the links between the roles and those links were also coded in the data. Table 5-2 lists the links between roles that were identified through the coding process. It also shows the number of interactions that were identified as occurring on that link in specific phases of the partnership. The rest of the analysis examines the data within the phases of the CHL – FHLU relationship identified in Section 3.4.2 and summarized in Table 3-2. As was discussed in chapter 3, these phases divide the ten-year history of the partnership into four phases according to major changes in one of the supply chain coordination constructs.

These phases are relevant because existing theory on the nature of inter-organizational networks and organizational design would attribute significance to the innovations implemented at the beginning of each phase. Earlier we outlined the types of work practices and organizational design mechanisms which have been suggested to increase coordination and performance in inter-organizational networks. In particular, the innovations that occurred in awareness and access, at the beginning of phases 3 and 4 respectively, are considered to change some organizational design and work practices considered important in the literature (Gittell 2000; Gittell 2002a; Gittell, Seidner and Wimbush 2010). The innovation in awareness promoted the use of new types of work practices, specifically encouraging the importance of the role of the coordination contact who fills a role of boundary spanner or cross-functional liaison (Provan and Milward 1995; Grandori and Soda 1995; Gittell 2000; Gittell 2002a; Gittell, Seidner and Wimbush 2010), increased team work with the implementation of more cross-functional team meetings (Gittell 2002a; Gittell, Seidner and Wimbush 2010), and introduced an

emphasis on performance measurement through the introduction of quality control software and additional reporting on surgical interventions and outcomes (Pilotti and Pozanna 1990; Grandori and Soda 1995; Gittell 2000; Gittell, Seidner and Wimbush 2010). Similarly, the innovation in access resulted in improved work design and routines as facilitated by improved hospital layout and increased capacity (Malone, Yates and Benjamin 1987; Phillips 1960; Gittell 2002a).

The next step in the analysis is to understand why and how the network ties are changing over time and what, if any, impact the innovation in the 3-A constructs have on the level of relational coordination in the supply chain. The data indicates that indeed the level of relational coordination is increasing over time and there are notable shifts in the nature, volume, and types of interactions in the different phases of the relationship. As can be seen in Table 5-2, most ties appear active throughout the relationship, however, all changed in magnitude at some point. To provide additional insights in the analysis of the evolution of the network, each tie was classified depending on the nature of the interactions. (See Table 5-2 for the classification of the network ties.) As was discussed in detail earlier, relational coordination theory presents the overall construct as two mutually reinforcing dimensions of communication and relationship each of which has specific sub-dimensions (Gittell et al. 2000; Gittell 2006, 74-94; Gittell 2009). If the primary interactions along a network tie had to do with the relationship dimension then that tie was designated as a “relationship” tie. (These will be delineated with dashed arrows in the network diagrams.) If the primary mode of interaction for a tie was related to communication, then that tie was designated as a “communication” tie. These ties are presented as solid arrows in the network diagram. Finally, if the tie contained

approximately equal interactions between the relationship and communication dimensions then it was designated as a “balanced” tie and is depicted with broken dashed arrows. The network present during the first phase of the relationship, which occurred just before and during the first year of the partnership, is presented in Figure 5-3.

Overall, the total volume of interactions between the sites grows throughout the duration of the partnership and, interestingly, experiences a substantial increase between the 2nd and 3rd phases. The type of interactions between sites makes a shift from communication (i.e. information flow) being much more frequent to communication and relationship sharing equal focus. This shift or balancing between the dimensions of relational coordination seems to occur most substantially in the 3rd and 4th phases. Additionally, the burden of much of the communication and relationship interactions between organizations expands to include the volunteer organization. In the first phases the primary interactions were between the focal outreach program and in the later phases there are also significant volumes of interactions between the partner site and the volunteer network. This reinforces the role of the volunteers as being an additional, critical organization in the network which plays a complementary role to the outreach program. This shift would indicate that the partnership is nearing maturity and the outreach program will shortly be able to step away from an active role with the site and continue on in a less active maintenance or facilitator role. The next several sections will discuss the evolution of the network over the phases by the different types of links. Figures 5-4, 5-5 and 5-6 illustrate the network in phases 2, 3 and 4 with the volume of interactions indicated by the thickness of the arrows and the nature of the links indicated by the type of arrow as described earlier.

Figure 5-2: Initial Network of roles and relationships between CHL outreach/assistance program and the partner site, FHLU

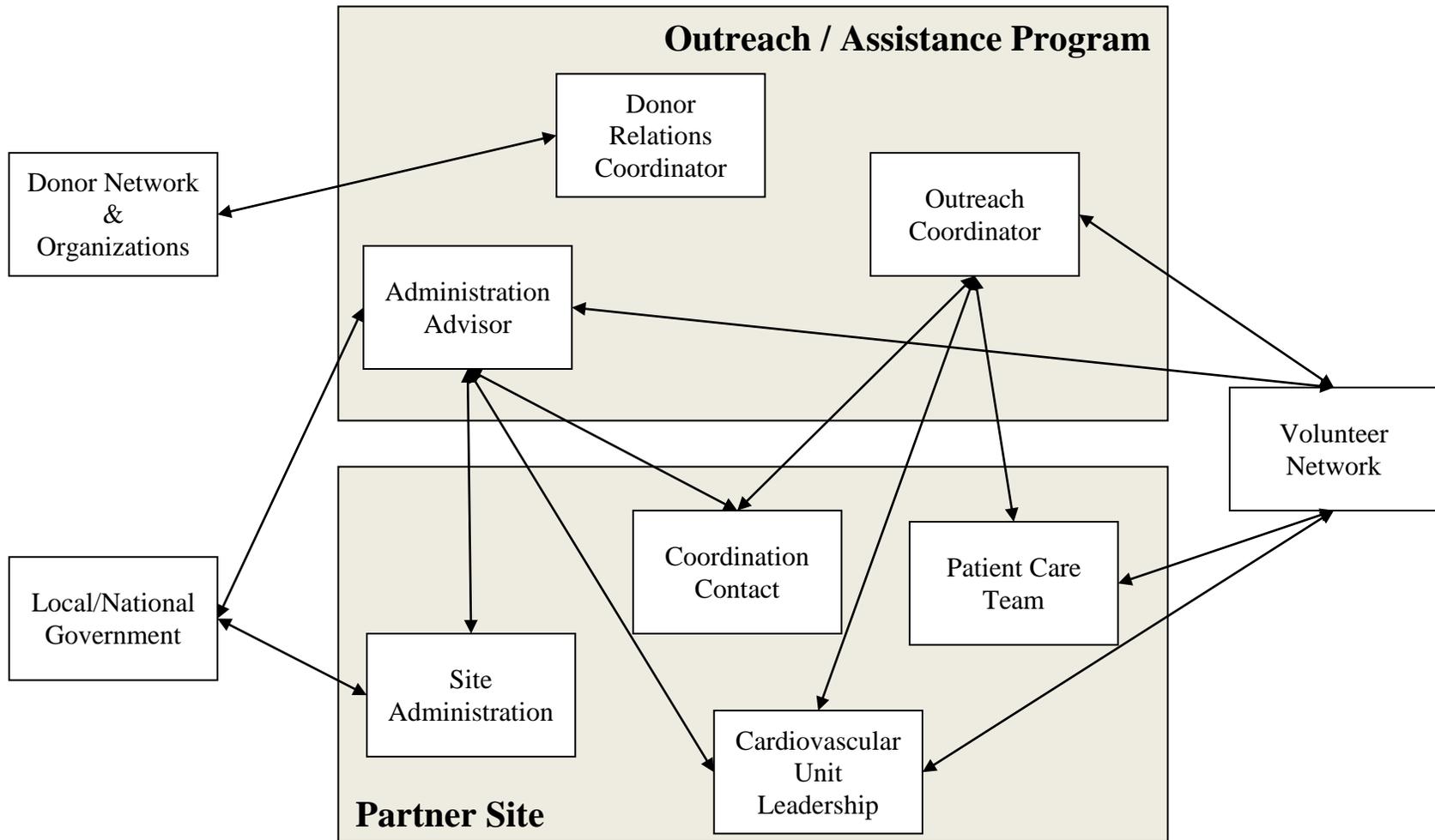
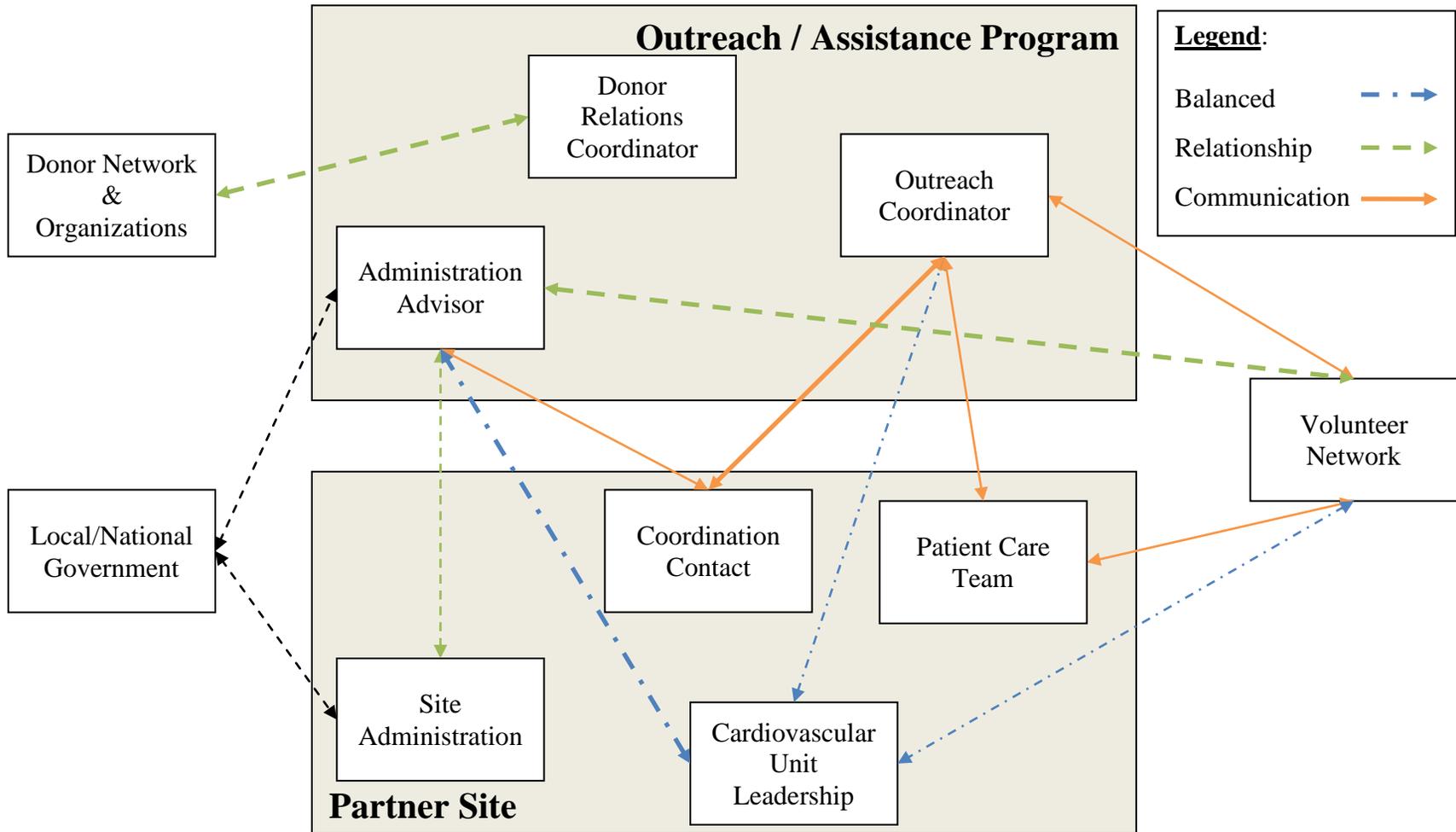


