# SERVICE DESIGN FOR THE COMPLEX CUSTOMER: AN EMPIRICAL ANALYSIS OF MENTAL HEALTH INTEGRATION AT INTERMOUNTAIN HEALTHCARE

by

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## ABSTRACT

In 1998 Intermountain Healthcare instituted a mental health integration program in its primary care clinics. Mental health patients typify complex customers: those who supply multiple inputs into service processes whose inputs can expand across multiple service providers or multiple service visits. In this study, customer complexity is measured on a continuum by the number of co-morbidities of the patient (customer).

It is hypothesized that complex customers receive better service from integrated service offerings than modular service offerings because complex customers have the most difficulty coordinating and combining services. The intensity of service integration is defined by the amount of coordination and combination of disparate service processes done by the service provider on behalf of the customer; in this study integration is measured by the practices' compliance to Intermountain Healthcare's mental health integration program. This study tests the hypothesis that integrated clinics decrease patients' healthcare asset usage, which is assumed to also correlate with better care.

The theory is tested by contrasting two patient cohorts: one serviced in integrated clinics and the other serviced in nonintegrated clinics. The patients' medical records are followed for 3 years, and the hypothesis tests are performed using hierarchal models based on the Negative Binomial Regression for count outcomes. These findings offer support for the hypothesis that more integrated service offerings require complex patients to use fewer medical assets.

The main study reveals two important theoretical contributions to the service management literature: an examination of integration and modularity of service design and recognition of the complex customer. While integration and modularity of product design are prevalent in the literature, this study examines integration and modularity in service design. Services can be integrated along both location and coordination, potentially offering swifter and more even flow through the service process. In attempting to coordinate disparate service processes, the complex customer acts as co-designer of the service supply chain. Recognition of the complex customer requires service management to look at service supply chains as part of a natural service supply chain that requires coordination with other service's processes outside the firm before the service can be completed.

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# CHAPTER 1

# INTRODUCTION

Healthcare delivery in the United States is a two-trillion-dollar business (Hackbarth, Reischauer, & Miller, 2007). Despite the vast sums that are spent in healthcare, visiting a hospital or healthcare provider can expose a patient to risks; nearly 100,000 people a year die because of medical errors. Many more who do not die are significantly harmed because of errors (Chassin, Galvin, & Quality, 1998). The need to find healthcare solutions that increase quality and decrease costs is urgent and pressing. In 2006 *Newsweek* spent an entire issue on the subject of health care improvement, but lasting improvements and a subsequent decrease in the cost of care is rarely seen or written about.

Books and numerous papers record and recite the problems ailing the American healthcare system (Chassin et al., 1998; Christensen, Bohmer, & Kenagy, 2000; Herzlinger, 1997, 2007; S. J. Spear, 2005). My purpose is to focus the discussion on healthcare improvement in one small segment of the two-trillion dollar morass: mental healthcare and process service management. Mental health providers service some of the most difficult and complex patients in healthcare; thus, studying mental health services provides a window for viewing improvement processes in one of the most difficult service environments.

I hypothesize that the more complex the customer, the better (and more efficient) care will be provided via an integral service design rather than modular design. In the context of my study, my measure of customer complexity is the number of co-morbidities of depressed patients; my measure of integrality of design is the degree to which a clinic has adopted Intermountain Healthcare's (IH) process of "mental health integration." My measure of care outcomes includes cost, visits to the ER, visits to the primary care doctors, and the use of pharmaceuticals. I find support for my hypothesis by measureable differences in decreased visits to the ER by those in the mental health integration program and by lower or neutral use of the other healthcare resources. These findings lead to managerial insights about the reasons for and against implementing integrated and modular service designs, and about how using a cascade service model can assist service providers in offering integrated care in capacity-constrained situations.

### 1.1 Studying Mental Health

There is value in studying the extremes of the customer service environment because in these extremes we often find the customer service frontier and the innovation that comes out of necessity. It is no surprise that healthcare in general is fraught with difficult customers, but even within healthcare, the frontier of difficulty is found in caring for patients with mental disabilities.

> According to a study by the World Health Organization (WHO), the leading source of disease burden, unipolar major depression was ranked as the second most disabling disease in developed economies. The WHO Global Burden of Disease study ranked diseases according to disability-adjusted life-year, which combines the measures of mortality and morbidity, including disability, into a single measure for the purpose of comparing various illnesses and their impact on the population. But when only disability was considered, unipolar depression was the leading cause of years lived with disability for all sexes and all ages. (Pincus, 2006, p. S3)

In other words, mental health-related diseases constitute a serious threat to the US healthcare system; current news items, such as a front-page article in *USA Today* entitled "Mentally ill wait unduly long in ER" (Appleby, 2008), seem to support the notion that the US struggles under its current architecture to adequately serve the depressed customer segment. These long delays are especially disconcerting when one considers that nearly 10% of all ER visits have depression listed as a primary or secondary diagnosis. The costs associated with these visits have accounted for nearly 8% of all hospital costs (Russo, Hambrick, & Owens, 2005).

The majority of patients seeking mental healthcare seek care from their primary care clinics (Schulberg, Katon, Simon, & Rush, 1998). These patients exhaust primary care providers (PCP) because of their overutilization of medical services and because of their nonadherence to care, which leads to inefficient processes for both the patients and the providers (Ford, 2006). Even when referring patients to a mental health specialist is an option, estimates show that only 50% of those referred out of clinics visit the specialist more than once; many patients avoid the mental health system, returning to their PCP at a later date, showing no improvement (Ford, 2006).

This study is important precisely because it studies primary care patients. Most healthcare studies in operations management focus on hospital care (i.e. Berk & Moinzadeh, 1998; Black, Carlile, & Repenning, 2004; Butler, Keong Leong, & Everett, 1996) because it is repeatable and because hospitals provide a uniform reporting mechanism. Studying primary care across multiple clinics, however, is more difficult because tracking patients and uniformly reporting on them is difficult at best. Intermountain Healthcare's information system and its program of integrated mental health services presents a unique opportunity to study an increase in service integration in the primary care arena.

Additionally, this study also contributes to the literature by defining and studying integration and modularity in service provision. Up to this point, integration and modularity have mainly been defined through their application to the design and assembly of products (Salvador, 2007); this dissertation's application of integration and modularity is a small but significant extension of the literature. This study tests the hypothesis that integrated services are beneficial to complex customers and that as customers' complexity increases, the benefit of integration also increases. Through studying service integration, I highlight its necessity by also defining the complex customer and demonstrating how the capability of the complex customer affects the benefits the customer is likely to receive from the integration of services.

### 1.1.1 IH's Efforts and How They Relate to My Study

Starting in 1998, Intermountain Healthcare (IH) began a courageous and dedicated fight to restructure the way primary care delivers mental healthcare. (Because of the barriers to receiving mental healthcare, primary care has become many patients' sole provider of mental healthcare (Schulberg et al., 1998; Simon, VonKorff, & Barlow, 1995).) This program has been led by world-renowned researchers like Dr. Brent James, Dr. Lucy Savitz, Dr. Brenda Reiss-Brennan, Dr. Wayne Cannon, actuary Pascal Briot, and countless other dedicated staff and clinicians. To launch the program, IH applied for and received a grant from the Robert Wood Johnson Foundation, which funded the first clinic's testing and development of the Mental Health Integration (MHI) program. From that first clinic, the process has spread to numerous other clinics and partners in more than four other states.

IH's information system tracked information regarding both its integrated clinics and its traditionally run primary care facilities, allowing for comparisons of integrated versus modular care for depressed patients. The opportunity to gather and analyze this rare data set makes this study unique and compelling. Additionally, IH's eagerness to engage in this study and examine MHI from an operations perspective also facilitated the study's success and feasibility.

## 1.2 Dissertation Roadmap

The remainder of the document will proceed as follows: Chapter 2 of this dissertation consists of the empirical model and study. First, I contrast IH's Mental Health Integration process with the traditional care for mental health administered in primary care clinics. Second, I define integrated services and contrast this definition with the literature on product integration. Third, I outline my hypotheses for studying the benefits of an integrated healthcare model. In the penultimate section I describe the data, the testing procedures for the data, and summary of the data results. In the final section, I discuss the limitations of the study and how the results apply to managers, the field of operations, and service management theory.

In addition to the main study, this dissertation introduces theoretical propositions and important connections to the service management literature. These writings are found in Chapters 3 and 4. Chapter 3, "Service Integration and Modularity," discusses in detail the theoretical ramifications of integrated versus modular services, including a 2 x 2 matrix mapping service industries according to the manner in which they integrate. In greater detail it maps and contrasts product modularity to service modularity and integration. Chapter 4, "The Complex Customers and Their Effect on the Service Supply Chain," discusses the theoretical ramifications of complex customers and why their role in service design predicts the success of integration for less able customers.

After the three main chapters, there are also a number of Appendices, which approach literature and other theoretical ideas at greater length. Appendix A connects this study to the service design literature. Appendix B discusses the additional complexity that results from integrating services. Appendix C goes into greater detail about the statistical tests and records programming results for the empirical tests. Appendix D takes ideas learned from the study and relates them to a teaching philosophy and presents a paper to be submitted to an operations teaching journal.

# CHAPTER 2

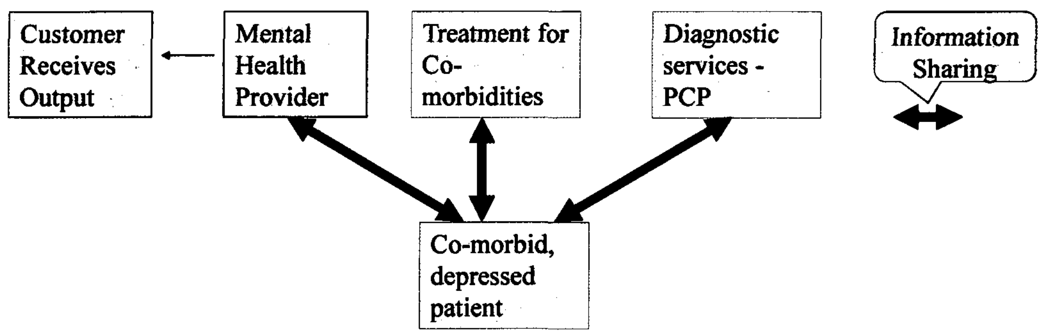
# EMPIRICAL ANALYSIS OF MENTAL HEALTH INTEGRATION AT INTERMOUNTAIN HEALTHCARE

## 2.1 The Traditional Model of Mental Healthcare Versus Mental Health Integration

To explain the uniqueness of Intermountain Healthcare's (IH) Mental Health Integration (MHI) model, I will first describe the system of treatment at a traditional non-MHI primary care clinic. In a non-MHI primary care clinic, the process of care for a patient with depression follows a typical pattern. A patient enters the service system by visiting the primary care clinic, where she waits in the office until she can be seen. After a period of time, the patient follows a nurse or physician assistant into an available examination room. The nurse records all the vital signs and takes preparatory notes for the primary care physician (PCP). Typically, the patient waits a second time after the nurse finishes for the arrival of the doctor. At the arrival of the PCP, a conversation about the patient's symptoms and health problems begins as the PCP attempts to diagnose the patient's malady.

If the patient does not recognize her own symptoms, the doctor (who usually has had minimal training in mental health) may or may not recognize that certain outward physical maladies the patient is suffering (often called somatic complaints) are symptoms of an underlying mental health problem. Possibly after multiple visits, the PCP correctly diagnoses the patient with depression. After the diagnosis, the doctor either prescribes a medication or refers the patient to an external mental health provider. If the PCP refers the patient to an outside clinician, the PCP will receive little to no feedback from the mental health specialist on the progress being made by the patient because of the state of fragmentation between medical and behavioral services. A typical patient in Utah will wait up to 4 months to see a mental health provider, during which time her mental health needs often worsen due to neglect. Additionally, if the patient has multiple aliments (co-morbidities), she will require care from multiple doctors, and she will be required to coordinate the care she receives between the disparate providers of service for each illness. In essence, the traditional primary care clinic requires the patient to manage her long-term care for her chronic disease and to coordinate her care across multiple specialties. The care design supports those who are adept at navigating a modular service systems, but the system lacks structure to support those who struggle to manage such a system (see Figure 1).

In contrast to the non-MHI process, MHI clinics focus on offering integrated care to those who suffer from mental health sicknesses and other chronic diseases. The beginning of the process is similar to the process at the traditional primary care clinics. A patient enters the service system by visiting the primary care clinic, where she waits in




Modular care system, where the patient (customer) is expected to coordinate service needs between the disparate service providers. Note: in this scenario the PCP diagnoses the patient and refers the patient out for treatment for both her diabetes and depression, but other scenarios are also plausible such as where the PCP performs all three tasks or where the PCP also refers out the diagnosis.

Figure 1: Traditional primary care

the office until she can be seen. After a period of time, the patient follows a nurse or physician assistant into an available examination room. The nurse records all the patient's vital signs and takes preparatory notes for the PCP. After the nurse finishes, the patient waits for the arrival of the doctor. At the arrival of the PCP, a conversation about the patient's symptoms and health problems begins as the PCP attempts to diagnose the patient's malady. At this point, the two processes begin to diverge as mental health integration engages. In the MHI program, PCPs receive extra basic training in mental health, giving the MHI PCPs additional skill in recognizing symptoms and conditions of depression. Additionally, the PCPs are supplied with a mental health packet consisting of validated survey instruments prepared by mental health specialists. The packet assists doctors, giving them diagnostic tools to assist in measuring the severity of a patient's mental illness. Once the doctor has gauged a patient's severity, the doctor sorts the patients according to the severity of their mental health symptoms and other chronic conditions, using IH's "Treatment Cascade Model (TM—Intermountain Trade Mark)."

If the patient is sorted into the severe category, the entire mental health team will be activated, and the patient may also be referred out to mental health facilities. If the patient is sorted into the moderate category, the whole team will be activated, but the patient will most likely not be referred to outside resources. Patients in the mild category will be monitored by the PCP and only be referred to other team members if their condition escalates. The important differentiating factor between MHI clinics and traditional clinics is who is responsible for the integration of care between the PCP and other providers: in MHI clinics, integration is done by the clinic's staff in partnership with the patient as described below.

Patients sorted into a care group begin to receive integrated support (i.e., treatment from different team members) according to the severity of their needs. The MHI model integrates all the disparate groups needed to support a mental health patient using three additional tools not found at non-MHI clinics: the mental health packet, the care manager, and mental health providers in the primary care facility.

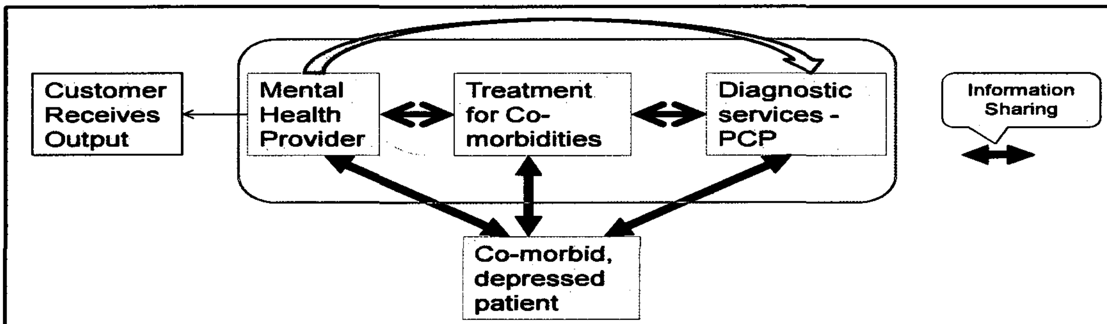
The mental health packet mentioned previously acts as the first tool of integration. (The packet contains self-assessment evaluations the doctor can give to patients to complete.) By using the tool, PCPs gain understanding of the severity of their patients' needs and direction in how to sort patients into treatment pathways. The packet, in effect, serves to provide a base of understanding of the patient's overall mental health condition that the entire MHI team can use to rally around and to support the patient. Furthermore, integration from the packet is augmented through physician training. For example, the PCP receives continuing education on the treatment of mental health conditions via training seminars and case reviews conducted by mental health specialists such as Psychiatry APRN and/or psychiatrists.