Table 5-2: Network Ties by Phase

	Phase 1	Phase 2	Phase 3	Phase 4	Classification
Donor Network ~ Donor Coordinator	12	6	2	3	Relationship
Administration Advisor ~ Site Administration	6	10	19	21	Balanced
Administration Advisor ~ Coordination Contact	3	3	12	1	Communication
Administration Advisor ~ Unit Leadership	12	31	21	21	Balanced
Outreach Coordinator ~ Coordination Contact	9	23	27	7	Communication
Outreach Coordinator ~ Unit Leadership	2	6	12	7	Balanced
Outreach Coordinator ~ Patient Care Team	1	1	0	1	Communication
Volunteer Network (Medical Advisor) ~ Administration Advisor	9	7	2	4	Relationship
Volunteer Network ~ Outreach Coordinator	5	17	28	4	Communication
Volunteer Network ~ Unit Leadership	4	7	28	31	Balanced
Volunteer Network ~ Patient Care Team	2	3	13	23	Communication
Administration Advisor ~ Government (Partner nation)	0	4	5	0	---
Site Administration ~ Government (Partner nation)	0	0	0	1	---

Figure 5-3: CHL & FHLU Network - Phase 1 (1998-1999: Initial years of partnership - no significant innovations)



We will begin by discussing the network links that are relational in nature. The first of these is the donor network tie which was strongest in phase 1 and dropped off to low levels in later phases. This decrease is explained by the relative stability of the funding for this particular partnership, with the major contributions toward CHL's ability to continue their involvement with FHLU coming from a single major corporate donor. Following a similar pattern, relationship was the primary focus of the tie between the volunteer network and the administration advisor. The volunteer network includes those in leadership roles (primarily cardiac surgeons in this setting) and those in supporting roles. The medical volunteer leadership communicated strongly in the first phase with the administration advisor about the relationship and emphasized shared goals and shared knowledge. They then maintained these types of updates at a lower rate throughout the partnership. In addition to the link with the volunteer network, the link from the administration advisor with the site administration was also relationship focused. In stark contrast however, this link started fairly weak in phase 1 and strengthened rapidly through phases 2 and 3, maintaining strong ties in phase 4. These relational links seem to be quite important to the establishment and continued growth of an effective partnership.

Shifting the focus to links in the network that appeared more balanced in nature, these balanced ties have proportional levels of communication and relationship interactions. Over time, the volume of these balanced interactions increases significantly. Significantly, the balanced links in this network all connect roles in another organization with the cardiovascular unit leadership role in the focal partner site. The primary balanced link in Phase 1 connected the administration advisor in the outreach program to the cardiovascular unit leadership. This connection grows significantly in phase 2 and

settles down to a moderate but quite active level in phases 3 and 4. The outreach coordinator to unit leadership link maintains a steady presence through all phases and serves a very important role in establishing a stable, functioning and effective relationship. It is the link from the unit leadership to the volunteer network that changes the most. This balanced connection grows from a very low level in phases 1 and 2 to a significant level in the 3rd and 4th phases. By the fourth phase this link, along with the relational link between the administration advisor and site administration, are the key influences in the network. We posit that the timing of the growth in these last two links, that have been identified as key to the efficacy of the network, are connected to an increase in the innovative work practices that were associated with the innovation in awareness that occurred at the beginning of phase 3. The increased use of team meetings, boundary spanners, and performance measurement at this point in time would explain the rapid increase in relational coordination and the improved balance of the overall relational coordination construct between the communication and relationship dimensions. Similarly, the improvement in phase 4 is attributed to the innovation in access and the improvement in work design and routines as facilitated by the new hospital building and substantially higher knowledge levels of the staff.

The final category of network ties are those that primarily serve as conduits of communication in order to facilitate the relationship. These links are more functional and less strategic in nature when it comes to guiding the progression of the partnership. The primary communication oriented links are strongest in phases 2 and 3 and have resumed lower levels by phase 4. Communication links occur between both the administration advisor and outreach coordinator in the outreach program and the coordination contact

for the partner site. In particular, there is heavy volume of communication by the outreach coordinator, especially during the middle phases of the partnership. There is also smaller, but important, communication between the administration advisor and the coordination contact in all phases of the partnership. The outreach coordinator also communicates consistently with the patient care team at the partner site during all four phases. Additionally, there are two communication based links used significantly by the volunteer network. One with heavy utilization in the second and third phases is between the outreach coordinator and the volunteer network. The primary function of this tie is to help plan and prepare the teams for the trips to the site. Finally, there is interesting growth in the volume of communication between the volunteer network and the patient care team at the partner site. This volume steadily increases, especially in the last two phases and is particularly strong in the last phase. As has been discussed, these last two phases were characterized by improved work practices and organizational design mechanisms which would allow for better intra and inter-organizational communication which would serve to facilitate such a change in the network.