The care manager, the second tool of integration, is a registered nurse who acts as an extension of the doctor. Most primary care physicians have only 15 to 20 minutes to spend with a patient, adequate for the most routine checkups but insufficient for visiting with a patient who exhibits undiagnosed and complex symptoms. The care manager acts as an extension of the doctor by meeting with the patient at the doctor's request, providing education about the chronic disease, making appointments with mental health professionals, and introducing patients to community resources like the National Alliance on Mental Illness (NAMI). Essentially, she acts as the coordinator of care for those who most need assistance, becoming the relationship manager for chronically ill patients and increasing their access to care.

To achieve full integration, MHI clinics bring mental health providers into the primary care clinics: this comprises the third tool of integration in the MHI program. These mental health specialists include APRN psychiatrists, psychologists, psychiatrists, and licensed social workers. Hired by the clinic and receiving hourly pay, they are incentivized to be full team players who consult with PCPs and see patients. The advantage of this arrangement comes from the teamwork achieved by the entire MHI team working together rather than as independent contractors. In the best clinics, they act seamlessly with the clinic as equal partners and in the best interest of the patient. This also has the important impact of reducing the waiting time for patients to see a mental health specialist. One PCP I spoke with said his clinic would fall apart without the MHI program because it had become so integral to his clinic. He said having the mental health specialists in the clinic allowed the doctors to "rub shoulders" together, to collaborate in the hallway, and to quickly address immediate patient needs.

The MHI program's increased integration addresses two weaknesses traditional care systems demonstrate when serving chronically ill patients. MHI addresses these weaknesses by coordinating both the long-term and the cross-discipline care needed for chronically ill or complex patients; for example, the care manager coordinates the care of chronically ill patients, tracking them, organizing their appointments, coordinating visits with mental health specialists and disparate specialists for co-morbid patients, and working as an extension of the primary care doctor (see Figure 2).

IH's redesign of services to support mental health patients displays its organization's commitment to excellent patient care. The system parallels the recommendations of Harvard Health Policy Researcher Regina Herzlinger.




An integrated care system, where the service providers assist the patient in coordinating service needs between the disparate service providers. Note: in this scenario the PCP diagnoses the patient , the care manager and PCP jointly educate about and treat the patient for diabetes, and a mental health specialist treats the patient for depression jointly with the PCP. The box denotes all the providers reside in the same clinic.

Figure 2: Mental health integration

In her book *Who Killed Health Care?*, Herzlinger (2007) describes her ideal for the care of diabetic patients:

> The 20-plus million diabetics in the United States illustrate the problem. Many suffer from several diseases at the same time. Among diabetics, nearly half also suffer from high blood pressure and up to a tenth from asthma, heart disease, and behavioral problems. Diabetics require a team that devises and provides appropriate plans for their complex medical care—endocrinologists, cardiologists, nephrologists, dermatologists, podiatrists, and behavioral support specialists, among others. Yet even though this integrated team represents the most sensible way to deliver treatment to diabetics, most victims of the disease cannot find it. Instead, they are treated by many different specialists spread out in several different offices and practices. As a result many diabetics receive inadequate care. For example, only 36 percent of fully insured elderly diabetics had a crucially important test that measures long-term levels of sugar in the blood. These abysmal results are even worse for African-Americans and poor people. (p. 168)

In a similar manner to Herzlinger's recommendation for diabetic care, MHI organizes resources around the physician to help care for mental health patients. MHI co-locates a mental health specialist in the PCP's clinic as a paid team member, and MHI provides a care manager who connects patients with community resources, mental health professionals, and other medical specialists to provide seamless relational care.

In addition to Herzlinger, Christensen also advocates for different forms of integration. Christensen, Grossman and Hwang (2009) highlight two examples of what they label "solution shops." In Colorado and also in Minnesota at the Mayo Clinic, groups of specialists meet together to discuss diagnoses and treatment options in real time. These joint meetings integrate the care across specialties and increase the level of care and accuracy of diagnoses, which leads to a faster resolution and treatment plan for the patients.

In summary, there is a case to be made that IH's integrated approach to treating mental health should lead to better outcomes for patients. This settlement maps to the product architecture argument stating that in theory integrated products perform at a higher level (Baldwin & Clark, 2000). The next section will define the difference between an integrated and a modular service and will explain theoretically why integrated services like integrated products lead to positive outcomes for patients.

## 2.2 Integrated Versus Modular Service Design

### 2.2.1 Why Differentiate Between Integrated Versus Modular Service Design?

If the choice between a modular versus an integrated service system boils down to customer preference or customer convenience, the choice becomes nothing more than a marketing tool for service providers to differentiate themselves from other providers. But if the choice between modular and integrated design affects the quality of the service offering for all customers or even just certain niche customer groups, the choice becomes a vital service design issue for those service providers who serve these customer groups. This paper hypothesizes that complex customers receive benefits from integration because they are required to navigate disparate service offerings.

> *A complex customer is defined to be one who: 1) demands multiple processes, 2) experiences interactions between these processes, and 3) could benefit from assistance in managing the interactions and interfaces between these processes. Customer complexity increases with the number of processes, the extent of interactions, and the degree of customer ineptness in managing service interactions and interfaces.*

A patient with a single need (i.e., needs only a physical) is simple and not complex, but once a patient has at least two needs, complexity can be measured on a continuum. As the number of needs increases, so does the patient's complexity. Because modular service offerings require that the customer coordinate and combine the service offerings, those customers who find this coordination process the most arduous will benefit the most from service process integration. As the complexity of the customers' needs increase, the value of service process integration for these customers will also increase; thus, understanding integrated versus modular service design is vital for the care of a large portion of the customer population (complex customers/patients).

Frei (2006) noted that customers introduce capability variation into service processes, or in other words, some customers are more capable of performing tasks than others. This paper hypothesizes that customers become less capable of performing their role of coordinating and designing their service supply chain (see Chapter 4) as their needs become more complex, and thus integrated service offerings, which carry more of the coordination burden in behalf of customers, offer a higher level of service.

It is important to note that complex customers can be mapped on a continuum of capability. Some complex customers (on the high-end of the continuum) "ably" possess the requisite knowledge and ability to coordinate and compile all the needed independent service processes into a complete package, reaching optimality with little or no assistance, but they may still benefit from integration. For example, a financial professional may be perfectly capable of coordinating all the services to sell her home, but she may still derive benefit from hiring a real-estate agent to coordinate the services in her behalf. Other complex customers (further down the continuum of ability) possess insufficient knowledge or skill to coordinate and bundle all the needed independent services into a coherent service package, failing to reach an optimal outcome without service provider assistance.

Unlike the less complex patients, who complete their service in a single visit to the PCP, complex patients will require multiple visits to the same PCP or visits to multiple specialists to be fully served. Because complex patients will require service from disparate providers or visits, they can seek care from an integrated service provider or a more modular provider. In the next section, the continuum between service modularity and service integration will be defined.

### 2.2.2 Integration Versus Modularity

Service literature says little to nothing about the idea of integration versus modularity in service design and delivery. One partial reason for this absence could be because, as Sampson (2000) noted, service supply chains are short because of their JIT nature, and thus it is easier to differentiate service steps as separate processes instead of integrating them as a whole. Another reason could be found in Tsai, Verma, and Schmidt's (2007) book chapter, which details the literature on service design. The authors and the literature they cite never mention modularity and integration by name, but they do comment on factors in the service design process, which would affect a service process's ability to integrate. (In Appendix A, I discuss how the concepts of modularity and integration build on the literature of service design.) A third reason why the concepts of modularity and integration are not mentioned often in service management comes from a misunderstanding of the service the complex customer is trying to accomplish or a misunderstanding of the complex customer's "service concept" (Goldstein, Johnston, Duffy, & Rao, 2002). For example, it is safe to assume that patients visit a doctor seeking the "service" of getting better; thus with chronic disease, multiple visits are required to a single primary care doctor to accomplish the "service" and all the visits in totality constitute a single service transaction.

Some may argue this distinction of multiple visits being a single service transaction is trivial or unimportant. In order to demonstrate my point more clearly and to counter these arguments, one need only compare a patient to a student. Segregating each doctor visit would be like selling a student a semester long course but treating her as a new customer at each class period because each class is treated as a separate service transaction; or it could be likened to an accident victim going to the hospital with multiple organ failure and assuming each doctor who sees the patient constitutes a wholly unique service process having nothing to do with the service processes that came before. An article by Goldstein et al. (2002) criticizes service management literature for forgetting the "service concept" in service design; likewise if each doctor visit is not combined, it would be in effect separating the service concept from the service design. In summary, there are valid reasons why service integration and modularity are not commonly found in the service literature, but when the multiple needs of the complex-customer are considered, it becomes clear there is a need to describe and define integrated service processes. Because of the absence of integration in the service management literature, the product design literature where the discussion of modularity is pervasive will be used to build a theory of integration and modularity in service processes.

### 2.2.3 Applying Modular Versus Integrated Product Design Theory to Services

There is extensive literature on modular versus integrated design as it relates to physical products. Recently two surveys of the research have been published (e.g., Fixson, 2007; Salvador, 2007). A discussion about modules or components lies at the root of all the papers on integrated and modular design because modules have been inconsistently treated in the product design literature (Salvador, 2007). For example, some authors suggest modules are like chemical compounds and physically nonseparable parts of larger products (Pine, 1993); others allow simple component parts to be considered potential modules (Kusiak & Huang, 1997) while others suggest modules must have some complexity (Baldwin & Clark, 2000). Finally, some suggest that only discrete components and subassemblies, which are separable parts of larger products, should be considered as modules (Lele & Karmarkar, 1983). Out of the many definitions, I prefer Ulrich's definition of a component because it could easily describe service process and is synonymous with module.

> I define a component as a separable part or subassembly.... a component can be thought of as any distinct region of the product, allowing the inclusion of, for example, a software subroutine in the definition of a component. (2007, p. 2)

McClelland and Rumelhart's definition is also similar:

> A module is a unit whose structural elements are powerfully connected among themselves and relatively weakly connected to elements in other units. Clearly there are degrees of connection, thus there are gradations of modularity. (as cited in Baldwin & Clark, 2000, p. 61)

For the remainder of the paper I will borrow Ulrich's definition of a component/module and liken it to an independent service routine, which can be separated from a larger service routine and be performed by the customer or an additional service provider.

In one sense almost every service process can be defined as modular since almost any product or process can be broken into separate parts or "components" (Schilling, 2000). Because all service systems consist of components, the important question to answer is, "When do segmented services processes constitute a modular versus integrated service system?"

As it applies to physical products, modularity is viewed as follows (e.g., Baldwin & Clark 2000): A modular product architecture is one where there is a well-defined interface connecting different modules (or components). Within any given module, a change in the design of one part can have a big impact on the performance of each other part (there is a high degree of interaction between the parts inside that module). For example, if you change the diameter of the pistons within the engine of a car you may also have to change the design of the piston rings, the connecting rods, the crankshaft, and a host of other parts. But across modules, a change in the design of a part in one module has little impact on the performance of a part within a different module (there is little interaction between parts across modules). Again referencing the car example, changing the piston diameter may not significantly impact the transmission design. The modular design requires that tight specifications be developed to define the interface between modules—these specifications define exactly what each module is supposed to "deliver" in terms of output and performance. At the interface between the engine and the transmission there is a standard flywheel interface.

In contrast, an integral product architecture is one where the components have a high degree of interaction. Ulrich defines it this way, "An integral architecture includes a complex mapping from functional elements to components and/or coupled interfaces between components" (2007, p. 3). It is generally accepted that an integral architecture offers the highest possible level of performance, as every component in this design can be tailored to deliver the very best performance for the product as a whole. Some research suggests that innovation breakthroughs happen most often in integrated products (Fleming & Sorenson, 2001) because in a modular design, it may be necessary to compromise on any one part in order to make that part independent from parts in some other module. But an integral design has disadvantages, in that it may not be flexible enough to handle different customer preferences and needs. If you had a fully integral car and wanted to offer both 4-cylinder and 6-cylinder engines, each version of the car would have its own entirely unique design, whereas a modular design would allow you to simply swap one engine for the other (see Figure 3).

Modularity relates to primary care in the following way: In a normal "modular" care setting, the primary care physician (PCP) gives the initial diagnosis and sends the patient to another module (e.g., the psychiatrist). The PCP writes a prescription and sends the patient to yet a different module (the drugstore) to get the prescription filled. The patient must manage the interface between these modules, shouldering the responsibility for the continuation and coordination of care. *Thus in a modular service the customer/patient shoulders most of the burden of coordination of care and serves as a necessary interface between service processes (components).* As suggested earlier, the patient may be referred to a specialist by a primary care physician, but the management

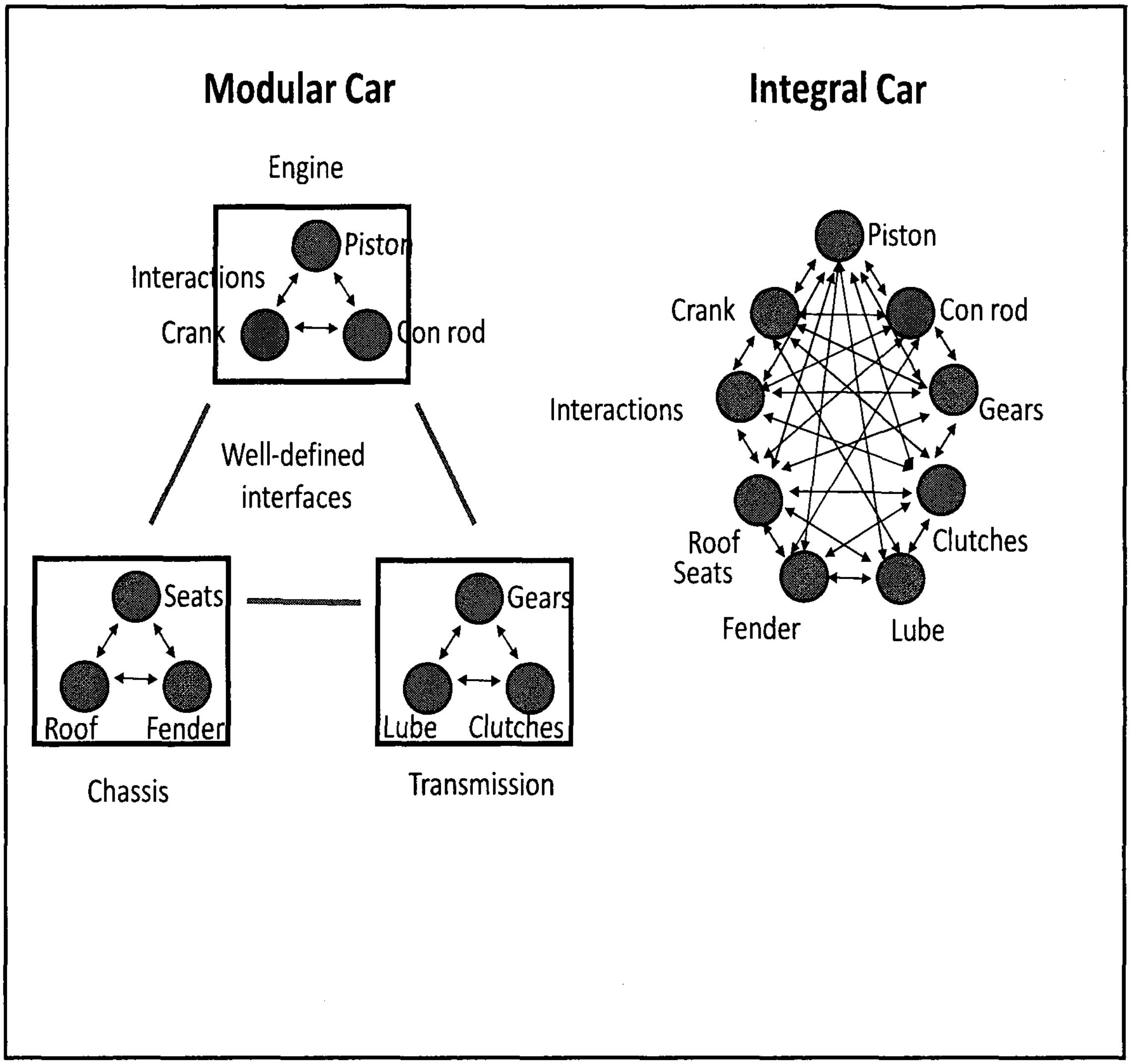



Figure 3: Modular product design versus integrated product design

of the appointment and the communication of the disease symptoms done by the patient, with no direct communication between care providers. This research hypothesizes that as the responsibility of integration increases in difficulty, service quality of the entire system will deteriorate. The literature suggests self-coordination of care in a modular service environment is difficult for depressed patients.

> Moreover, while referral to a mental health specialist may be one option for getting patients the right treatment, it is estimated that only 50% of those referred actually have more than one visit. Most patients will never engage in the mental health system and instead return to the PCP at a later time without any improvement in symptoms. (Ford, 2006, p. S10)

The typical modular care provided by primary care clinics contrasts starkly with integrated care offered in an MHI clinic. To care for depressed patients, MHI clinics rally entire teams, which display complex communication patterns. For example, the doctor and the care manager carefully coordinate patient care options and build bridges between community organizations and mental health specialists; they create multiple communication routines between service providers and the patient; and the process creates a coupling of services as mental health specialists, care managers, and primary care doctors share office space. *In an integrated service offering, disparate providers communicate and coordinate care for the customer and (possibly) share location (customer/patient takes on a lesser burden of coordination).* An integrated healthcare service process is one where the patient takes on a lesser burden of care coordination and where disparate providers are linked by coupled communication routines and shared location (see Figure 4).

The basic ideas from product architecture also apply to service design, but there is a subtle difference in service design, which creates problems when a direct transfer of terminology is attempted: customers! Customers are a necessary and sufficient part of every service (Sampson & Froehle, 2006). But while Baldwin and Clark (2000) claim modular products have well-defined interfaces between modules, in modular services, on the other hand, the main interface between service processes is the customer. Customers are anything but a well-defined interface (Frei, 2006). They are generally a very heterogeneous interface and they introduce significant variation into service processes (Frei, 2006). The fact that customers function as the integrating interface causes the large divergence between services and products.

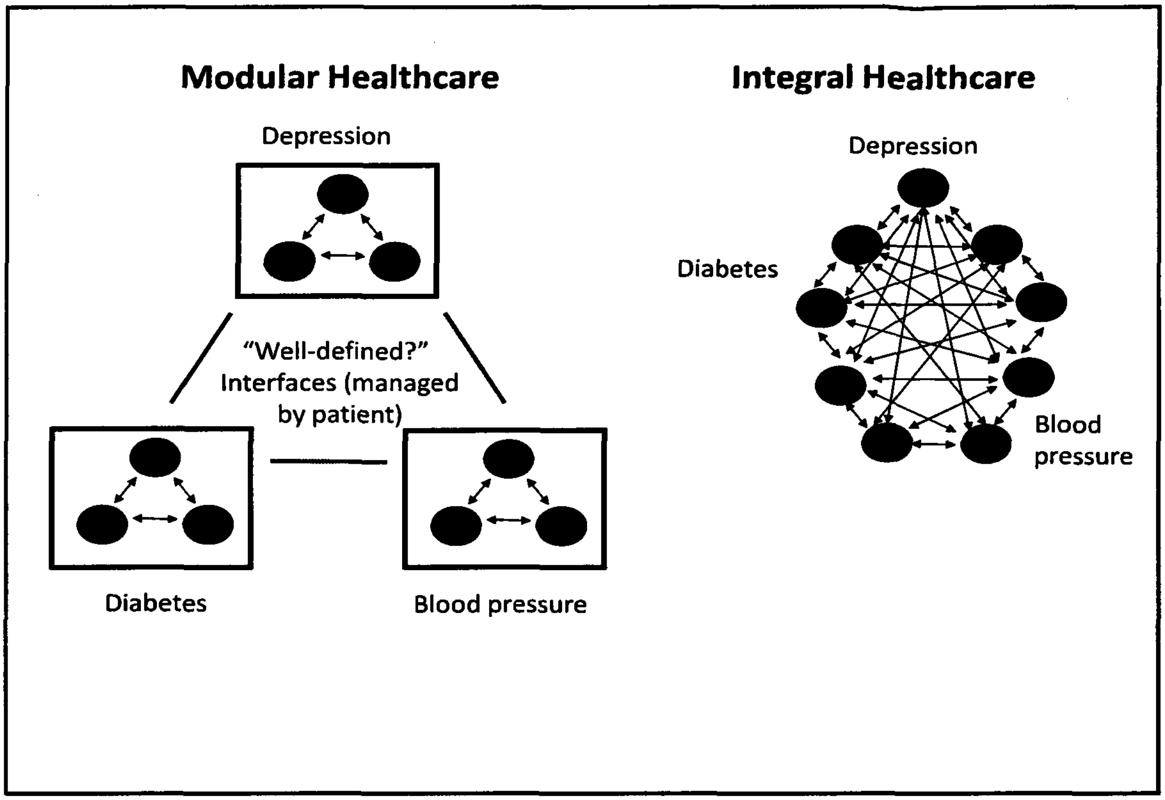



Figure 4: Modular services versus integrated services

To continue the analogy of the automobile, to create an end-use vehicle, both the modular vehicles and the integrated vehicles must do two things: first bring together Figure 4: disparate modules and second determine how they will communicate. The difference between modular and integrated vehicles lies in the way the modules communicate. Because customers are an integral part of the service supply chain, two scenarios are possible in services that are unthinkable in vehicle product design. First, in services disparate modules might never be brought together, because the customer is in charge of this process and can, if needed, traverse long distances to link the service supply chain such as between an airport and a hotel on a business trip. Imagine a car sold to a customer where all the parts were connected by long wires, but the parts were scattered across suppliers' sites in multiple states. Second, imagine a vehicle in which the modules are brought together, but no plans are made for how each module will communicate with the other modules because the customer will be in charge of communication and coordination. Imagine a vehicle where none of the internal parts are connected but they are all there. While both of these scenarios are unthinkable in car production and design, they happen daily in services because a customer is a co-designer (see Appendix B) and supplier (Sampson, 2000) in the service supply chain, and in most cases the customer is a very able provider of coordination and the combination of services. Indeed, in many instances the customer insists on having the autonomy to fit pieces together in the order and manner she pleases. Car companies would not dream of giving customers the power of deciding when and how modules in automobiles operated. Likewise, iPhone customers have been begging for years for the ability to swap batteries out, but Steve Jobs has not yet felt the need to comply.

It is important to note that integration for services is rarely black and white; it is better defined as a continuum. Just as Schilling (2000) warned in the product design literature that on some level all products can be considered modular, so also services are best understood as integrated versus modular when they are compared one to another. For example, a PCP office with mental health integration might be considered modular when compared to a full service hospital because of its large staff and more complete service offerings, but in comparison to traditional PCP offices it is more integrated. Thus a truly modular service occurs when the customer collects and communicates between all service processes without assistance (the customer coordinates her entertainment on a Friday night between the restaurant and the movie theater or coordinates her care between multiple doctors' offices). While a comparatively more integrated process brings services together and performs part or all the communication and coordination on behalf of the customer (the Alamo Drafthouse in Austin Texas serves dinner and shows movies and in the MHI model, a mental health provider, a PCP, and care manager all reside in one office to provide integrated and coordinate care).

As defined earlier, a complex patient is one who has multiple needs and thus demands service from multiple service processes, and it is the management of disparate interfaces between service modules that causes the majority of service issues for complex customers. Additionally, the hypothesis that complex customers will have more difficulty managing traditional modularized healthcare compared to managing integrated healthcare organizations has support in the traditional product literature as well. The product literature speaks about “virtual products,” which can be likened to a modular healthcare system, which must be pieced together to form a “virtual service product.”

> In some markets, such as home entertainment, users create virtual products by assembling collections of products provided by diverse manufacturers. Modularity at the level of the entire system, when combined with standard interfaces, allows for the virtual artifact to evolve and change through independent actions by individual manufacturers. (Ulrich, 2007, p. 14)

Customers faced with virtual service processes must be adept at mixing and matching products to arrive at an optimal outcome. To extend Ulrich’s home entertainment system analogy, if I am an audiophile or “techy” I would most likely enjoy putting together disparate parts to build an optimal system; on the other hand, if I am not confident in my abilities, I will probably buy the stereo as a complete set from a single manufacturer. The complex customer on the low end of the ability spectrum can be likened to the nonaudiophile customer. The medical literature strongly supports the idea that most depressed patients and their primary care physicians will find the mixing and matching of service processes difficult at best (Ford, 2006). In the product architecture literature, the difficulty of mixing and matching product parts puts pressure on a system to integrate (Schilling, 2000); thus, the product design literature theoretically supports the idea that customers who find it difficult to combine component service process may significantly benefit from receiving integrated care.

In support of this concept, Dr. Provonost (Gawande, 2007) studied hospitals staffed with internists and found these hospitals produced better outcomes in safety and efficiency for patients because in effect the internist acted in a similar manner to MHI's care managers by coordinating care for patients in the modular environment of the hospital. Integration need not require extra staff: It can also be facilitated by technology; the digital integration of medical and information systems in a hospital in Hackensack, NJ, led to a drop in mortality of 16%, a shortening of the average length of stay by 24% (evidence of decreased medical asset usage), and an increase in the hospital's operating margins from 1.2% to 3.1% (Mullaney & Weintraub, 2005). In line with these results, Schmenner (2004) theorized that the best performing services increased the swift and even flow of customers through a process; it may be that integration increases the swift and even flow of complex patients through the healthcare system, giving an advantage to patients in an integrated system (Schmenner, 2004).

When the concept of the complex customer is combined with the concepts of integrated and modular services, it becomes clearer that customers are selecting multiple service processes to complete their service needs, and that these service processes can either be delivered in an integrated fashion by the supplier or they can be pieced together in a more modular fashion by the customer. In effect, customers play the role of co-designers of the service supply chain in addition to their role of customers in the service supply chain. For example, the customer might choose to eat at the Olive Garden and travel to AMC theaters, or she might choose to have all the processes delivered in one setting; either way, she can be considered co-designer in the look and delivery of the bundle of service processes she needs as a complex customer. This role of co-designer is in addition to other roles the service management literature has identified for customers such as supplier (i.e., bringing her car to Jiffy Lube (Sampson, 2000)) and co-producer (i.e., participating in physical therapy (Mills & Morris, 1986)). (The topic of the complex customer being a co-designer in the supply chain is more deeply covered in Chapter 4.)

## 2.3 Hypotheses

### 2.3.1 Overview

When compared to traditional care, mental healthcare at IH is integrated into primary care clinics, bringing disparate specialists together in a co-located setting, hiring care managers to facilitate the coordinating of care processes for IH's most complex patients, and providing tools to assist in diagnosis. Through integration, IH makes navigating the healthcare system easier for complex patients because it assists these patients in their role as co-designer and supplier to the care process. IH contrasts with traditional/modular care where the patient as co-designer is fully in charge of seeking out disparate care providers and as supplier is in charge of facilitating the coordination of care between the processes.

### 2.3.2 Filling in the Gaps in the Literature

Some theories suggest the activities involved in integrating services might not always produce optimal outcomes for all parties involved. Detractors claim integration disaggregates centralized mental health services, decreasing the value of economies of scale and pooling (Netessine & Rudi, 2006). Integration also combines a value-adding process with a solution shop, which Christensen et al. (2009) claim is an expensive and not particularly effective strategy. Additionally, critics claim, integration unfocuses primary care clinics (Herzlinger, 2007; Skinner, 1974), creates additional variation (Cayirli & Veral, 2003), and produces additional bottlenecks in the service process (Manager, 2004). These disagreements come because the boundaries of beneficial and detrimental integration have not been clearly defined. In the following paragraphs I demonstrate how the theory of integration's benefit to complex customers fills in an important gap in existing service management literature.

The gap in service literature can be traced to the extensive literature in services on the customer as a co-producer (Sampson, 2001; Tsai et al., 2007). The service management literature has recognized the important role customers play in the production of services (Mills & Morris, 1986), and it has even been recognized that the customer is a supplier in the service supply chain (Sampson, 2000). I extended this idea by demonstrating that the customer is also a co-designer of the service supply chain (see Chapter 4 for greater detail). The gap in the literature is not in the customer's key role, but in research surrounding the customer's likelihood to fail at the co-designer and supplier tasks.

Because customers are an essential part of the service process (Sampson & Froehle, 2006), it is obvious that their role would contribute to the quality of the service process. Frei (2006) acknowledges the variation customers introduce into service processes and points out that service businesses have the responsibility to control customer-induced variation. She tells the following story about Starbucks's efforts:

> Starbucks provides an excellent example of the deft handling of capability variability. The coffee shop chain allows customers to choose among many permutations of sizes, flavors, and preparation techniques in its beverages. In the interests of filling orders accurately and efficiently, Starbucks trains its counter clerks to call out orders to beverage makers in a particular sequence. It is all the better when the customers themselves can do so. Therefore, Starbucks attempts to teach customers its ordering protocol in at least two ways. It produces a "guide to ordering" pamphlet for customers to peruse, and it instructs clerks to repeat the order to the customer not in the way it was presented but in the correct way. The tone is not one of rebuke, but nevertheless most customers learn to avoid the implied correction by stating their order in the way that helps Starbucks's operations—with no hit to the service experience. Indeed, for some customers, getting the order right is an aspiration, a small victory on the way to the office. It's a clever solution, achieving an uncompromised reduction of variability. (p. 97)

As Frei points out, controlling customer-induced variation is vital, but what is missing in the literature is the role of customer-made mistakes while coordinating broader networks of service and care. Mistakes made by the customer in her role as a co-designer of the service supply chain have not been addressed and are a missing key to increasing service quality and decreasing service process rework. Recent studies of hospital readmissions have shown many patients make mistakes in self-care after being released from the hospital for surgery (Bisognano & Boutwell, 2009): up to 70% have problems with medication (Naylor, Foust, Boling, & Cappuzzo, 2005) and half of the patients being readmitted never saw a physician (Bisognano & Boutwell, 2009), causing 12 billion dollars in unnecessary readmissions in the United States. A chief medical officer at a large health system in the United States described his after-surgery experience in this manner:

> He was mostly delighted with the care he received, but, when asked if he had experienced any surprises, he responded this way: "The pain was a surprise—mostly because each nurse seemed to have his or her own theory of pain management. Some predicted and managed pain aggressively, and others 'followed the orders' to the letter, even when I was in severe pain, without consulting the surgeon. The biggest surprise was at home. I was alone, fearful, uninformed, and disconnected. I had no real education on how to care for myself and no way to reach out for information, guidance, consolation, and care. I thought maybe it was because I am a physician, but now that I am sensitive to this, I see this failure happening everywhere." (Bisognano & Boutwell, 2009, p. 4)

If a highly trained doctor and administrator at a well respected hospital has misgivings about his own care, it is clear that self-managed care is a part of the process that may be prone to mistakes, especially for complex patients. These mistakes are not costless to the care system (Hackbarth, Reischauer, & Miller, 2007). I propose service integration is a tool for mitigating and decreasing mistakes made by customers in their role as designer and supplier of the service process.

For those interested in the literature on human mistakes I refer them to Reason's (1990) book entitled "Human Error," which summarizes the literature in psychology on the theory behind human mistakes. He provides the following definitions:

> Slips and lapses are errors which result from some failure in the execution and/or storage stage of an action sequence, regardless of whether or not the plan which guided them was adequate to achieve its objective.
>
> Mistakes may be defined as deficiencies or failures in the judgmental and/or inferential processes involved in the selection of an objective or in the specification of the means to achieve it, irrespective of whether or not the actions directed by this decision-scheme run according to plan. (p. 57)

In other words, complex customers are more likely to make slips, lapses, and mistakes because they are required to access more service modules, and in unfamiliar modules like medicine, judgment failures are more likely as witnessed by the high rate of hospital readmissions (Bisognano & Boutwell, 2009). Service integration acts like a service Poko yoke to mitigate and eliminate lapses and mistakes customers make in their role as co-designer of the service process (Stewart & Grout, 2001).

In most service processes this is not a concern because it is unimportant if a customer has a nonoptimal family vacation or night out. Usually, customers do not even realize their own failures because they rarely have multiple trips to Hawaii to compare experiences. In healthcare and education our views are quite different, especially when we begin to see service failure in terms of rework. As previously cited, we have rework in terms of failed mental health patients ending up in the ER (Russo et al., 2005) and rework in the terms of high rates of readmission (Bisognano & Boutwell, 2009). Just imagine what university ratings would look like if they were judged by the number of students who dropped out or failed to find employment after graduation; it might make the educational community more finely examine their level of rework.