Figure 5-4 CHL & FHLU Network - Phase 2 (2000-2002: Innovations in Affordability)

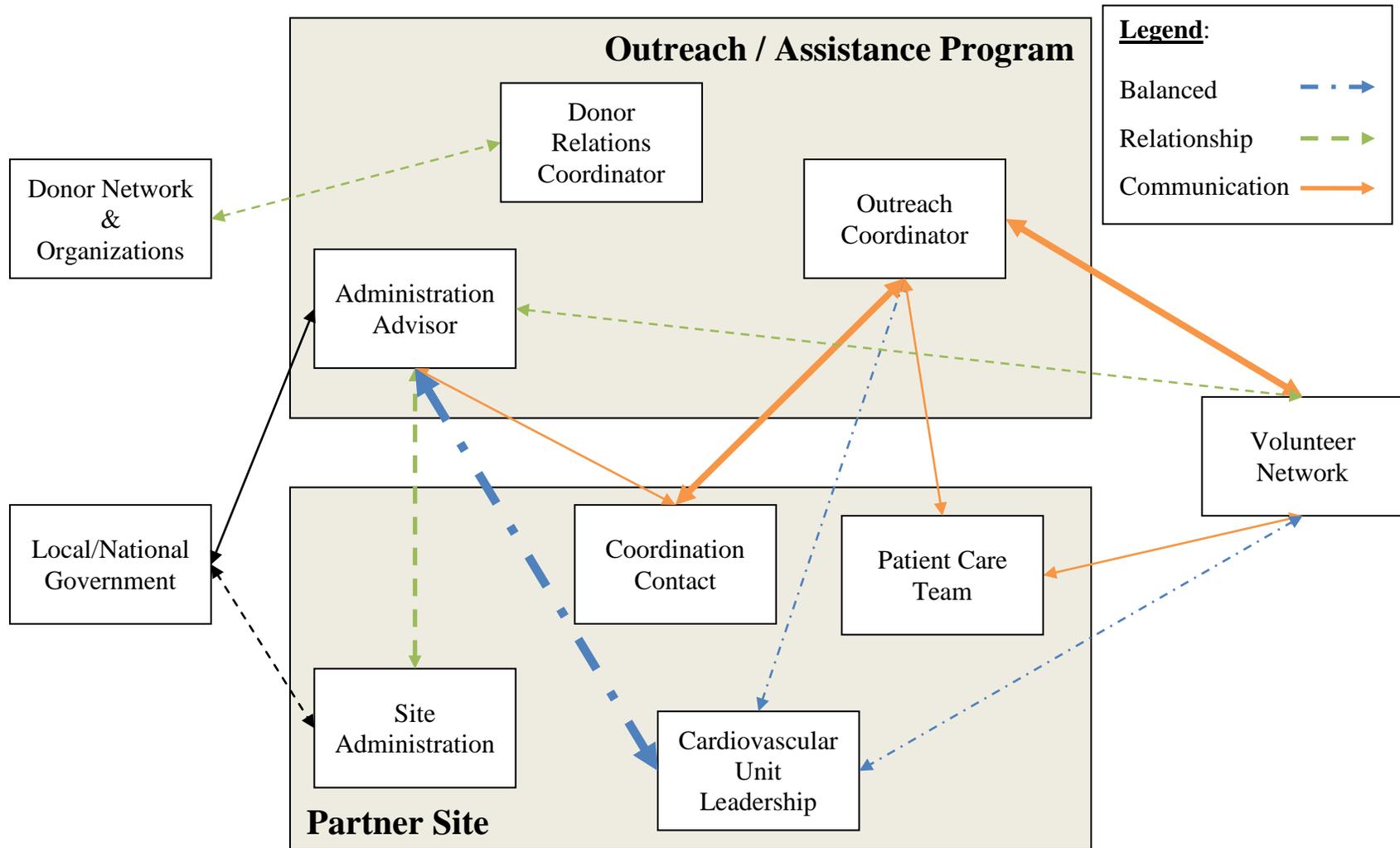


Figure 5-5 CHL & FHLU Network - Phase 3 (2003-2005: Innovations in Provider Awareness)

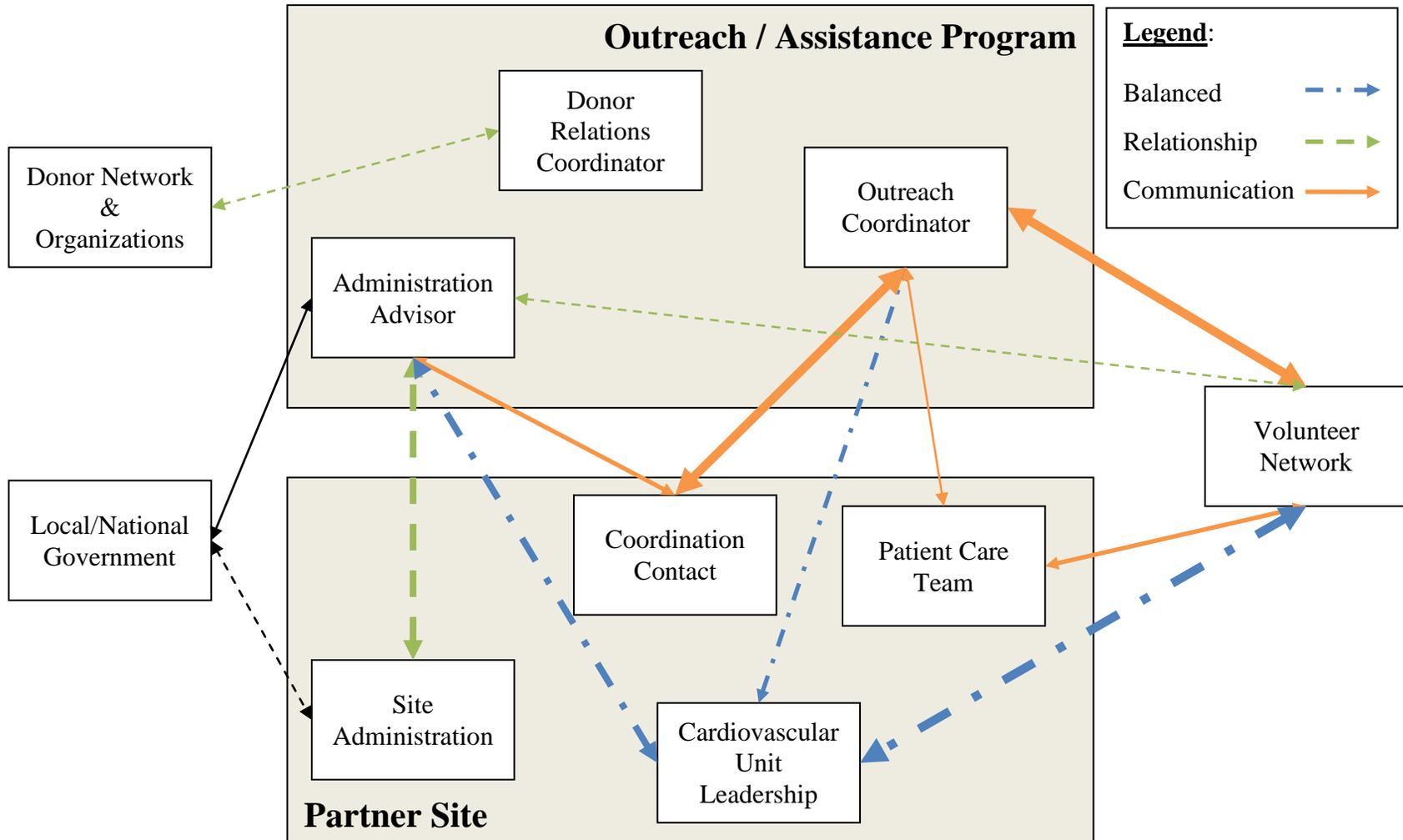
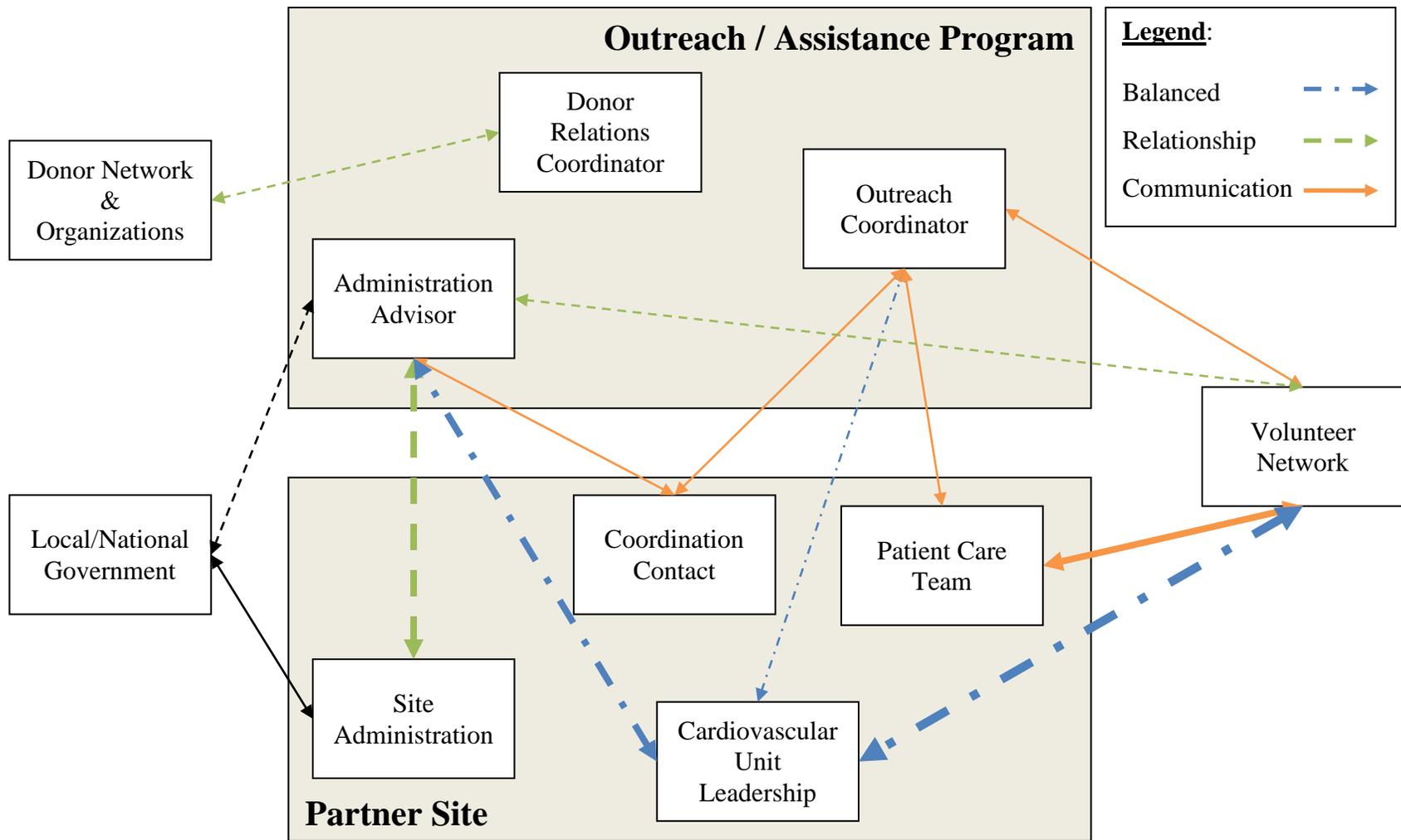