This premise is also supported by the medical literature: Brief physician visits with co-morbid patients are not conducive to consistent care and treatment, even when evidence-based medicine is available (Bodenheimer, 2007), because patients not only need education about the disease, they also require self-management training, which is impossible for doctors to provide in short timed visits (Bodenheimer, Lorig, Holman, & Grumbach, 2002). Understanding these shortcomings to primary care leads to the expectation that for chronically ill and co-morbid patients, an integrated team approach to care may be more effective (Bodenheimer, Wagner, & Grumbach, 2002). Research indicates that dedicated integrated teams can make a difference in mental healthcare (Grumbach & Bodenheimer, 2004; Reiss-Brennan, Briot, Cannon, & James, 2006). Thus, the more complex a patient is, the more that patient will benefit from receiving integrated care. Ford commented about how inefficient nonintegrated care is:

> Moreover, patients with depression frequently overuse medical services and markedly drive up primary health care costs...This combined overutilization of medical services and nonadherence to prescribed care leads to an inefficient process in which both patients and providers suffer. (2006, p. S10)

In integrated care, we should be able to observe more efficient care defined as using fewer resources to receive treatment because as customers make fewer mistakes in their role as co-designers and suppliers, they will need less rework. If patients do not get better, they overuse resources at the primary care clinic and in more expensive hospital settings.

*I posit customer/patient complexity increases the likelihood of the customers making lapses and mistakes in their role as designer of service processes, which leads to service rework and the overuse of resources. Service integration mitigates this effect. As the complexity increases, the mitigating influence of service integration increases.*

### 2.3.3 Testable Hypotheses

2.3.3.1 General Hypothesis 1

MHI (integrated care) is more efficient and effective than standard (modular) care for complex patients. As the complexity of a patient increases (as measured by the number of co-morbidities), MHI increases the efficiency of care for the patient. Efficiency and effectiveness are measured by fewer ER visits, fewer primary care visits, fewer central Psych visits, and more compliance with medication during 3 years of continuous care (see the next section for more detail on the data set). (See Figure 5.)

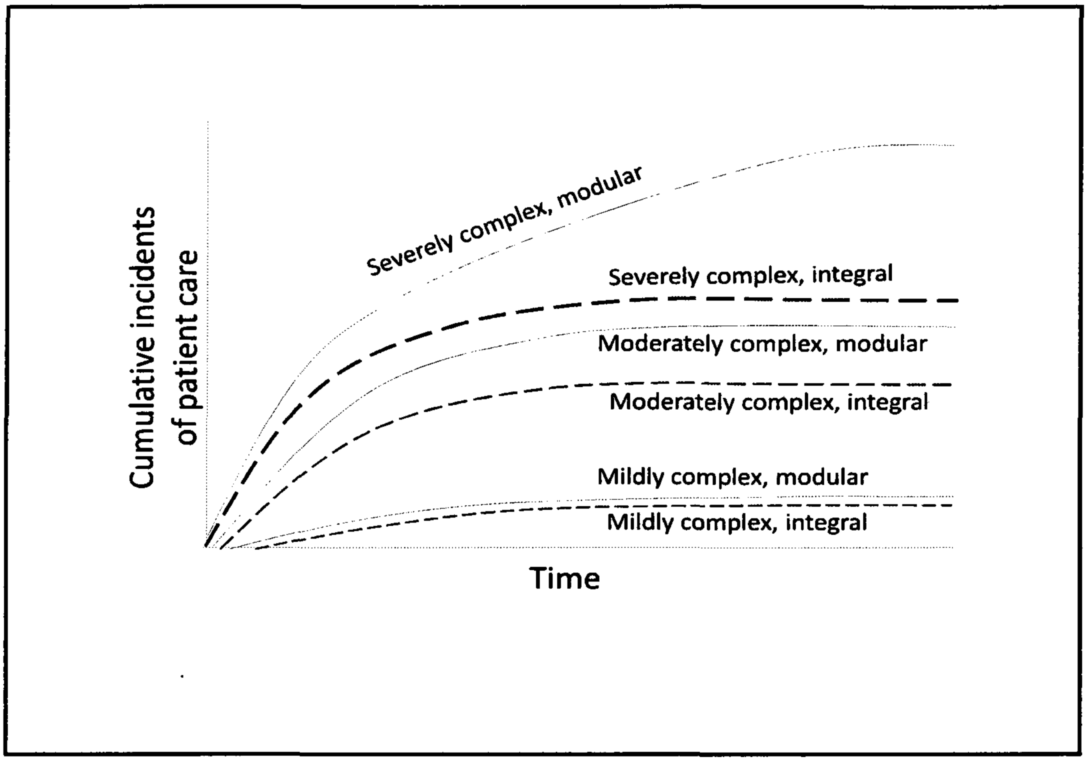



Figure 5: General hypothesis

The general hypothesis breaks down into five working hypotheses:

Proper treatment and care for depression should lead to fewer depressed patients having escalated symptoms or fewer breakdowns and thus fewer ER visits. Fewer ER visits would lead to greater capacity in the ER room and less service rework.

**Hypothesis 1.** MHI patients will use the ER less often than non-MHI patients. Additionally, these results will be accentuated by an interaction effect between patient complexity and the potency of the MHI process.

*Y variable = Number of visits to the ER. Main X variable = MHI versus non-MHI treatment group, and the interaction effect between MHI and the number of co-morbidities a customer has. (Control variables will include sex, age, visits to instacare, number of co-morbidities, psych services, and care manager intervention. The controls will all be addressed in greater detail in the next section.)*

2.3.3.2 General Hypothesis 2

Ford (2006) pointed out that depressed patients who receive inadequate care eventually return to their primary care doctors and over use resources; thus, integrated care should possibly lead to fewer visits to the primary care doctor. This is congruent with an interview I had with an IH primary care doctor: He told me he sees his patients less often under the program. MHI may increase the capacity of primary care doctors and allow them to see more patients.

**Hypothesis 2.** MHI patients will visit their primary care physician less often than non-MHI patients. Additionally, these results will be accentuated by an interaction effect between patient complexity and the potency of the MHI process.

*Y variable = Number of visits to the primary care doctor. The main X variable = MHI versus non-MHI treatment group, and the interaction effect between MHI and the number of co-morbidities a customer has. (Control variables will include sex, age, visits to instacare, number of co-morbidities, psych services, and care manager intervention.)*

2.3.3.3 General Hypothesis 3

The current centralized mental health system (a modular service, where IH aggregates its mental health providers) is overburdened and could be considered a scarce resource (as manifested by long wait times). Therefore if the MHI system can keep patients from needing treatment or can decrease their need for services from the centralized mental health specialists, then capacity will have been increased in mental health care.

**Hypothesis 3.** MHI patients will use centralized mental health specialists (in the behavioral health network) less often than non-MHI patients. Additionally, these results will be accentuated by an interaction effect between patient complexity and the potency of the MHI process.

*Y variable = Number of visits to behavior health, main X variable = MHI versus non-MHI treatment group, and the interaction effect between MHI and the number of co-morbidities a customer has. (Control variables will include sex, age, visits to instacare, number of co-morbidities, psych services, and care manager intervention.)*

2.3.3.4 General Hypothesis 4

Integrated care leads to consistent treatment. I hypothesize that integrated care will lead to more consistent use of pharmacy prescriptions, and thus MHI patients will have more prescriptions filled because they are receiving consistent and even care.

**Hypothesis 4:** MHI patients will fill more prescriptions during the 3-year period than non-MHI patients. Additionally, these results will be accentuated by an interaction effect between patient complexity and the potency of the MHI process.

*Y variable = Scripts filled during the 3-year period, main X variable = MHI versus non-MHI treatment group, and the interaction effect between MHI and the number of co-morbidities a customer has. (Control variables will include sex, age, visits to instacare, number of co-morbidities, psych services, and care manager intervention.)*

2.3.3.5 General Hypothesis 5

It follows the line of reasoning that if patients use fewer total healthcare services they should also have lower overall patient healthcare costs. Costs are difficult to measure and even more difficult to be accurate with. Co-pays, different insurance plans, deductibles, etc., all make measuring cost difficult because being sure that apples are being measured to apples is a difficult chore with costs and imprecision. Despite not being able to accurately measure all costs, the measurement will still be used, based on the insurance plan's allowable cost to offer the most accurate test possible. Though not precise, this measurement is necessary as a check to the previous tests. Additionally, previous medical literature predicts that it will be difficult to discover a cost offset through providing additional care (Sturm, 2001) because medical managers lack the skills to narrowly offer additional services only to the niche patient groups, which would most likely benefit from them.

**Hypothesis 5.** MHI patients will have less total medical utilization as measured by allowable charges than non-MHI patients. Additionally, these results will be accentuated by an interaction effect between patient complexity and the potency of the MHI process.

*Y variable = allowable costs from the insurance agency, main X variable = MHI versus non-MHI treatment group, and the interaction effect between MHI and the number of co-morbidities a customer has. (Control variables will include sex, age, and number of co-morbidities.)*

## 2.4 Description of Data Set, Testing Procedures, and Results

### 2.4.1 Data Set

The patient populations used to construct the test population consisted entirely of patients newly diagnosed with depression in 2006. *(Patients are identified in the IH depression registry by insurance claims with either of two billed diagnoses of depression (ICD-9 296.2X, 296.3X, 298.0X, 296.82, 296.90, 300.4, 309.0, 309.1, 309.28, 311, and 646.4); or a billed diagnosis of depression and a filled antidepressant prescription within the same 365-day window).* By designing the study population in this manner, I was able to control for two potential confounding factors. First, other studies have shown industry-wide trends in the way doctors prescribe medication and recommend other therapies to treat depression (Armstrong, 2009). For example, comparing patients diagnosed in 2003 to patients diagnosed in 2006 would be difficult because of changes in industry-wide uses in medication for treating the disease. Second, by only examining patients who were newly diagnosed with depression in 2006, I control for the length of treatment patients receive for their depression. For example, a patient who has been diagnosed with depression and been receiving treatment for more than 10 years is likely different from a patient who has been receiving treatment for depression for only the last 6 months.

The data sets retrieved from Intermountain Healthcare contained 3 continuous years of the patients' data, beginning in 2006 and extending to the end of 2008, using two distinct data capturing methods. The longer the treatment time periods, the greater amount of power the integrated treatment would have on potential patients, so the longer periods of time were preferable to shorter periods. Data experts at IH concluded 2006 would be the earliest and cleanest year for capturing patients classified with a diagnosis of depression. For all patients diagnosed with depression in 2006, I obtained all their data of medical usage through 2006, 2007, and 2008 using IH's two methods for collecting data.

The first method consisted of gathering all the data from IH's insurance arm called SelectHealth, and then from this selecting patients who were patients at IH PCP offices. This first method was the most preferred because it gathered all claims to the insurance from patients' use of medical services both inside and outside IH medical facilities. For example, patients insured by SelectHealth could visit IH's LDS hospital ER or the University of Utah hospital's ER and Select Health would have a record of each visit. The records from SelectHealth patients provided the most complete picture of medical service usage possible. All the patients in this data set were continuously enrolled in SelectHealth for the entire 3-year period to ensure completeness. The downside to using this method of extraction is that it constricts the sample to only SelectHealth/IH patients: a very homogeneous and smaller sample size.

The second method for gathering patient information consisted of tracking facility and doctor usage within IH facilities, regardless of where insured (or if insured). The advantage of this extraction method comes from its ability to track the usage from Blue Cross, Medicare, United Health, SelectHealth, and even uninsured patients. The disadvantage of using this extraction method comes from the possible gaping holes it leaves in the patient's record because patients who visit the LDS hospital ER will have a record while patients who visit the University hospital ER will not have a record of usage. Because of the deficiencies in this second method of extracting the data, the second data set is an exploratory and confirmatory data set; only the first data set is relatively complete enough to be relied upon to accurately reflect results.

IH determined approximately 28,000 patients were newly diagnosed with depression in 2006, but not all of these patients were usable for testing purposes because we required 3 years of data and they had to visit a primary care clinic enough to be mapped to its use. Using the first extraction method we found 5,011 patients who were diagnosed with depression in 2006 and were continuously enrolled in SelectHealth insurance from 2006 to 2008. Of those patients, only 2,991 could be mapped to an IH clinic, which means the remaining SelectHealth patients chose to have their primary care needs met by non-IH providers or were diagnosed in a hospital and did not attend a clinic regularly enough to be mapped to it. Because I have documentation on the clinic integration progress for each clinic in IH and not on those clinics not owned by IH, I cannot group patients according to their sharing of a common clinic resource. I kept only patients who could be mapped to an IH clinic in the sample because it allowed control for variation in the ownership of the clinic and in the amount of service integration at the clinic. The final sample (SelectHealth group) of continuously enrolled SelectHealth patients consisted of 2,991 patients (to see more detailed statistics on this group see Table 1). Using the second extraction method, I found (treatment facility group) 11,091 patients with 3 years worth of data who could be mapped to an IH clinic (to see more detailed statistics on this group see Table 2). It is worth noting the 2,991 in the first group are also included in this group, but their data are less complete because they are extracted using the second method; thus, it misses visits to non-IH facilities. Because the first group has the most complete data, we use it as the primary test group and the second set, using a wider population, is used to confirm the results found using the smaller group, which consists of only Select Health patients. The primary difference between the original 28,000 diagnosed with depression and the smaller test populations is caused by patients' failing to have 3 years' worth of complete data or failing to map to a IH primary care clinic. Tests of those who dropped from the sample because of a lack of complete data reveal that dropped patients were not statistically different in age, sex, or complexity from the sets used in the statistical tests.

| Table 1: SelectHealth data set | | | | | | |
|---|---|---|---|---|---|---|
| | 10 Integrated clinics | | | 46 Non-Integrated clinics | | |
| **Patient Charactersitics** | Mean | Upper CI | Lower CI | Mean | Upper CI | Lower CI |
| Patients | 990 | | | 2001 | | |
| Average Age | 38.6 | 39.4 | 37.8 | 40.3 | 40.9 | 39.8 |
| Gender | 66.6% | 69.5% | 63.6% | 66.4% | 68.4% | 64.3% |
| | Integrated | | | Non-Integrated | | |
| **Chronic Condition** | Mean | Upper CI | Lower CI | Mean | Upper CI | Lower CI |
| CAD | 0.70% | 1.2% | 0.2% | 1.70% | 2.3% | 1.2% |
| CHF | 0.70% | 1.2% | 0.2% | 1.50% | 2.1% | 1.0% |
| Diabetes | 8.60% | 10.3% | 6.8% | 9.80% | 11.2% | 8.5% |
| Depression | 100.00% | 100.0% | 100.0% | 100.00% | 100.0% | 100.0% |
| Asthma | 6.60% | 8.2% | 5.1% | 8.00% | 9.2% | 6.9% |
| Cancer | 3.30% | 4.5% | 2.2% | 4.00% | 4.9% | 3.2% |
| No Comorbidity | 82.23% | 84.6% | 79.8% | 79.30% | 81.1% | 77.5% |
| One Comorbidity | 15.57% | 18.9% | 12.3% | 16.80% | 19.5% | 14.2% |
| Multiple Comorbidity | 2.20% | 3.1% | 1.3% | 3.90% | 4.7% | 3.0% |

| Table 2: Treatment facility data set | | | | | | |
|---|---|---|---|---|---|---|
| | 10 Integrated clinics | | | 46 Non-Integrated clinics | | |
| **Patient Charactersitics** | Mean | Upper CI | Lower CI | Mean | Upper CI | Lower CI |
| Patients | 3634 | | | 7462 | | |
| Average Age | 45.0 | 45.5 | 44.4 | 46.3 | 46.7 | 45.9 |
| Gender (Female) | 70.0% | 71.5% | 68.5% | 69.7% | 70.7% | 68.6% |
| | Integrated | | | Non-Integrated | | |
| **Chronic Condition** | Mean | Upper CI | Lower CI | Mean | Upper CI | Lower CI |
| CAD | 3.10% | 3.6% | 2.5% | 4.1% | 4.6% | 3.7% |
| CHF | 2.90% | 3.5% | 2.4% | 4.0% | 3.6% | 4.5% |
| Diabetes | 12.80% | 13.9% | 11.7% | 13.8% | 14.6% | 13.0% |
| Depression | 100.00% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |
| Asthma | 3.2% | 3.7% | 2.6% | 3.1% | 3.5% | 2.7% |
| Cancer | 4.50% | 5.2% | 3.9% | 5.3% | 5.8% | 4.8% |
| No Comorbidity | 79.90% | 80.2% | 78.4% | 76.4% | 77.4% | 75.5% |
| One Comorbidity | 15.90% | 18.0% | 14.9% | 18.1% | 19.5% | 16.7% |
| Multiple Comorbidity | 4.20% | 4.9% | 3.6% | 5.5% | 5.9% | 5.0% |

All the patients in both cohorts have a diagnosis of depression (a chronic disease) and thus they all fit the definition of being complex patients/customers because at a minimum they need to return to their PCP for continued care. There are two factors that differentiate patients beyond their depression as determined by the literature. These two factors are severity of the disease and the level of complexity defined by the number of co-morbidities patients have. Because the data were inadequate to control for the severity of the depression, the level of patient complexity as measured by the number of co-morbidities a patient has is the only measure used.

The patients patronized doctors at 56 IH clinics with varying degrees of integration. All the clinics were ranked on a scale from 0 to 5 by the specialists at IH according to preset guidelines as to the clinic's adoption of mental health integration. Clinics rated as 0 had never been briefed on the program. Those rated as 1s and 2s had been briefed on the program to some extent and were included in future plans to have the MHI implemented at the clinics. Clinics rated as 3 had started the implementation process in a very limited fashion. The clinics had started passing out PHQ9s to their patients, but none of the additional support or team members required for integration were operating with the clinic. Level 5 clinics had fully implemented and sustained MHI key elements—leadership, team-based care, information technology, partnering with community resources, and financing. Level 5 clinics demonstrated budget neutral impact on net operating income 3 to 4 years after implementing MHI. Level 4 clinics were similar to level 5 clinics but were not as mature and may not have had all team members in place.

Because the 0 to 5 grades are subjective as to their cut off and definition, it was determined that all 4- and 5-ranked clinics would be considered integrated and all the others would be considered nonintegrated, creating a dichotomous variable. Level 4 and 5 clinics are integrated (MHI clinics) and 0 to 3 clinics are considered modular (non-MHI). In this study the 10 level 4 and level 5 clinics were considered integrated, while the remaining 46 clinics with ratings from 0 to 3 were considered nonintegrated.

### 2.4.2 Matching Clinic Demographics to Ensure Accuracy

In one of my discussions with researchers at IH, the concern was brought up that the demographics of the clinics might be a deciding factor in the results. To be conservative, an additional cut of the data was made to control for demographics by matching clinics. In an earlier study with a separate group of data, IH researchers had matched four non-MHI clinics to four MHI clinics by size, insurance mix of patients, rural versus urban, and size of doctor staff. The SelectHealth data set was used. These tests singled out the four non-MHI clinics and the four MHI clinics singled out by IH in their previous study. The sample size dropped from 2,991 to 589. While 589 is a statistically strong sample size, the number of patients with multiple co-morbidities in this matching data set drops significantly from the full data set, thus decreasing the power of the tests for the interaction effect. I used the same process to test all three data sets and present all the results in unison.

### 2.4.3 Testing Procedures for All Hypotheses

If linear regressions are used to predict count outcomes, they may result in inefficient, inconsistent and biased outcomes; it is safer to use models specifically designed for count outcomes (Long & Freese, 2006).

Count outcomes are unique because the outcomes are not continuous, but divided into specific response outcomes. For example, visits to the ER for each patient can be counted exactly; a patient either has 2 or 3 visits to the ER: not 2.5. Because outcomes are not continuous, count regressions are required. To understand count regressions, it is important to first understand the Poisson regression in its basic format as displayed in Equation 1 (Long & Freese, 2006).

$$(1)\ Pr(y \mid \mu) = \frac{e^{-\mu}\mu^{y}}{y!}\ for\ y = 0,1,2,\ldots$$

where $\mu$ is the number of expected times an event will occur in a fixed period of time; thus, in my study $\mu$ is the expected number of times a patient will go to the ER between 2006 and 2008, $y$ is a random variable indicating the number of times an event did occur, or the number of times a patient did go to the ER. Some patients, of course, will go to the ER more times than the average and sometimes less than average. The expected count, $\mu$, is related to the probability of the observed count $y$ as specified by the Poisson distribution where $\mu$ is > 0 (Long & Freese, 2006).

According to Long (1997) there are four characteristics of the Poisson regression, which are important to remember when considering count regressions.

> 1. $\mu$ is the mean of the distribution. As $\mu$ increases, the mass distribution shifts to the right.
> 2. $\mu$ is also the variance. Thus Var ($y$) = $\mu$, which is known as equidispersion. In real data, many count variables have a variance greater than the mean, which is called overdispersion. (This is an important consideration in light of my eventual use of the Negative Binomial regression.)
> 3. As $\mu$ increases, the probability of a 0 count decreases. For many count variables, there are more observed zeros than predicted by the Poisson distribution. In reality many count data sets do not follow the Poisson distribution.
> 4. As $\mu$ increases, the Poisson distribution approximates a normal distribution. (p. 350)

These restrictions often make the Poisson a poor fit, especially in the face of heterogeneity of action, because the Poisson distribution considers all counts as independent. For example, if a Poisson regression predicted the number of articles a PhD could be expected to publish during his/her career, it most likely would perform very poorly; there would be a large 0 count for the number of PhDs who enter industry, and there would also be an additive effect from PhDs who do publish becoming more likely to publish again. Large 0 counts and the additive effect from the propensity of actors to perpetuate activities at which they gain competence causes overdispersion in the regression model; thus a model less constricted than the Poisson model is required (Long & Freese, 2006).

The negative binomial model accounts for over dispersion in the following manner. If the Poisson regression could be supposed to have the following generic formula with three independent variables (Long & Freese, 2006):

$$\mu = \exp\left(\beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \beta_3 x_{i3}\right)$$

The negative binomial regression could be considered to add an error term to the equation, which is uncorrelated to the $x$'s.

$$\mu = \exp\left(\beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \beta_3 x_{i3} + \varepsilon_i\right)$$

$$\mu = \exp(\beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \beta_3 x_{i3}) \exp(\varepsilon_i)$$

$$\mu = \exp(\beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \beta_3 x_{i3})\delta_i$$

We assume $\delta$ is drawn from the gamma distribution (Long, 1997). The real telling effect is the effect on the variance or dispersion function according to Long and Frees (2006). The Poisson variance equation is as follows:

$$\text{Var}\,(\,y_i \mid x_i) = \text{E}\,(\,y_i \mid x_i) = \mu_i.$$

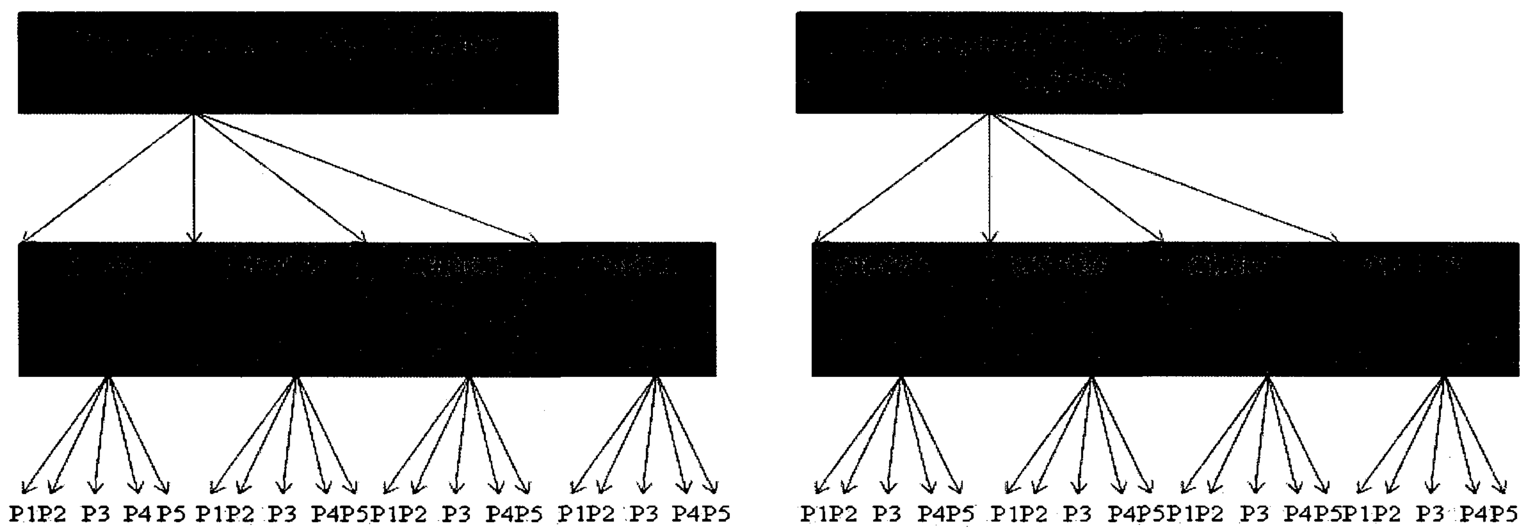
As the equation demonstrates, this defines equidispersion because the conditional mean equals the conditional variance. But in the real world counts are usually overdispersed, or in other words the variance exceeds the means conditional variance. The negative binomial regression accounts for this variance in the following equation with $\alpha$.

$$\text{Var}\,(\,y_i \mid x_i) = \mu_i + \alpha\,\mu_i^2$$

Thus as $\alpha$ approaches 0 the negative binomial regression reduces to the Poisson regression.

In addition to the data being count data, it also has a two-level hierarchal data structure, which must also be accounted for. This is exemplified in Figure 6, which depicts a traditional hierarchical linear model that I have modified to display a simplified MHI environment.

Normal OLS regression or ANOVAs are insufficient because of the multilevels of the data. Each patient is nested in a clinic. By using hierarchical linear modeling (HLM) we can separate the variation in the models between the levels of the model, and thus we can effectively use means as outcomes (Raudenbush & Bryk, 2002).




Clinics are nested in treatments and patients are nested in clinics in the statistical design.

Figure 6: Hierarchical design for integrated services

In the end we want to discover the variation in the treatment type, but we also have to take into account that not all the variation is independent since patients treated at one clinic should have correlated errors when compared to other patients at the same clinic. HLM allows us to isolate the variation at each level and helps us to overcome the problem of correlated errors caused by patients using the same clinics.

Hierarchical models have been popular in educational research for some time but are now finally gaining traction in operations research as well. DeHoratius and Raman (2008) studied a cross HLM model where the individual products were nested in both the store and their product categories to study inventory record inaccuracy. Hierarchical models have also been applied to healthcare empirical research in operations. To study the effects of operations in nonprofit versus profit nursing homes, Chesteen, Heigheim, Randall, and Wardell (2005) grouped patients in nursing homes into a hierarchical model.

### 2.4.4 Tests

Taking all these previous concerns into account I tested and applied the models for the first hypothesis in the following manner:

**Y** = Total ER encounters over 3 years, **X** = sex, age, number of co-morbidities, care manager interaction, visits to mental health specialists for depression, instacare, integrated clinic effect, the interaction effect.

2.4.4.1 Explanation for the Use of X Variables in Equation

**1. Sex** – important control variable

**2. Age** – important control variable

**3. Number of co-morbidities** – the measure I use to differentiate between the complexity of patients. As the patient's number of co-morbidities increases so does his/her complexity. All the patients have depression, and there is the possibility of up to five other medical co-morbidities that are closely measured by IH, so a patient's score on this variable can range from 1 to 5. The five possible co-morbidities are coronary artery disease (CAD), congestive heart failure (CHF), diabetes, asthma, and cancer. One might ask, "Are there more medical co-morbidities?" The answer is yes, but these are five well-defined and well-tracked base co-morbidities, and IH classified these five as the five most common medical co-morbidities occurring with depression. Another question is, "What about mental co-morbidities?" (such as schizophrenia). Again the answer is yes, they are important, but they currently are not as well-defined and traceable in the medical records. A third question is, "Is it viable to treat ordinal data (the co-morbidities) as continuous in this circumstance because some might think having cancer is a little worse than having asthma, for example?" Again, this is a legitimate concern, but as I presented my tests to multiple healthcare researchers, they felt it was a legitimate use of the data because literature has supported the high correlation between the number of illnesses a patient has and the severity of the patient's condition. A final question is, "What happens when the diseases are all treated separately as independent dichotomous variables?" All the following results were run with the co-morbidities treated continuously and separated dichotomous variables, and the answers were consistent.

**4. Care manager interaction** – this variable is a count for the number of times a care manager accessed and made a notation to a patient's medical record. While an imperfect measure, it was the best proxy available for gauging the amount of interaction the care manager had with a patient. This measure was used in the equation to assure that drops in the use of the ER, PCP, etc. were not simply replaced by greater use of another resource (the care manager). The results were robust to the care manager's presence being dropped from the model.

**5. Visits to a mental healthcare specialist for depression** – this variable counts the number of office visits a patient has with a mental health care specialist for her depression. These visits were used as a control in the equation to assure that drops in the use of the ER, PCP, etc., were not simply replaced by greater use of another resource (visits to the mental health specialists). The results are robust to the medical specialist's presence being dropped from the model.

**6. Instacare visits** – medicine is making a change and many patients have started to use instacare or urgent care more often than they use their PCP or ER. These visits were used as a control in the equation to assure that drops in the use of the ER, PCP, etc., were not simply replaced by greater use of another resource (instacare visits). The results are robust to the instacare variable's presence being dropped from the model.

**7. Clinic effect** – The main effect tests integrated clinics (rated by IH's MHI group as either 4 or 5) against nonintegrated clinics (all other IH clinics classified as either a 3 or lower). It is a dichotomous variable.

**8. Interaction effect** – created by multiplying the clinic effect times the number of co-morbidities variable. The interaction effect tests the hypothesis that as a patient increases in complexity she benefits more from treatment in an integrated clinic.

This yields the following model: (Total ER Visits) = Constant + $B_1$*(sex) + $B_2$*(age) + $B_3$*(Number of co-morbidities) + $B_4$*(Care Manager Interaction) + $B_5$*(Visits to Mental Health Specialists for Depression) + $B_6$ *(Instacare visits) + $B_7$*(MHI Effect) + $B_8$*((MHI Effect) * (Number of co-morbidities)) + $\varepsilon$

Using the above variables, I tested the data (the testing process is documented and described in more detail in Appendix C) using the negative binomial regression model (NBRM) with a hierarchal data structure. Long and Feese (2006) recommend the following postestimation analysis for count regressions: the Wald test, likelihood ratio, measure of fit, and collinearity. The postestimation analysis supported the regression results as being consistent and stable. As can be witnessed in Figure 7, the NBRM has a superior fit when compared to the Poisson regression, which in early tests also trumped OLS regression results.

**Test of Hypothesis 1.** MHI patients will use the ER less often than non-MHI patients. Additionally, these results will be accentuated by an interaction effect between patient complexity and the potency of the MHI process (results shown in Table 3).