Figure 5-6 CHL & FHLU Network - Phase 4 (2006-2008: Innovations in Access)



The preceding examination of the evolution of the network of relationships in the CHL-FHLU partnership contributes to our understanding of the evolution of the relational coordination construct over time in a network of organizations, i.e. a supply chain. During the passage of time, the focus of the exchanges in the network changes from heavily communication oriented to more balanced, with relationship oriented exchanges playing a more frequent role. At the same time, there is a significant increase in the overall volume of the exchanges in the network and, though this somewhat masks the change in the nature of the exchanges, this increase in relational coordination is explained by the occurrence of the innovations in awareness and access. These two innovations are important because of their connection to organizational practices that have been shown to influence relational coordination in other studies (Gittell 2000; Gittell 2002a; Gittell, Seidner and Wimbush 2010). Finally, specific ties within the network appear to have certain characteristics which persist through time. Those ties which are primarily conduits of communication exchanges seem to continue to function in that capacity as the relationships mature.

Through this analysis of the network evolution, we conclude that the relational coordination construct between organizations will increase over time in an inter-organizational network and would have an impact on the performance of the network similar to studies of relational coordination in intra-organizational settings (Gittell 2000; Gittell 2002a; Gittell, Seidner and Wimbush 2010). Secondly, that the relational coordination construct in an inter-organizational network will initially have an emphasis on communication and over time will gain a balance between the communication and relationship dimensions. Finally, that specific network ties will have certain

characteristics (i.e. communication, relationship or balanced) and will maintain similar characteristics throughout the development of the network.

More significantly, in connection to the three coordination elements of the health care supply chain, we show that there is a similarity between the 3-A constructs and the organizational design mechanisms that have been shown to influence relational coordination and organizational performance. Based on the evolution of the 3-A constructs in this network, we conclude that innovation in affordability does not improve relational coordination between organizations. However, an innovation in access does improve treatment volume through its effect on relational coordination. And in addition, the relationship between access and relational coordination is moderated by awareness in such a way that access has a greater positive impact on relational coordination as awareness is increased. This analysis of the development of relational coordination in this inter-organizational context provides insights which help to explain the increase in relational coordination between organizations. It also suggests that relational coordination plays a mediating role between the supply chain coordination mechanisms of affordability, provider awareness and access and the performance of the inter-organizational network. We posit that the supply chain coordination mechanisms serve a similar purpose to the intra-organizational work practices discussed in previous work on relational coordination theory and we propose to examine the influence of significant changes in these mechanisms in an inter-organizational context, specifically, the CHL-FHLU health care supply chain (Gittell 2009; Gittell et al. 2008b).

5.5 Relational Coordination Conceptual Framework

Our undertaking in this chapter is to explore the role and importance relational coordination in supply chains over time and to empirically test the hypothesis that relational coordination will have a similar mediating impact on inter-organizational networks as it does on intra-organizational networks. Given the nature of the network of relationships, we would expect there to be increasing relational coordination over time between the organizations and, additionally, that the presence of more relational coordination will have a positive impact on the outcome of increasing surgical volumes (Gittell and Weiss 2004; Gittell 2009; Weinberg et al. 2007a). The previous section presented the mapping and evolution of the network of relationships within the supply chain in order to develop a conceptual model that was sufficient to explain how the 3-As impact performance in the supply chain. This section examines the impact of the relational coordination construct on supply chain performance through testing its ability to increase volume and quality of care. The inclusion of the relational coordination construct into the 3-A framework incorporates important human interaction dimensions. It also helps to explain how interventions in supply chain design -- such as changes to the affordability, provider awareness and access constructs -- ultimately impact the delivery component of the health care supply chain and, ultimately, result in an increased volume of care.

Our premise, similar to what has been shown in studies within organizations, is that as the relational coordination construct increases it will help to explain the process whereby the supply chain coordination mechanisms of affordability, provider awareness, and access impact the ultimate outcomes in the health care supply chain. Based on the

literature that has examined organizational design theory and the role of work practices and work design, we posit that innovation in awareness and access will positively impact the relational coordination construct and that relational coordination will have a positive impact on performance (Gittell 2000; Gittell 2002a; Gittell, Seidner and Wimbush 2010). In the same vein, we expect that innovation in awareness will increase the reliance on the coordination contact (boundary spanner), improved teamwork (more team meeting to discuss cases), and emphasized performance measurement (introduction of quality control software and more reporting on surgeries). Finally, an innovation in access will result in increased capacity and improved work design and routines because of the better facility layout and inter-departmental work design. Ultimately, these innovations will improve the inter-organizational coordination network and will allow for an increase in relational coordination which will positively impact the performance as measured in terms of treatment volume per year. Therefore, our hypothesis is that relational coordination will mediate the relationships of the supply chain coordination mechanisms on treatment volume. This hypothesis is illustrated in Figure 5-7 and formally stated as:

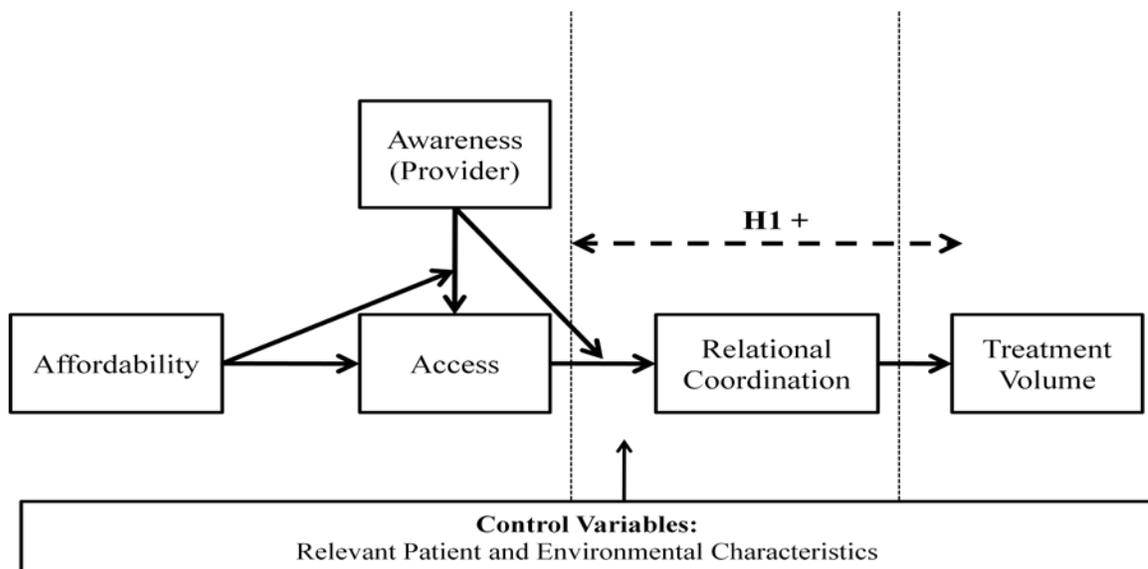
Hypothesis 1: Relational coordination mediates the relationship between the three coordination mechanisms in the health care supply chain (affordability, provider awareness and access) and treatment volume.

5.6 Research Design

To test this hypothesis, the data from the CHL and FHLU partnership was utilized. The research approach and data collection were presented in chapter two of this dissertation. The data for this particular study was extracted from the both the qualitative and quantitative data sets for the purposes of examining the influence of the relational

coordination mechanism between organizations in the 3-A framework. The data used to measure the relational coordination construct and the 3-A constructs comes from the coding process executed with the extensive qualitative data set. The quantitative data is used in combination with the qualitative data for the analysis presented in section 5.6. This combination utilizes the patient level data provided by CHL to aid in understanding the progression of the difficulty of surgeries over the nine year partnership. The use of the patient level data allowed us to increase the sample size while still examining the unit level constructs of relational coordination and the 3-As. These unit level measures were generated from the qualitative data analysis and then imputed to the individual patient level, thereby gaining a sample size of 152. In the following sections, the sample and the measurement for each of the dependent and independent variables as well as the control variables used in the course of the study will be described.

Figure 5-7: 3-A Framework with Relational Coordination



5.6.1 Dependent Variable

For this study the most relevant and available measure of the improved efficiency of the health care supply chain is the volume of surgeries performed by the unit at the FHLU site. Therefore, the dependent variable used in the analysis is the raw volume of surgeries performed by the unit in a given year. This variable was not normally distributed, and, therefore, a log transform of the raw annual volume of surgeries was used for the analysis. Because of the necessity of combining unit and patient level measures in this analysis, for each individual patient in the data set of 154 patients, the outcome is the total surgeries performed during the year they received treatment. The total volume is the only outcome variable examined because the in-hospital mortality rate was too low, overall, to facilitate an analysis of the quality of care as a dependent variable. However, in executing the analysis the mortality rate is included as a control variable to ensure that a decrease in quality of care (i.e. increasing mortality rate) was not a significant predictor of the increase in treatment volume.

5.6.2 Independent Variables

For the independent variables, the measures were generated from the qualitative data that was collected. Section 3.4 provides a detailed description of the extensive process of coding and review that was undertaken for the identification of each construct and the items that are used to form these constructs. For the constructs of affordability, provider awareness, and access the measures used in this study are the same as those in chapter 4. See Section 4.3.2 for an extensive description of how these variables were formed. Similar to the 3-As, the measures for relational coordination are generated from counts of

mentions of the seven specific dimensions of each of this construct as it has been used in previous studies (Gittell 2002a; Gittell et al. 2008b; Gittell 2000; Gittell 2009).

Therefore, for this construct there are seven items for which there is an annual count of references in the data. These items include four which are relevant to communication ties between organizations: frequent communication, timely communication, accurate communication and problem-solving communication. The relationship ties are represented by the three items of shared goals, shared knowledge, and mutual respect. See Table 5-3 for a list of these seven items which includes the number of occurrences for each phase of the relationship (as described in chapter 3) and the total relational coordination score for that phase.

In order to combine these items into an aggregate reflective score for the construct, it would have been ideal to run a factor analysis to ascertain if the items did indeed load on one construct as has been shown in previous work (Gittell et al. 2008b; Gittell 2008; Gittell 2000). However, because the sample size for these items was limited to 10 with one score for each year of the partnership, the results of a factor analysis were deemed not reliable enough to be usable. However, to explore the cohesiveness of the construct items a factor analysis was undertaken anyway. As a first step, the scores for each of the items was examined for normality. Given that there was some positive skewness to the items and, therefore, concern that they did not meet the normality assumptions, each item was transformed using a log transformation (Hair et al. 2006). See Table 5-4 for a summary of the seven relational coordination items with descriptive statistics and correlations.

Table 5-3 Relational Coordination by Phase

	Phase 1	Phase 2	Phase 3	Phase 4
Communication				
Frequent Communication	5	1	19	22
Timely Communication	4	4	13	19
Accurate Communication	3	6	11	17
Problem Solving Communication	3	7	6	13
Relationship				
Shared Goals	4	1	21	23
Shared Knowledge	3	2	6	18
Mutual Respect	1	1	2	16
Relational Coordination Score	23	22	78	128
Communication	65%	82%	63%	55%
Relationship	35%	18%	37%	45%

Table 5-4 Relational Coordination Item Descriptive Statistics and Correlations

Variable	Mean	s.d.	1	2	3	4	5	6
1. Frequency	1.214	1.047						
2. Timely	1.092	0.913	.744**					
3. Accuracy	1.183	0.746	.696*	.926**				
4. Problem-Solving	1.013	0.757	.519	.822**	.768**			
5. Shared Goals	1.201	1.057	.946**	.808**	.773**	.502		
6. Shared Knowledge	0.933	0.881	.693*	.770**	.694*	.742**	.696*	
7. Mutual Respect	0.681	0.736	.643*	.453	.504	.380	.559	.722*

Once these transformations were completed a principal component factor analysis was undertaken. The factor analysis confirmed that these seven items did indeed load on one factor with reliable measurement properties as reflected in a Cronbach's $\alpha = 0.937$. However, because of the previously mentioned limitations of the factor scores due to sample size, a different score for the construct was calculated using the mean score of each of the items identified. Because of the sample size, all further analysis was

performed using this second variable which was calculated as the mean score of the seven items instead of the factor scores.

5.6.3 Control Variables

The control variables used in our study are comparable to those frequently used in studies of health care processes which seek to link service design with volume and patient satisfaction outcomes. In fact, the controls utilized in this study are as consistent as possible with the recommended demographic and treatment related controls used in other studies of relational coordination in the health care setting (Gittell et al. 2000; Gittell 2002a; Gittell et al. 2008a,b; Gittell, Seidner and Wimbush 2010; Weinberg et al. 2007a,b). The reality is that patient and treatment characteristics have an impact on patient outcomes, as well as the volume of treatment that can be performed (Cleary et al. 1991; Kane, MacIejewski and Finch 1997; Young, Meterko and Desai 2000; Powers and Bendall 2004; Katz et al. 1996). In our data, the essential control variables for the patient included age and gender (Cleary et al. 1991; Kane, MacIejewski and Finch 1997). The treatment factors that were important were the frequency of treatment for a particular procedure by the cardiac unit, the difficulty score (RACHS) for that treatment, and whether or not the treatment was performed while a mission team was present (Kane, MacIejewski and Finch 1997; Young, Meterko and Desai 2000). For each patient in the dataset, the type of treatment was noted and the relative volume of that particular treatment in that given year was included as well (Farley and Ozminkowski 1992; Luft et al. 1990). Additionally, the data allowed for the inclusion of an indicator variable for whether the patient was given treatment during a training mission or at some other point

in the year. This control was included to account for the possible impact of the mission training visits that occurred in all but one year of the partnership. Finally, we also included considerations for the RACHS difficulty scale categories, 99% of the surgeries fell into categories one through three. For the final analysis, consistent with other studies, we did not include the patient gender because there was a lack of any significant variation in this category with almost the entire sample being one gender (Weinberg et al. 2007a).