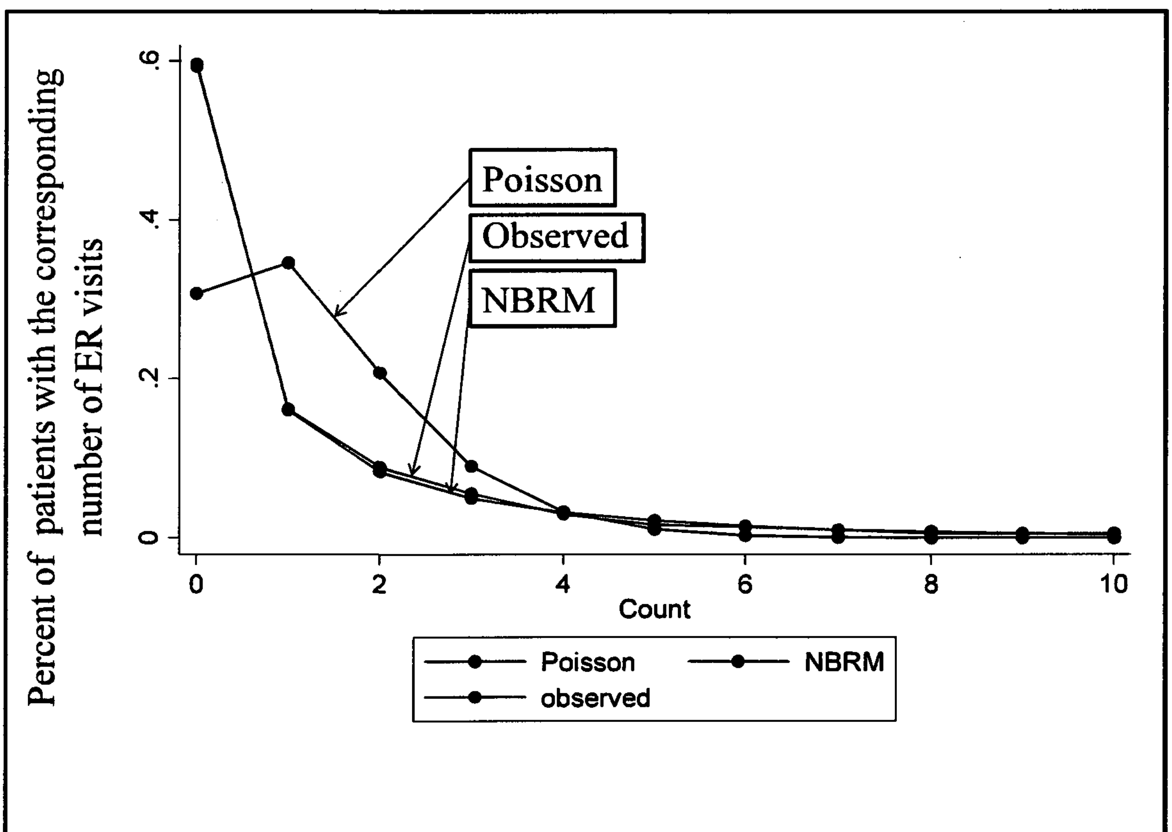



Figure 7: Model fit

As shown in Table 3, the highlighted portions are results significant at the .05 level. Hypothesis 1 is supported with both the main effect and interaction effect. The main effect is supported in all three data sets. As displayed in the odds ratio, patients in an integrated clinic will have 24% fewer visits to the ER when compared to those in modular clinics, and as the number of co-morbidities increases there is an extra additive effect of decreasing ER visits by 23.5% as number of co-morbidities increases. The interaction effect is supported visually as well as numerically as the data is graphed in Figures 8, 9, and 10.

**Test of Hypothesis 2.** MHI patients will visit their primary care physician less often than non-MHI patients. Additionally, these results will be accentuated by an interaction effect between patient complexity and the potency of the MHI process (see results in Table 4).

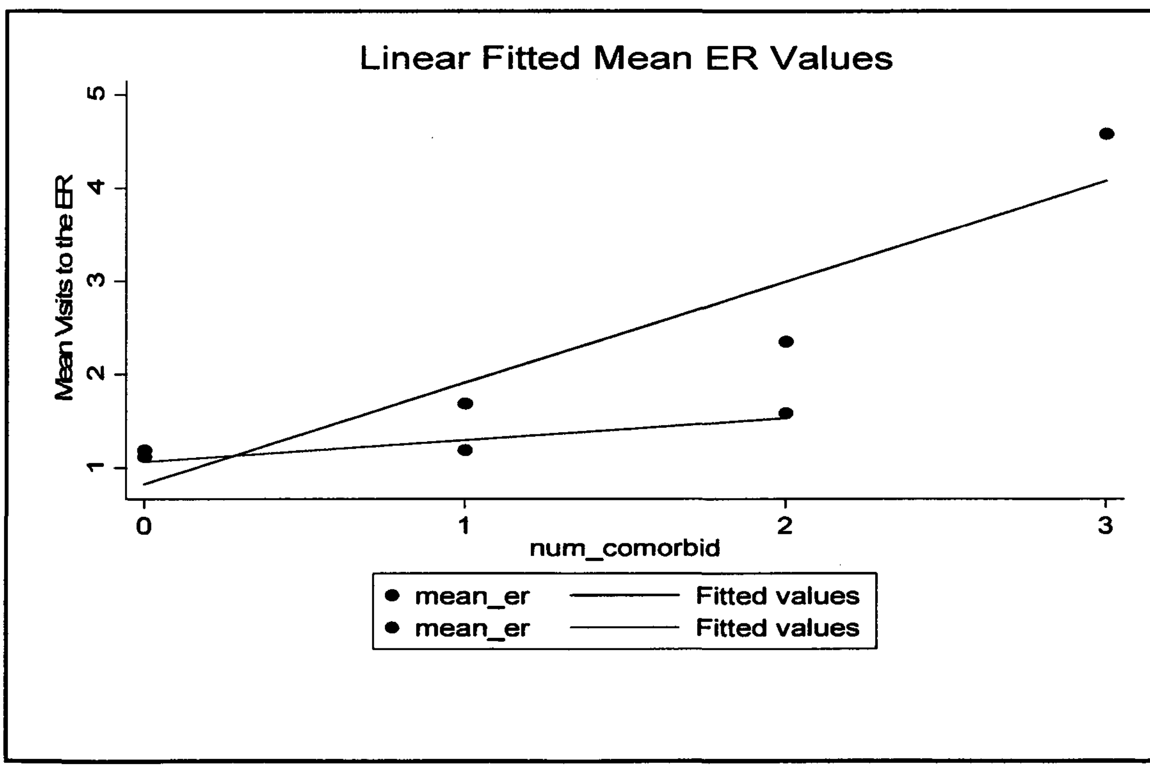



Figure 8: Linear fitted mean ER values

Table 3: Hypothesis 1 - visits to the ER

| | SelectHealth Data Set | | | Matched Data Set | | | Treatment Facility Data Set | | |
|---|---|---|---|---|---|---|---|---|---|
| | Z-Score | P-Value | Odds Ratio | Z-Score | P-Value | Odds Ratio | Z-Score | P-Value | Odds Ratio |
| Sex | -1.200 | 0.230 | | -3.270 | 0.001 | -23.4% | -0.470 | 0.640 | |
| Age | -2.100 | 0.035 | 0.6% | 0.140 | 0.887 | 0.0% | -9.810 | 0.000 | -0.6% |
| Number of Co-morbidities | 8.030 | 0.000 | 53.3% | 2.410 | 0.016 | 86.8% | 8.310 | 0.000 | 53.3% |
| Care Manager Interaction | 2.140 | 0.032 | 9.4% | 1.760 | 0.079 | 9.8% | 1.720 | 0.086 | 9.4% |
| Visits to a Mental Health Care Professional for Depression | 1.560 | 0.119 | | 3.160 | 0.002 | 3.5% | 8.450 | 0.000 | 1.1% |
| Instacare visits | 6.910 | 0.000 | 9.5% | 2.910 | 0.004 | 12.8% | 3.160 | 0.002 | 9.2% |
| MHI Effect | -2.350 | 0.019 | -24.4% | -2.120 | 0.034 | -45.5% | -3.910 | 0.000 | -39.4% |
| Interaction Effect MHI/# of Co-morbidities | -2.930 | 0.003 | -23.5% | -1.850 | 0.064 | -39.0% | 0.810 | 0.416 | |
| Commercial Payers | | | | | | | -11.630 | 0.000 | -60.8% |
| Medicaid | | | | | | | 3.950 | 0.000 | 47.6% |

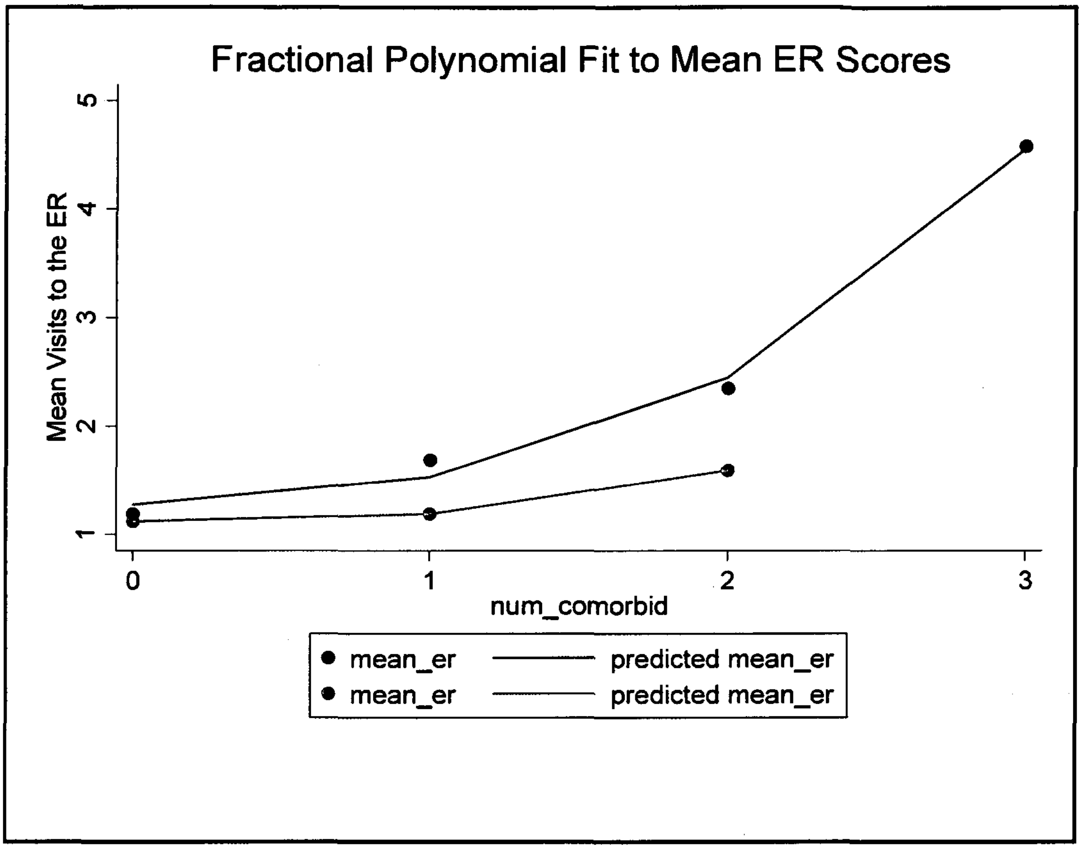



Figure 9: Fractional polynomial fit mean ER values

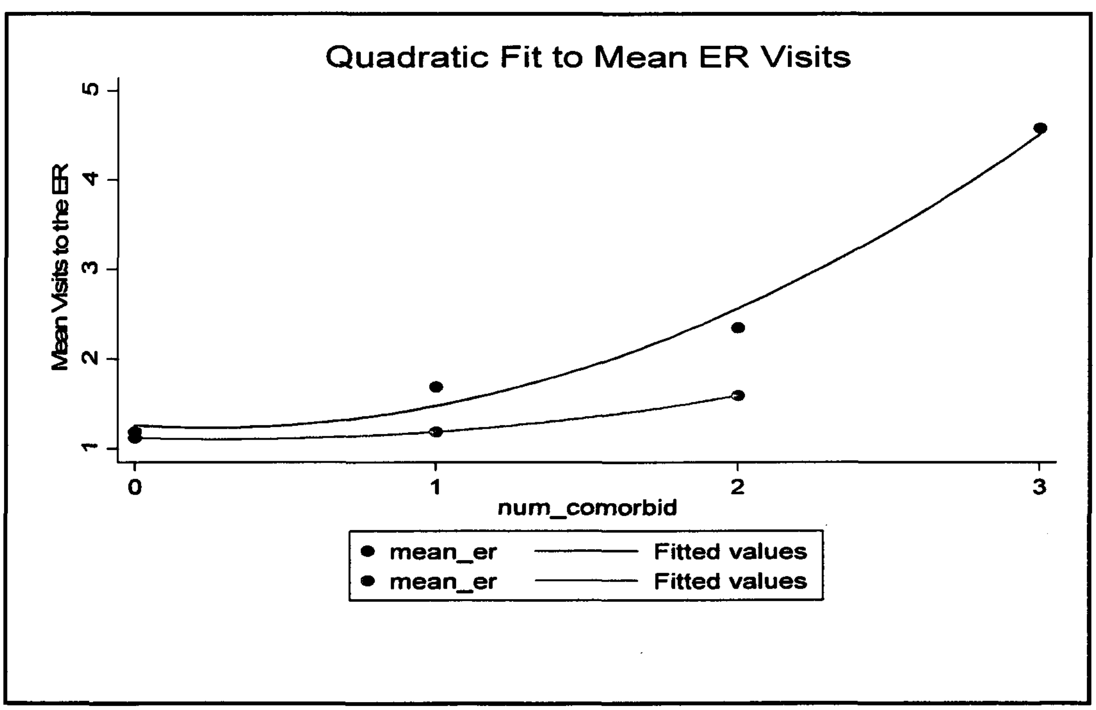



Figure 10: Quadratic fit to mean ER scores

Hypothesis 2 is not supported for either the main effect or the interaction effect, except in the matched data set; the matched data set does provide support for the notion that integrated clinics decrease the amount of PCP visits as witnessed by the P value. In the smallest but most controlled data set, the main effect is supported. This is potentially a promising result, but would need further study with a larger patient population to confirm the results.

**Test of Hypothesis 3.** MHI patients will use centralized mental health specialists (in the behavioral health network) less often than non-MHI patients. Additionally, these results will be accentuated by an interaction effect between patient complexity and the potency of the MHI process (results shown in Table 5).

As shown in Table 5, Hypothesis 3 is not supported for the main effect as evidenced by the insignificant P values. When the interaction effect is clearly not significant, it is dropped from the regression to provide a more accurate view of the main effect. The number of visits to psychiatrists at IH's central mental health clinic does not seem to be affected by the integrality or modularity of the service provided.

**Test of Hypothesis 4.** MHI patients will fill more prescriptions during the 3-year period than non-MHI patients. Additionally, these results will be accentuated by an interaction effect between patient complexity and the potency of the MHI process (results shown in Table 6).

As shown in Table 6, Hypothesis 4 is not supported for either the main effect or the interaction effect as evidenced from the insignificant P values. The number of co-morbidities a patient has clearly increases their needs for medications as logic and

Table 4: Hypothesis 2 - visits to the PCP

| | SelectHealth Data Set | | | Matched Data Set | | | Treatment Facility Data Set | | |
|---|---|---|---|---|---|---|---|---|---|
| | Z-Score | P-Value | Odds Ratio | Z-Score | P-Value | Odds Ratio | Z-Score | P-Value | Odds Ratio |
| Sex | 7.410 | 0.000 | 25.1% | 2.090 | 0.037 | 20.0% | -0.033 | 0.738 | |
| Age | 3.420 | 0.001 | 0.3% | 2.110 | 0.035 | 0.6% | 6.330 | 0.000 | 0.9% |
| Number of Co-morbidities | 7.790 | 0.000 | 28.2% | 3.270 | 0.001 | 21.4% | 8.100 | 0.000 | 20.2% |
| Care Manager Interaction | 2.820 | 0.005 | 7.5% | 2.640 | 0.008 | 3.7% | 3.460 | 0.001 | 3.5% |
| Visits to a Mental Health Care Professional for Depression | 1.040 | 0.297 | | 1.030 | 0.302 | | -1.920 | 0.055 | -0.7% |
| Instacare visits | 5.680 | 0.000 | 2.5% | 4.930 | 0.000 | 3.6% | 3.410 | 0.001 | 1.9% |
| MHI Effect | -0.970 | 0.331 | | -3.430 | 0.001 | -19.8% | 0.210 | 0.834 | |
| Interaction Effect MHI/# of Co-morbidities | -1.450 | 0.146 | | -0.820 | 0.413 | | -0.090 | 0.925 | |
| MHI Effect Without Interaction | -1.610 | 0.108 | | -4.350 | 0.000 | -20.8% | 0.200 | 0.842 | |
| Commercial Payers | | | | | | | -5.430 | 0.000 | -25.2% |
| Medicaid/Self Pay | | | | | | | 0.770 | 0.440 | |

Table 5: Hypothesis 3 - visits to centralized behavioral health

| | SelectHealth Data Set | | | Matched Data Set | | | Treatment Facility Data Set | | |
|---|---|---|---|---|---|---|---|---|---|
| | Z-Score | P-Value | Odds Ratio | Z-Score | P-Value | Odds Ratio | Z-Score | P-Value | Odds Ratio |
| Sex | 0.180 | 0.854 | | 0.310 | 0.393 | | NA | NA | NA |
| Age | -4.580 | 0.000 | | -7.300 | 0.000 | -3.9% | NA | NA | NA |
| Number of Co-morbidities | 0.860 | 0.390 | | -0.520 | 0.068 | 46.6% | NA | NA | NA |
| Care Manager Interaction | -0.210 | 0.837 | | -4.690 | 0.085 | 49.5% | NA | NA | NA |
| Instacare visits | 2.930 | 0.003 | | 2.220 | 0.000 | 7.6% | NA | NA | NA |
| MHI Effect Without Interaction | -1.380 | 0.169 | | 0.330 | 0.745 | | NA | NA | NA |

research would suggest, but currently there are no indicators that the integrality and modularity of a service affect rate of prescription usage.

**Test of Hypothesis 5: MHI patients will have less total medical utilization as measure by allowable charges than non-MHI patients. Additionally, these results will be accentuated by an interaction effect between patient complexity and the potency of the MHI process.**

Again as Table 7 displays, the hypothesis was not supported by the data in any of the data sets. The total cost measure is messy at best, and impossible at worst because it is based on SelectHealth's allowable insurance costs, which may or may not actually reflect reality.

#### 2.4.4.2 Summary of All the Results

Table 8 summarizes the results for each test, displaying first the effect of patients having a co-morbidity, then the main effect of visiting an integrated clinic, and finally an interaction effect for the cross between complexity and the use of integrated clinics. (Note: see Appendix C for greater detail on the tests performed to validate the tests.)

## 2.5 Discussion of Results and Managerial Implications

### 2.5.1 Discussion of Results

#### 2.5.1.1 Limitations of the Study

While the results of this study are promising, the study is limited by a number of factors. First, all the clinics were managed by the same firm. Partnering with only IH created a number of advantages such as the use of detailed information systems, the use of firm-specific data, and the ability to interview workers and attend company meetings,

Table 6: Hypothesis 4 - prescriptions

| | SelectHealth Data Set | | | Matched Data Set | | | Treatment Facility Data Set | | |
|---|---|---|---|---|---|---|---|---|---|
| | Z-Score | P-Value | Odds Ratio | Z-Score | P-Value | Odds Ratio | Z-Score | P-Value | Odds Ratio |
| Sex | 4.600 | 0.000 | 22.5% | 1.980 | 0.048 | 17.9% | NA | NA | NA |
| Age | 12.120 | 0.000 | 1.8% | 6.730 | 0.000 | 2.2% | NA | NA | NA |
| Number of Co-morbidities | 13.210 | 0.000 | 44.4% | 3.940 | 0.000 | 65.6% | NA | NA | NA |
| Care Manager Interaction | 0.620 | 0.534 | | 2.970 | 0.003 | 6.9% | NA | NA | NA |
| Visits to a Mental Health Care Professional for Depression | 3.840 | 0.000 | 1.2% | 5.270 | 0.000 | 1.7% | NA | NA | NA |
| Instacare visits | 9.740 | 0.000 | 3.9% | 7.750 | 0.000 | 5.1% | NA | NA | NA |
| MHI Effect | -1.630 | 0.103 | | -1.170 | 0.242 | | NA | NA | NA |
| Interaction Effect MHI/# of Co-morbidities | 0.700 | 0.487 | | -1.160 | 0.246 | | NA | NA | NA |
| MHI Effect Without Interaction | -1.530 | 0.126 | | -1.910 | 0.056 | -8.8% | NA | NA | NA |

Table 7: Hypothesis 5 - total costs

| | SelectHealth Data Set | | | Matched Data Set | | | Treatment Facility Data Set | | |
|---|---|---|---|---|---|---|---|---|---|
| | Z-Score | P-Value | Odds Ratio | Z-Score | P-Value | Odds Ratio | Z-Score | P-Value | Odds Ratio |
| Sex | 0.330 | 0.739 | | -0.490 | 0.623 | | NA | NA | NA |
| Age | 6.930 | 0.000 | 1.7% | 9.140 | 0.000 | | NA | NA | NA |
| Number of Co-morbidities | 13.530 | 0.000 | 90.8% | 4.280 | 0.000 | | NA | NA | NA |
| MHI Effect | -0.039 | 0.700 | | 1.240 | 0.216 | | NA | NA | NA |
| Interaction Effect MHI/# of Co-morbidities | -1.180 | 0.238 | | -1.740 | 0.082 | | NA | NA | NA |
| MHI Effect without Interaction | -0.640 | 0.522 | | | | | NA | NA | NA |

**Table 8: Summary of results**

| | SelectHealth Data Set | | | Matched Data Set | | | Treatment Facility Data Set | | |
|---|---|---|---|---|---|---|---|---|---|
| **ER Visits** | Z - Score | P - Value | Odd Ratio | Z - Score | P - Value | Odd Ratio | Z - Score | P - Value | Odd Ratio |
| Co-Morbid | 8.030 | 0.000 | 53.3% | 2.410 | 0.016 | 86.8% | 8.310 | 0.000 | 53.3% |
| MHI Effect | -2.350 | 0.019 | -24.4% | -2.120 | 0.034 | -45.5% | -3.910 | 0.000 | -39.4% |
| Interaction | -2.930 | 0.003 | -23.5% | -1.850 | 0.064 | -39.0% | Not significant | | |
| **PCP Visits** | | | | | | | | | |
| Co-Morbid | 7.790 | 0.000 | 28.2% | 3.270 | 0.001 | 21.4% | 8.100 | 0.000 | 20.2% |
| MHI Effect | -1.610 | 0.108 | | -4.350 | 0.000 | -20.8% | 0.200 | 0.842 | |
| Interaction | Not significant | | | Not significant | | | Not significant | | |
| **BHN specialists visits** | | | | | | | | | |
| Co-Morbid | 0.860 | 0.390 | | -0.520 | 0.068 | 46.6% | | | |
| MHI Effect | -1.380 | 0.169 | | 0.330 | 0.745 | | | | |
| Interaction | Not significant | | | Not significant | | | N/A | | |
| **All filled medications** | | | | | | | | | |
| Co-Morbid | 13.210 | 0.000 | 44.4% | 3.940 | 0.000 | 65.6% | | | |
| MHI Effect | -1.530 | 0.126 | | -1.910 | 0.056 | -8.8% | | | |
| Interaction | Not significant | | | Not significant | | | N/A | | |
| **Total Cost of Treatment** | | | | | | | | | |
| Co-Morbid | 13.530 | 0.000 | 90.8% | 4.280 | 0.000 | | | | |
| MHI Effect | -0.640 | 0.522 | | 1.240 | 0.216 | | | | |
| Interaction | Not significant | | | -1.740 | 0.082 | | N/A | | |

which provided a deeper understanding of the study context. Moreover, in testing hypotheses, the study controlled for factors dealing with firm-specific factors such as firm ownership, information systems, insurance plans, coverage options, and incentive designs for clinics. However, statistically the study cannot claim that the results generalize beyond IH. The decision to use a random effects model in the hierarchical design will allow the study to be generalized to cover the entire population of Intermountain Healthcare, but it would require data from multiple firms before any claims could be made beyond IH. That said, other studies that were not specifically looking at integrated services but included positive results from healthcare organizations that improved handoffs or cooperation (Gawande, 2007; Shah, Goldstein, Unger, & Henry, 2008; Tucker, Nembhard, & Edmondson, 2007) give supporting evidence that show the hypothesized relationships will hold beyond IH.

In addition to issues with external validity, there are also issues with internal validity. Because the study dealt with archival data, not all variability possibly affecting the system could be controlled for in the data set. It is plausible that other unmeasured factors such as doctor experience, nurse training, proximity to competition, and facility design all influence patient outcome. Variation across patients could be driven by numerous other factors such as prior experience with Intermountain Healthcare doctors, distance to facilities, employee health promotion, family size, where the patient ranks on the "ability" continuum, and other unmeasured factors.

2.5.1.2 Important Insights

Through healthcare integration, complex patients receive assistance in navigating the healthcare system. There is strong evidence that MHI clinics decrease the amount of rework depressed patients need (i.e., visits to the ER). Additionally, as the patient's complexity increases (i.e., more medical co-morbidities) there is an interaction effect, which means that the need of depressed patients to use the ER is decreased by a greater amount than it is for less complex patients. There is also weaker evidence that it also decreases the use of the PCP.

These results are consistent with a recent article by the award-winning medical author and surgeon Atul Gawande entitled *The Cost Conundrum* (Gawande, 2009). Gawande praised health systems like Mayo, Intermountain Health Care, and Grand Junction Colorado and highlighted their ability to integrate care between providers in behalf of patients. Gawande tells the following story:

> I talked to Denis Cortese, the C.E.O. of the Mayo Clinic, which is among the highest-quality, lowest-cost health-care systems in the country. A couple of years ago, I spent several days there as a visiting surgeon. Among the things that stand out from that visit was how much time the doctors spent with patients. There was no churn—no shuttling patients in and out of rooms while the doctor bounces from one to the other. I accompanied a colleague while he saw patients. Most of the patients, like those in my clinic, required about twenty minutes. But one patient had colon cancer and a number of other complex issues, including heart disease. The physician spent an hour with her, sorting things out. He phoned a cardiologist with a question.
>
> "I'll be there," the cardiologist said.
>
> Fifteen minutes later, he was. They mulled over everything together. The cardiologist adjusted a medication, and said that no further testing was needed. He cleared the patient for surgery, and the operating room gave her a slot the next day. (p. 6)

The interaction in this story works much like the "rubbing of shoulders" in the MHI model at IH. The consultation by multiple specialists in this story expedited the care for this complex patient, which increased her swift and even flow through the system. Likewise, MHI increases the swift and even flow for complex patients through the health system and decreases their need for expensive ER visits.

Service integration increases the swift and even flow of customers/patients by decreasing the burden of customers' role as designer and supplier in the service supply chain. Integration can do this by co-locating services, coordinating services, or both.

### 2.5.2 Managerial Implications

#### 2.5.2.1 Service Design

The theory presented in my dissertation challenges service providers to think beyond the simple tasks that they are providing to their customers. Service providers considering the advantages of integration must ask: "What other tasks might my customers be attempting to accomplish when they visit my service (How are they complex)?" "How can I provide these additional services, or how can I assist my customers in obtaining these services?" For example, Best Buy locations that include stereo installation service sell far more car stereos than Best Buy locations without them.

Additionally, the more likely a service is to provide service to complex customers, the greater the benefit customers will receive from its integration. Integrated Healthcare systems have been singled out as a vehicle for cost containment by our President and others (Gawande, 2009). Recent articles have also promoted educational advantages of using technology to engage parents and students more completely, which increases educational outcomes. Technology has the ability to facilitate service integration in a way unthinkable even 10 years ago (Butler et al., 1996); thus, there is a window of opportunity for service providers to better serve their most complex customers at lower costs. One need go no further than the mailbox to see offers of integrated billing from phone and cable companies.

2.5.2.2 Possible Pitfalls From Blindly Integrating

While integration does have benefits especially for the complex customer, there are dangers in following this strategy blindly.

1. Integration is difficult to orchestrate and to sustain. The Mayo Clinic has introduced two new operating sites outside of its original Minnesota location. Each site took at least a decade to develop and mature (Gawande, 2009). Likewise, IH started MHI 10 years ago, and needed a grant to fund its instigation. Other fully integrated facilities like Shouldice have yet to be successfully replicated.

2. Integration increases complexity in the service environment for the service provider (see Appendix B for detail).

3. Those who get the benefit may not pay the price. IH's primary care clinics support and pay for the training of MHI staff, and yet one of the primary beneficiaries are the local hospitals and insurance plans. Without integrated pay systems, the costs and the benefits are unequally distributed.

4. Service integration requires a long-term outlook because many benefits will only be reaped in the long-run. For example, integrating curriculum at a high school or university in the long-run may increase the learning of students (especially for the more complex students) and eventually increase the university's or high schools stature and reputation, but in the short-term, there will be large up-front costs to facilitate integration and create buy-in by disparate departments or decrease incentive complexity (see Appendix B).

5. Integration on any level increases fixed costs and demands larger flows of customers to produce profits. For example, as universities add degrees they increase

integration by co-locating services, but this also requires an increase in overhead and a larger student base to cover those costs. Additionally, patients have to stay in the integrated system long enough to experience long term reduced utilization. If the patient moves in and out of MHI and non-MHI you would likely not see the reduce utilization. This is one of the reasons the patients were mapped to clinics and why the patients in the samples were required to be continuously mapped to either MHI or non-MHI clinics.

2.5.2.3 How to Handle the Complex Customer

There are three ways to handle complex customers entering your service environment: specialize, facilitate, or integrate.

**2.5.2.3.1 Specialize and treat them simply.** Many service providers will succeed by ignoring their complex customers' needs and treating them like a simple customer who visits the service provider with one single need, returning home afterwards. This may be the best strategy for many providers because it allows them to specialize and become deeply knowledgeable and efficient at one task. So although the provider's scope is limited, the quality and price differential offered by the modular service provider encourages both simple and complex customers to enter the service queue. For example, there is a low priced gas station near my home, which I have visited at least 10 times, but I have never been inside the station because I have always used the pay-at-the-pump service. Complex customers entering this environment know all the design and supplier functions rest on their shoulders; in most instances, this is how the customer prefers it.

**2.5.2.3.2 Facilitate.** To facilitate a complex customer, a service provider can design their service to help customers integrate their needs without going all the way. In a sense the provider attempts to increase the customer's ability to design their own service process without providing the service for them. For example, a physician wanting to implement MHI, but not having the advantage of the IH's structure, could develop relationships with local psychologists to whom he could refer patients and have back and forth conversations between visits. Facilitation could also occur through location. A restaurant positioned near a movie theater increases integration for customers looking for a night out. McDonald's invested in Red Box and started its growth by providing spots for the machines outside their restaurants. In this way, McDonald's facilitated integration for its customers.

**2.5.2.3.3 Integration.** Service integration for the complex customer will always have its limits because of the heterogeneous nature of customer demand and the extra expense integration often incurs to implement, but carefully detailed integration concepts can increase service and can increase profits. The Disneyworld resort hotels and cruise lines have increased revenues and profits for Disney, but neither chain can compete with more modular and lower cost service options. There is a certain subset of complex customers for whom these chains provide the greatest benefit; if these complex customers are sorted and marketed to efficiently, Disneyworld can be profitably service both the complex and simple customers. The process is not for the faint of heart and must be managed carefully, but the thoughtful service provider will find profit in serving the complex customer from retail to healthcare and from recreation to education.

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# CHAPTER 3

# SERVICE INTEGRATION AND MODULARITY

## 3.1 Integrated Versus Modular Service Design

### 3.1.1 Chapter Preview

While discussion of product modularity is a well-documented stream of literature (Fixson, 2007; Salvador, 2007), service modularity and integration have received scant attention.

This chapter builds a theoretical base as well as a definition of modularity and integration in the service environment. This chapter's theoretical base draws heavily upon the literature of product modularity and other service management literature to create testable research propositions. The propositions can be applied to specific service environments and can inform decisions in practice and research.

This section purposefully strays away from discussions about IH's MHI model, in order to broaden the theoretical base of service integration to all service processes. Its purpose is to become a standalone theoretical paper.

The 2 x 2 model, the definitions, and the propositions are all significant contributions. I will end the chapter with future research questions for validating and extending the theoretical propositions.

### 3.1.2 Service Design

The service design literature says very little about modularity versus integration in contrast to the product design literature in which the scholarship is deep and well defined (Fixson, 2007; Salvador, 2007). Its absence is neither because the topic has been ignored nor because it is unimportant. Quite to the contrary, the service design literature, which is deep and growing (Tsai et al., 2007), covers many of the facets of service integration but describes the process in a drastically different manner than product design literature, thus obscuring the topic. For example, Shah et al. (2008) describes the process of multiple health organizations banding together to synchronize care and reduce heart attack fatalities, but the authors never mention the process of integrating modular service process, which facilitates the success of the enterprise. Likewise, Froehle and Roth (2007) recommend the building of complementary resources and capabilities to increase capability and the speed of service design, which could also be amended to declare the need for integrating current process or creating complementary modular processes.