5.6.4 Model Specification

The hypothesized relationships in the 3-A framework represent a system of equations which accounts for the impact of affordability and provider awareness on access and the subsequent impact of the 3-As on relational coordination and lastly on the volume of surgeries. Therefore, the empirical analysis will be conducted using a three-stage least squares (3SLS) regression procedure. The previously delineated controls were entered into the model in all three stages. We will use a 3SLS approach to this empirical estimation because the sample size was not large enough to allow for structural equation modeling. The general form of the 3-stage model specification that will be used to test the hypotheses is presented in equations (3), (4), and (5):

(3) Stage 1:

$$\begin{aligned}
 \text{Access} = & \beta_0 + \beta_1 \% \text{Diag}_t + \beta_2 \text{Mort}_t + \beta_3 \text{Age}_t + \beta_4 \text{Mission}_t + \beta_5 \text{RACHS2}_t + \beta_6 \text{RACHS3}_t \\
 & + \beta_7 \text{Affordability}_t + \beta_8 \text{Awareness}_t + \beta_9 \text{Affordability}_t * \text{Awareness}_t \\
 & + \varepsilon_t
 \end{aligned}$$

(4) Stage 2:

$\ln(\text{RelationalCoord}_t)$

$$= \beta_0 + \beta_1 \% \text{Diag}_t + \beta_2 \text{Mort}_t + \beta_3 \text{Age}_t + \beta_4 \text{Mission}_t + \beta_5 \text{RACHS2}_t \\ + \beta_6 \text{RACHS3}_t + \beta_7 \text{PrecictedAccess}_t + \beta_8 \text{Access}_t \cdot \text{Awareness}_t + \varepsilon_t$$

(5) Stage 3:

$$\ln(\text{Volume}_t) = \beta_0 + \beta_1 \% \text{Diag}_t + \beta_2 \text{Mort}_t + \beta_3 \text{Age}_t + \beta_4 \text{Mission}_t + \beta_5 \text{RACHS2}_t \\ + \beta_6 \text{RACHS3}_t + \beta_7 \text{PrecictedRelationalCoord}_t + \varepsilon_t$$

The second and third stages of the analysis will test the Hypothesis 1, which posits a mediating role of the relational coordination construct in the previously tested 3-A framework. In estimating these models, a robust OLS command (one that uses Huber-White estimators) will be used. This robust estimation procedure is used when it is necessary to relax the assumption that the data are independent and identically distributed and when data may violate the assumption of normally distributed error terms (Kutner et al. 2005). The use of robust OLS is recommended as a confirmation of the reasonableness of an OLS model and if the results are similar then outliers are considered to have a negligible effect in the data.

Finally, it is recommended that robust regression be used with bootstrapping to confirm the precision of the robust results. Therefore, to confirm the statistical significance of the model coefficients, we utilized a bootstrapping method with replacement using 250 samples from the dataset. We also executed the bootstrap method with 500 and 1000 samples in order to confirm that the significance levels for each of the

coefficients were stable across many replications (Kutner et al. 2005; Rosenzweig 2009; Efron and Tibshirani 1993).

Table 5-5 Empirical Results: 3SLS

<i>Independent Variables</i>	3-Stage Ordinary Least Squares					
	Stage 1		Stage 2		Stage 3	
	Outcome: Access		Outcome: Relational Coordination		Outcome: Treatment Volume	
<i>Constant</i>	0.2447 **	-0.4492 ***	-0.0039	-0.1967 *	2.3994 ***	
<i>% Diagnosis Yr</i>	0.1230 *	0.1434 **	-0.3310 ***	-0.2176 *	-0.0846 ***	
<i>Mortality</i>	0.0642	0.0783	-0.1721	-0.0951	-0.0034	
<i>Age</i>	0.0021	0.0060 ***	0.0013	0.0049 **	-0.0066 ***	
<i>Mission Case</i>	0.0617	0.0909 **	0.0717	0.1259 **	-0.1426 ***	
<i>RACHS1</i>	-0.0685	0.0439	0.0455	0.1050	-0.0960 ***	
<i>RACHS2</i>	-0.1444 *	-0.0731	0.0970	0.0970	0.0020	
<i>Awareness (Provider)</i>	0.1747 ***	0.4301 ***				
<i>Affordability</i>	0.0216 ***	0.0307 ***				
<i>Affordability* Awareness</i>		0.4614 ***				
<i>Access</i>			1.3954 ***	1.2332 ***		
<i>Awareness* Access</i>				0.4491 ***		
<i>Relational Coordination</i>					0.2524 ***	
R²	0.430	0.553	0.522	0.585	0.553	
F	19.25 ***	25.15 ***	30.49 ***	118.35 ***	32.67 ***	
N	152	152	152	152	152	

*p < 0.1, **p < 0.05, *** p < 0.01

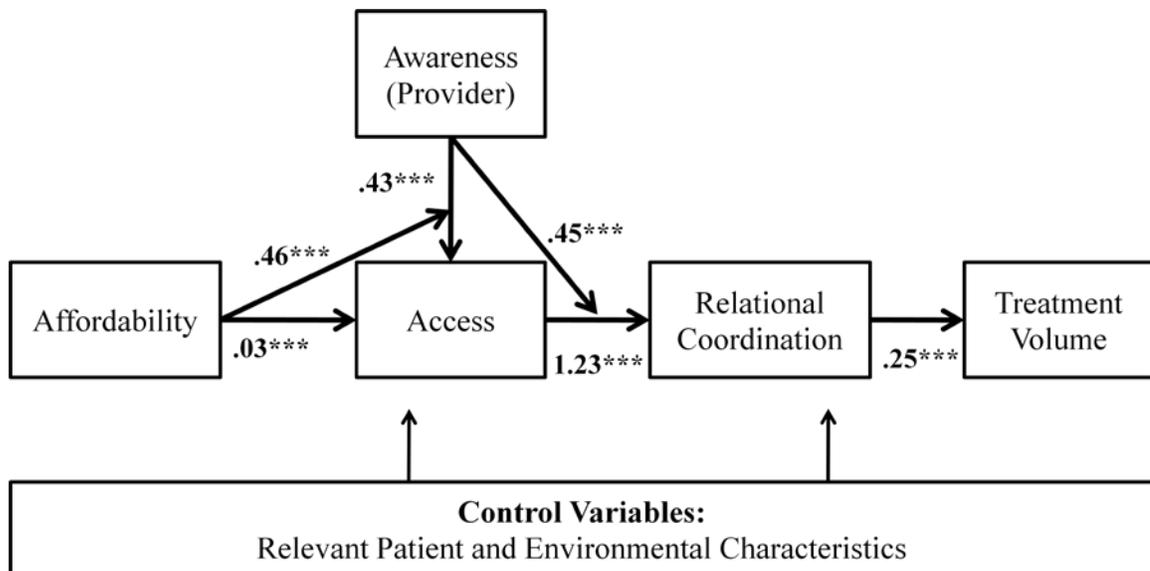
Note: Analysis conducted with Huber-White standard errors. Coefficients reported from robust regression results and significance after bootstrap with 250 replications.

5.7 Results

As has been seen in other studies of relational coordination, the construct was found to be a significant mediator between the supply chain coordination dimensions and the outcomes of the supply chain. The results of the 3SLS model are presented in Table 5-5. Consistent with chapter 4, the results for the first stage show significant direct influences of affordability ($\beta = 0.021$, $p < 0.01$) and provider awareness ($\beta = 0.43$, $p < 0.01$) on access. The moderating effect of changes in affordability on the impact of changes in provider awareness shown through the interaction term is also significant ($\beta = 0.46$, $p <$

0.01). In the second stage, the results show a significant direct effect of access on the relational coordination construct ($\beta = 1.23, p < 0.01$), as well as a significant effect of the moderating influence of awareness on the direct effect of access ($\beta = 0.45, p < 0.01$). This moderation was modeled using an interaction term between the provider awareness and access variables. Finally, in the third stage, which investigates the direct impact of relational coordination on the treatment volumes for care, the model and coefficient are significant. The direct impact of relational coordination on treatment volume has a coefficient of 0.45 with a p-value less than 0.000.

Figure 5-8 Results Summary 3SLS



The detailed results are presented in Table 5-5. Also included in this table are the models for stages 1 and 2 without the interaction terms included. The explanatory power of the models increases with the addition of the interaction term, showing that the model is improved with the inclusion of these moderating effects. The results are summarized in Figure 5-8. The control variables with the most influence in the models are the percent

diagnosis per year, the patient's age, and whether the surgery was performed while a mission team was present. The in-hospital mortality is never a significant model predictor but is retained to ensure that the model contains a proxy for quality of care while examining the reasons for increasing treatment volumes. The significance of all three stages of this analysis gives support to our hypothesis of a mediating role for relational coordination between innovations in the 3-As and outcomes in the health care supply chain.

5.7.1 Additional Analysis for Model Robustness

The inter-organizational context utilized by this analysis was examined over a 10-year time frame. Because of the longitudinal nature of the data, an additional analysis was performed using fixed effects models to ensure that the results remained consistent with the use of a method that accounts for the time dimension in the data. The fixed effects models use the phases which were defined and described in Section 3.4.2 and summarized in Table 3-2 as the groups for the analysis. Each phase in the data corresponds to a major innovation in one of the 3-A dimensions, and, therefore, is expected to have an impact on the outcomes as well as the constructs of interest. A 3-stage approach for the fixed effects models was used which is similar to that in the previous section.

The results of this analysis can be seen in Table 5-6. The coefficients for all the variables of interest were significant and in the anticipated direction. Also, the magnitude of the relationships was remarkably similar to those of the 3SLS analysis. As was the case in chapter 4, the control variables in the fixed effects analysis were generally

insignificant but the overall models were significant and had satisfactory explanatory ability. Bootstrapping analysis with 250, 500 and 1000 iterations was also employed to check the precision of the p-values reported in the initial analysis.

Table 5-6 Empirical Results: Fixed Effects

Independent Variables	3-Stage Fixed Effects					
	Stage 1		Stage 2		Stage 3	
	Outcome: Access		Outcome: Relational Coordination		Outcome: Treatment Volume	
Constant	-0.0814	-0.6209 ***	0.3592 ***	0.2132 **	2.3430 ***	
% Diagnosis Yr	-0.0322	-0.0550	-0.0568	-0.0200	-0.0350 *	
Mortality	0.0256	0.0072	-0.0155	0.0208	-0.0071	
Age	-0.0009	-0.0003	-0.0002	0.0012	-0.0008 *	
Mission Case	0.0472	0.0036	-0.0404	-0.0241	-0.0151 *	
RACHS1	-0.1014 *	-0.0766	0.0097	0.0356	-0.0035	
RACHS2	-0.1149 **	-0.0692	0.0320	0.0398	0.0055	
Awareness (Provider)	0.4785 ***	0.5424 ***				
Affordability	0.0188 ***	0.0518 ***				
Affordability*Awareness		0.7585 ***				
Access			0.7920 ***	0.7757 ***		
Awareness*Access				0.2910 ***		
Relational Coordination					0.1266 ***	
R ² within	0.6742	0.8533	0.6641	0.7504	0.2668	
R ² between	0.1014	0.335	0.1505	0.1103	0.9842	
R ²	0.3854	0.4139	0.2242	0.2897	0.5437	
Groups	4	4	4	4	4	
F	36.21 ***	89.82 ***	39.83 ***	52.62 ***	7.33 ***	
N	152	152	152	152	152	

*p < 0.1, **p < 0.05, *** p < 0.01

Note: Analysis conducted with Huber-White standard errors. Coefficients reported from robust regression results and significance after bootstrap with 250 replications.

5.8 Discussion

The goal of this chapter was to extend the proposed 3-A framework by examining the human roles and relationships between organizations in a health care supply chain. In order to accomplish this goal, we relied on the theoretical lens of relational coordination to provide insight into the dynamics of the relationships in an inter-organizational

context. A review of the literature and existing theory on supply chains and relational coordination revealed no existing empirical studies of relational coordination in an inter-organizational context of this nature. Therefore, this study proposed that the mediating relationship which characterizes the role of relational coordination between interventions and performance in intra-organizational functions should also exist in the supply chain or inter-organizational functions. To further explore this proposed relationship, the qualitative and quantitative data on the CHL-FHLU partnership was utilized.

The qualitative data analysis first revealed the important roles within and between the organizations in the supply chain. The qualitative data was also coded for the existence of the seven dimensions of the relational coordination construct. Evidence was found for the relational coordination construct, both communication and relationship dimensions, between organizations. The qualitative data was also coded to help identify the important relationships between the human roles that exist in the organizations. These data were then leveraged to create a network of ties in the supply chain that revealed the important relationships between roles, the type of interactions between the roles, and the growth and development of relational coordination in the four different phases of the partnership.

This qualitative analysis resulted in several significant insights on the role of relational coordination in the health care supply chain. The examination of the evolution of the network revealed that the relational coordination construct between organizations increased over time in this supply chain and had an impact on performance similar to studies of the same construct in intra-organizational settings (Gittell 2000; Gittell 2002a; Gittell, Seidner and Wimbush 2010). The second insight is that the relational

coordination construct in a supply chain network begins with an emphasis on communication and moves toward a balance of the communication and relationship dimensions. Finally we ascertained that a specific network tie will have a certain characteristic (i.e., communication, relationship or balanced) and will maintain this characteristic throughout the development of the network.

Importantly, the literature review and network analysis also uncovered that the 3-A constructs in the health care supply chain are functioning in a very similar way to organizational design mechanisms which have been shown to influence organizational performance through relational coordination in intra-organizational settings. Because of the significant increase in the relational coordination score and the increasing level of balance between the elements of relational coordination in the third and fourth phases, we conclude that innovations in both provider awareness and access will have an impact on the relational coordination construct. This phenomenon in the supply chain would indicate that there is a mediating relationship of the relational coordination construct between the 3-As and supply chain performance. The empirical analysis shows this to be the case in the health care supply chain for the FHLU site. Both the 3SLS and the 3-stage fixed effects analyses show a significant mediating relationship of relational coordination between the 3-As and supply chain performance.

5.9 Conclusion

In conclusion, the results of this conceptual model building effort and empirical analysis show strong promise for the relevance of relational coordination theory in the supply chain management domain. This examination of the development of the relational

coordination construct as it functions between several organizations in a health care supply chain over time, allows us to understand the dynamics of how this construct strengthens as inter-organizational relationships progress. In particular, it illustrates the changes that occur in the construct when innovations in the coordination constructs of affordability, provider awareness and access are implemented.

This study contributes to the literature in a number of ways. It extends the relational coordination literature by showing the applicability of the theory of relational coordination in an inter-organizational context, specifically, the health care supply chain for underserved communities in emerging economies. We empirically demonstrated the role of relational coordination as a mediator between the three coordinating mechanisms of a health care supply chain (affordability, provider awareness and access) and supply chain performance. Insights from this investigation also contribute to the supply chain management literature by advancing the body of research on human roles and relationships in the health care supply chain. Finally, it expands our understanding of how innovations relevant to the coordination mechanisms of the health care supply chain impact performance outcomes such as treatment volume.

This study will have an impact on practice through its clear and concise presentation of the roles and relationships that are important to organizations, such as CHL, who seek to increase the availability of quality health care in underserved communities around the world. In fact, the insights gained from the analysis of the evolution of relational coordination in the supply chain and the importance of both the communication and relationship dimensions of relational coordination should aid such organizations in

increasing the speed with which they develop partnerships. Such acceleration in the development of effective partnerships should impact the speed at which they are able to increase the volume of available health care in underserved communities.

Similar to the previous two studies, this examination of relational coordination in the supply chain context is limited by several factors. The field study conducted in the context of one inter-organizational setting limits the generalizability of this study beyond the health care context of emerging economies. The link between awareness and relational coordination is also limited to the provider awareness aspect of that construct and gives insights primarily based on an increase in short-term and long-term training opportunities for health care providers. Finally, the sample size for the execution of the 3SLS method is small, future research should be conducted with more extensive data sets.

Despite these limitations, the results of this study provide a basis for much additional interesting research into the role of relational coordination in the supply chain management context. For instance, it would be insightful to examine this mediating role of relational coordination in additional supply chains, both service supply chains and more traditional manufacturing or goods related supply chains. Future studies in this arena would benefit from collecting data across different industries and multiple levels of the supply chain.

Chapter 6

The results of this dissertation inform the global delivery of quality health care in underserved communities by providing a well-grounded and empirically tested integrated framework that defines and clarifies our understanding of the essential coordination mechanisms of affordability, access and awareness in the health care supply chain. The results of the first two studies (Chapters 3 and 4) specify how these supply chain mechanisms can be influenced through innovations in the 3-As which enable the delivery of greater quality and quantity of care in underserved communities. Importantly, these results provide clear definition and measurement for the constructs of access, awareness and affordability that will aid in the execution of additional research that seeks to understand the complexities of the health care supply chain. The third study (Chapter 5) of this dissertation adds to our understanding of the 3-As by examining and extending the theory of relational coordination. This study provides insight into the dynamics of the human roles and relationships between organizations in the supply chain and ultimately how the 3-As affect supply chain performance.

For practitioners, the results will provide detailed insights into the influence of learning and training in the health care supply chain on the quality and quantity of care delivered at sites in underserved communities. Taken together, the results from the three studies of this dissertation will advance both the quality management and supply chain management literatures, and begin shaping the intersection between quality management and supply chain management, from both the academic and practice standpoints. Last but not least, the results of these three studies will enable the partnering organization,

Children's HeartLink, and other similar NGOs, along with their health care supply chain partners (such as the 1st Hospital of Lanzhou University, the other partnering organization), to better understand the enablers and barriers underlying the success of their partnerships. Ultimately, this will aid in improving the quality and quantity of care delivery in underserved communities. It will also help these outreach organizations understand how to more efficiently utilize their limited resources to forge new partnerships which operate effectively in underserved communities.

6.1 Affordability, Awareness and Access

In chapter 3, the methodological approach of field study was used to examine the impact of innovations in the coordination constructs of affordability, awareness and access on the health care supply chain. This involved a detailed mid-range theory building effort that focused on the definition of the constructs and the development of reliable and valid measurement items that could be used to identify these constructs in future studies. Furthermore, pattern analysis was used to identify the relationships between these constructs in order to develop a conceptual framework, the 3-A framework, that could be used to examine and predict the impact of changes in these coordination mechanisms in the health care supply chain. The interrelatedness of the coordination dimensions (affordability, awareness and access) was expected but the nature of the interrelatedness and the number of connections between the constructs was unexpected.

The outcomes of this study are two-fold. It presents both well developed multi-item scales for measuring affordability, awareness and access, as well as an integrative

framework of the inter-relationships between these constructs and the volume of treatments provided in the health care supply chain. The measure for affordability includes items that reflect institutional factors like cost savings and discounting, government related factors such as grants and public insurance options, and personal mechanisms which include loans, payment plans and private insurance. Finally, affordability is also influenced by what charitable funds, either internal or external to the country, are generally available to the population for that specific time period. The awareness construct has two important dimensions, each of which would be measured with its own set of items. These are the patient and provider sides of awareness. The provider awareness dimension is measured in training opportunities both practical and conceptual and the duration of these learning opportunities. The patient awareness dimension is measured by items such as the level and type of disease prevention programs, the level of patient education initiatives, and the general publicity of the health care facility relevant to the specific service offering. This field study primarily provided insights into the provider awareness dimension. However, some of the key items that must be measured to assess patient awareness were also identified. The access dimension is measured relevant to the state of the infrastructure necessary to facilitate care and includes items relevant to facility and capacity, local availability of supplies and medical devices, as well as staffing levels.

The key elements of the 3-A framework were identified by an earlier study; however, the relationships in the framework were developed in this study. The results of the analysis of these inter-relationships were somewhat counter-intuitive. The fact that both affordability and awareness do not have a direct relationship to treatment volume was not

unexpected but what was not expected was the direct influence of changes in affordability and provider awareness on the level of access in the framework. Similarly unexpected were the moderating relationships of innovations in the affordability and awareness dimensions on the direct effects in the model. The insights generated in this study provide a much more detailed understanding of the supply chain coordination mechanisms and how they may be used to influence the volume and quality of care in a health care supply chain for underserved communities.

6.2 The 3-A Framework

The analysis presented in chapter 4 provides an empirical examination of the proposed 3-A framework utilizing measures of the constructs from the field study data. This examination provides an initial verification of the framework and justifies future studies of this conceptual framework of health care supply chain design. The construct measurement was conducted by generating items utilizing counts per year of the relevant dimensions in the field study data. These items were then analyzed using principal components factor analysis and final construct measures were calculated as mean scores of these items. The supply chain coordination constructs measured and tested in this empirical model were affordability, provider awareness and access.

A 2SLS regression analysis was performed in order to estimate the mediation model. This analysis utilized robust regression to minimize the impact of the small sample size and any possible impacts of outliers or other violations of the regression assumptions. This analysis was then tested for robustness using the bootstrap procedure with each of 250, 500 and 1000 repetitions with replacement. The results of the analysis supported all

of the five hypothesized relationships in the framework. Interestingly, these results contain large coefficients on the moderating effects and much smaller than expected influences for the direct effects. The study results support the appropriateness of the 3-A framework and lay the foundation for future research into the complementarity between the 3-A constructs as well as the generalizability of the framework to additional settings and industries.

6.3 Mediating Impact of Relational Coordination

To further investigate the mechanisms through which changes in the coordination mechanisms of the 3-A framework influence the outcomes of a health care supply chain, the third study utilizes the theoretical lens of relational coordination. While previous studies of relational coordination have shown significant performance impacts of increases in intra-organizational relational coordination, this study extends that work into the supply chain or inter-organizational context. This chapter utilized the field study data to examine the human roles and relationships in the health care supply chain and their impact on the effectiveness of innovations in the coordination dimensions of affordability, provider awareness and access on supply chain performance. This study included an analysis of the network of relationships over the four phases of the CHL-FHLU partnership. This examination revealed an increasing level of relational coordination between organizations with notable changes in the relational coordination construct occurring after innovations in both provider awareness and access. This study provides initial indications that relational coordination is influenced by these coordination

mechanisms in inter-organizational contexts, i.e., the supply chain, and that an increasing level of relational coordination will lead to improved supply chain performance.

To provide further support for the role of relational coordination in the supply chain, as indicated by the conceptual model development and the network analysis in this study, an empirical examination of the role of relational coordination in the 3-A framework was executed. This analysis tested the mediating relationship of relational coordination between the 3-A constructs and supply chain performance by estimating a 3SLS regression analysis. This estimation was conducted using robust regression and was supplemented by a bootstrapped analysis of 250, 500 and 1000 repetitions with replacement. These methods were used to mitigate the impacts of small deviations from the regression assumptions or the effects of outliers in the data. All three of the constituent models were significant and the proposed mediating role of the relational coordination construct was supported in this data set. The results of this study serve to enhance our understanding of the mechanisms through which the 3-As or the coordination constructs in the supply chain serve to impact performance. In this particular case, the impact of innovations in provider awareness and access serve to increase relational coordination between organizations which in turn significantly impacts the treatment volume.

6.4 Limitations and Future Research

The limitations include the generalizability of this work given that it is a field study conducted in the context of one inter-organizational setting. However, as has been argued in earlier chapters, this method allowed us to provide an in-depth definition and

development of the new constructs and the relevant framework. In addition, the nature of the field study allowed for the examination of the dynamics of changes in the conceptual framework over time. A limiting factor of the empirical results of this study is a small sample size. This limitation was mitigated through the use of robust regression and bootstrapping techniques but further studies are necessary to reinforce the results of our research. Another limitation of this study is the narrow definition of quality of care. An in-hospital mortality measure is meaningful, but in future studies a more comprehensive measure of quality would be desirable. Thirdly, this study identifies patient awareness as an additional important dimension to the larger awareness construct but does not examine it in detail. Patient awareness will likely play a key role in the design of the health care supply chain but, of necessity, this study leaves that role only partially defined.

The theoretical underpinnings for this dissertation research still require significant examination. In future research, we intend to collect additional data that allows the examination of these theories in increasingly broader applications. One potential project would involve the collection of survey data from a global cross-section of health care supply chain members and further testing the 3-A framework of health care supply chain design. This study would seek to provide further support for the relationships in the proposed model by examining it in multiple organizations and countries. Additionally, given the unexpected nature of the moderating relationships among the affordability, provider awareness, and access dimensions, future studies to examine the complementarity of these three constructs would likely provide significant insights into how to leverage innovations in one or more of these constructs to have a profound impact on improved outcomes in health care supply chains. We will then further refine our

measurement and hypotheses with regard to how awareness, access and affordability act in complementary ways to further enable increased levels of quality health care globally.

Also of interest are studies that examine the behavior of each of the coordination elements individually. These studies may give more insight into the nature and importance of single innovations in the coordination elements and how these innovations impact the health care supply chain as a whole. As mentioned previously, future studies would ideally examine a much more comprehensive measure of care quality which addressed considerations of patient follow-up treatments, re-admittance rates and complication rates. Finally, this study has focused on the patient population as a whole and can make claims to how changes in the health care supply chain influence the overall treatment volumes. In future work, it would be desirable to gather data which could investigate more specifically the individual level impact of these changes to the design of the health care supply chain and execute an analysis of a multi-level nested model to further test the 3-A framework.

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