One of the reasons for this lack of clarity in the service design literature derives from its focus on service providers. The literature, while highlighting the importance of customer satisfaction, correctly addresses management (because managers are their audience) by testing firm-level data and encouraging changes in the way management perceives or approaches service design. The literature does describe the way customers view the service process or interact with the process (i.e., Alam & Perry, 2002). It can be likened to a response one might receive from an Intel executive if the executive were asked, "Are you a modular corporation?" The executive would most likely tell the tale of how chip design, sales, marketing, and manufacturing all work seamlessly in an integrated fashion to create the most powerful chip producing company in the world. And from the executive's perspective, she would be right; on the other hand, if the same question were asked of Intel's customers, they would most likely comment on the modular nature of Intel's product and how it can be plugged into a multitude of diverse computer products. Thus the idea of modularity versus integration is obscured by the management literature's focus on its customers: management.

This study contributes to the literature in three primary ways. First, it defines modularity and integration in terms of service management and differentiates them from definitions used in product design. Second, it highlights how the amount of service integration increases along the vectors of location and coordination (i.e., as services physically co-locate and as they coordinate more they become more integrated). Finally, it translates accepted research propositions proposed by Schilling (2000) in AMR, which focus on when systems move toward and away from integration into service management propositions.

3.1.2.1 Product Design Literature

Because the product design literature richly describes modularity and integration, this paper will draw heavily upon product design literature to build the definition of service integration and modularity. Schilling (2000) begins her paper on the theory of modularity in the following way:

> Modularity is a general systems concept: it is a continuum describing the degree to which a system's components can be separated and recombined, and it refers both to the tightness of coupling between components and the degree to which the 'rules' of system architecture enable (or prohibit) the mixing and matching of components. Since all systems are characterized by some degree of coupling (whether loose or tight) between components, and very few systems have components that are completely inseparable

> and cannot be recombined, almost all systems, to some degree, modular. (p. 312)

The product design literature stresses that modularity and integration are not meant to be black and white concepts but rather two ends of a continuum that can only be measured by contrasting products or systems. Likewise, service processes should also be viewed as a continuum of service products, varying between levels of modularity and integration contained in the service process.

Because modularity and integration are continuums, the concept of a module or a component must be defined to assist our ability to contrast service processes on a continuum. The product design literature has treated modules and components inconsistently (Salvador, 2007); for example, some suggest modules are like chemical compounds and physically nonseparable parts of larger products (Pine, 1993); others allow simple component parts to be considered potential modules (Kusiak & Huang, 1997); while others suggest modules must have some complexity (Baldwin & Clark, 2000). Finally, some suggest only discrete components and subassemblies, which are separable parts of larger products, should be considered as modules (Lele & Karmarkar, 1983). Out of the many definitions, I prefer Ulrich's definition of a component because it could easily describe service process and is synonymous with module.

> I define a component as a separable part or subassembly.... a component can be thought of as any distinct region of the product, allowing the inclusion of, for example, a software subroutine in the definition of a component. (2007, p. 2)

McClelland and Rumelhart's definition is also similar:

> A module is a unit whose structural elements are powerfully connected among themselves and relatively weakly connected to elements in other units. Clearly there are degrees of connection, thus there are gradations of modularity. (as cited in Baldwin & Clark, 2000, p. 61)

For the remainder of the dissertation I will borrow Ulrich's definition of a component/module and liken it to an independent service routine, which can be separated from a larger service routine and be performed by the customer or an additional service provider.

As it applies to physical products, modularity is viewed as follows (e.g., Baldwin & Clark 2000): A modular product architecture is one where there is a well-defined interface connecting modules (or components). Within any given module, a change in the design of one part can have a big impact on the performance of each other part (there is a high degree of interaction between the parts inside that module). For example, if you change the diameter of the pistons in the engine of a car you may also have to change the design of the piston rings, connecting rods, crankshaft, and a host of other parts. But across modules, a change in the design of a part in one module has little impact on the performance of a part in a different module (there is little interaction between parts across modules). Again using the car example, changing piston diameter may not significantly impact transmission design. The modular design requires that tight specifications be developed to define the interface between modules—these specifications define exactly what each module is supposed to "deliver" in terms of output and performance. At the interface between the engine and the transmission there is a standard flywheel interface.

In contrast, an integral product architecture is one where the components have a high degree of interaction. Ulrich defines it this way: "An integral architecture includes a complex mapping from functional elements to components and/or coupled interfaces between components" (Ulrich, 2007, p.3).

It is generally accepted that an integral architecture offers the highest possible level of performance, as every component in this design can be tailored to deliver the very best performance for the product as a whole. Some research suggests that innovation breakthroughs happen most often in integrated products (Fleming & Sorenson, 2001) because in a modular design, it may be necessary to compromise on any one part in order to make that part independent from parts in some other module. But an integral design has disadvantages, in that it may not be flexible enough to handle different customer preferences and needs. If you had a fully integral car and wanted to offer both 4-cylinder and 6-cylinder engines, each version of the car would be its own entirely unique design, whereas a modular design would allow you to simply swap one engine for the other.

The product design literature accepts the design structure matrix as an instrument to measure the continuum of product integration and modularity (Baldwin & Clark, 2000). Smith and Eppinger (1997) present the basic model of a design structure matrix (see Figure 11). The design structure matrix maps the components affected by the change in a singular component; thus the most integrated component in the system is component two, which if changed would require the change of the other three components. The stronger the connections and the more complex the interface between components, the greater the measurement of the product's integration.

In products, multiple modules or components must be involved in the construction and use of the product for the discussion of modularity and integration to even apply. For example, having a conversation about a crowbar made of single bar of steel as being either modular or integrative in design is nonsensical. It only has one module; thus it can be neither modular nor integrated in design. The product must have multiple components

| | | A | B1 | B2 | B3 | B4 | C | D |
|---|---|---|---|---|---|---|---|---|
| System Design | A | X | | | | | | |
| Component 1 | B1 | X | X | X | X | | | |
| Component 2 | B2 | X | X | X | X | X | | |
| Component 3 | B3 | X | X | | X | | | |
| Component 4 | B4 | X | X | | X | X | | |
| Prototype | C | | X | X | X | X | X | |
| Testing | D | | | | | | X | X |

Figure 11: Basic design structure matrix

before modular and integrated designs can even be compared. Services also require this same constraint.

Customers must have a need for multiple services before we can compare the modular versus integrated responses to their needs. A customer who only needs gasoline will not interact with either a modular or integrated service process because a single service process like a crowbar cannot be defined on the modular to integrated service process continuum.

To summarize and simplify the conclusions in the literature, integral products have components bound together with complex interactions and multiple interfaces that are not easily separable and increase the value of the product by their interaction; in contrast, modular product designs have well-defined interfaces but their interactions are more loosely connected and easily separable.

### 3.1.3 Integration and Modularity in Services

The basic differentiating factors in product modularity, interaction management and interface management also apply to service design, but there are some subtle differences in service design, which creates problems when a direct transfer of terminology is attempted. For example, Baldwin and Clark (2000) claim modular products have well-defined interfaces between modules. In modular services, what is the well-defined interface between services? I propose the interface is the customer (Sampson & Froehle, 2006), which is hardly a well-defined or reliable interface! For example, Biognano and Boutwell (2009) document an epidemic of hospital readmission creating 12 billion dollars in extra costs in the country. Surprisingly, most readmitted patients never connect with primary care physicians to receive needed and extended care. It was the patient/customer's job to be the interface between these processes, but they failed to perform their task in an adequate manner, causing unnecessary hospital readmissions.

Frei (2006) defines the five types of variation customers introduced into service production processes, demonstrating their inability to be a well-defined interface. They are generally a very heterogeneous interface, causing significant differences in defining integration and modularity in services. In addition to customers not being well-defined interfaces, they also are quite variable in their ability to manage interactions between service modules.

To continue the analogy of the automobile, to create an end-use vehicle, both the modular vehicles and the integrated vehicles must do three things: first bring together disparate modules, second define their interface, and third facilitate and manage the modules' interactions. The difference between modular and integrated vehicles lies in the way the modules' interfaces are designed and interactions managed. Because customers are an integral part of the service supply chain, two scenarios are possible in services that are unthinkable in vehicle product design.

First, in services some disparate modules are never brought physically close together, because the customer (co-designer: see the next chapter) is in charge of selecting from all the available service processes, and the customer can if needed traverse long distances to link the service supply chain together. Imagine a car sold to a customer where all the parts were connected by long wires, but the parts were scattered across suppliers' sites in multiple states. Second, imagine a vehicle in which the modules are brought together, but no plans are made for how each module will communicate with the other modules because the customer ("designer") will be in charge of communication and coordination. Imagine a vehicle where none of the internal parts are connected but they are all in one place.

While both of these scenarios are unthinkable in car production and design, they happen daily in services as customers experience modular services, co-designing the mixture and order of service process, supplying themselves and their possessions to distant and disparate processes (Sampson & Froehle, 2006). In most cases (such as a night out), the customer is capable of performing the coordination, bringing together of disparate services processes, and acting as a common interface, which is required in a modular service environment. Indeed, in many instances the customer demands to have the autonomy to configure service processes in the order and manner she pleases; the heterogeneity of customers' wants and needs create a fertile environment for modular services. On the other hand, modular product companies, like car companies, would not dream of giving customers the power of deciding how modules interfaced and in deciding how modules communicated. Likewise, iPhone customers have been begging for years for the ability to swap batteries out, but Steve Jobs has not yet felt the need to comply.

Thus the customer's role as both supplier (Sampson, 2000) and co-designer (see Chapter 4 for more details) of the service process illuminates two characteristics that both refine the customer interface and facilitate the management service interaction: co-location and coordination.

The definition of modular versus integrated services hinges on the role of the customer as co-designer and supplier of the service components. I define modular and integrated services as follows:

*In a modular service process the customer shoulders most of the burden of coordinating and combining services and serves as the primary interface and manager between service processes (components).*

*In an integrated service offering, disparate service providers communicate, manage, and coordinate service in behalf of the customer and (possibly) share location (customer takes on a lesser burden of coordination and service management between components).*

## 3.2 Illustrating Integration and Defining Its Characteristics

Consider a customer who wants to buy a night out on the town with his companion. This night out includes two simple components: dinner and a movie. He could choose Olive Garden for dinner and a visit to the local AMC Theaters 12 for the movie. This would be a very modular service offering. He would be required to provide transportation and coordination between events. The Olive Garden, which is a totally separate service module, may take too long preparing dinner and cause him to miss his show. In this environment the customer is in total control, for better or for worse, in coordinating and designing the components in his total service offering of a night out.

Now consider two other options the customer might have. In contrast to the earlier selection, the customer might visit the Megaplex at the Jordan Commons in Draper Utah. At the Jordan Commons over five restaurants, an Imax theater, and 16 stadium-seating screens are housed in the same complex. The customer choosing to visit Jordan Commons now has his options co-located for him and to a certain degree coordinated for him by large electronic boards that announce movie start times. The restaurant and movie choices are still his to make, but the complex has in some respects simplified his burden of service coordination.

His second option is to take integration even one step further by visiting the Alamo Drafthouse in Austin, Texas. The Drafthouse not only co-locates services but also coordinates the dinner and the entertainment. The Alamo Drafthouse allows patrons to buy drinks, eat dinner, and watch a movie or live entertainment option all in one location. By examining online comments from some customers, the Alamo Drafthouse finds a loyal following from those who value being served beer while watching a movie!

As the aforementioned example demonstrates, integration has two characteristics: location and coordination (see Figure 12). Thus a truly modular service occurs when the customer collects and communicates between service processes (see Figure 12, Quadrant 1: The customer coordinates her entertainment on a Friday night or coordinates her care between multiple doctors' offices). These types of services are modular in design (single service process in location) and modular in use (meant to be coordinated by the

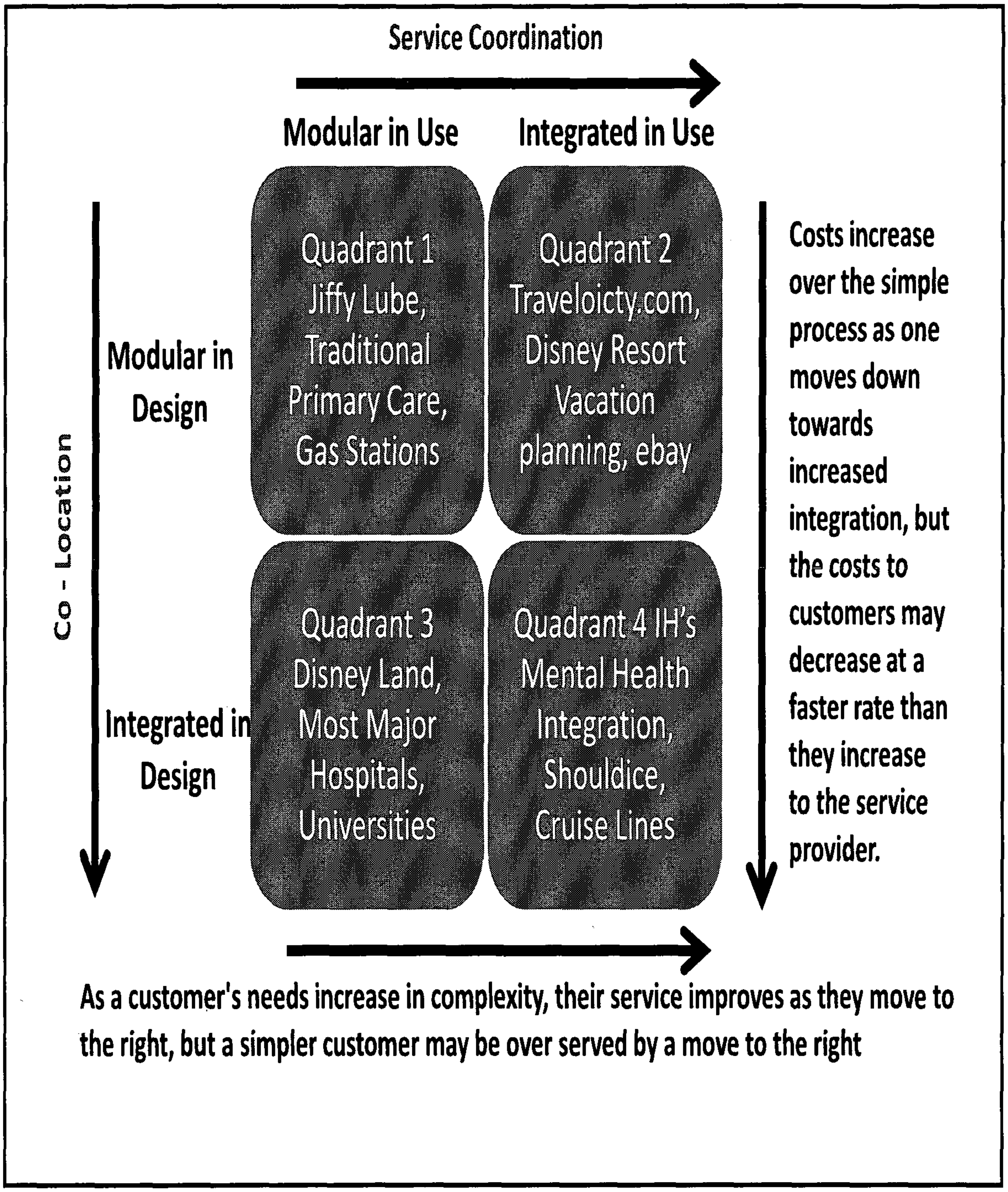



Figure 12: The four quadrants of service integration. *Author's note:* This representation is not a typology, but instead a diagram demonstrating how integration flows along two axes of co-location and coordination of services. As will be explained later in the dissertation, the level at which a process is examined is vital to determining its level of integration.

customer).

A partially integrated service can communicate between disparate modules for the customer but not physically combine the services (Quadrant 2: at Travelocity.com, flights, hotel rooms, and rental cars can be purchased and in medical services I could have a medical home or care manager who assists me in making appointments and follows up with my care); these services are integrated in use by the way they coordinate services in the customer's behalf, but they are modular in design because of disparate ownership and operation of providers.

On the other hand, some service providers physically bring the services processes together, but do not coordinate the service (Quadrant 3: Disneyland brings together disparate rides, shops, and restaurants and allows the customer to choose in what order and how many to use, or a hospital with multiple departments requires that the patient or her representative decide which departments to activate to create a care plan); these processes are integrated in design because of the physical proximity of providers, but they are modular in use because the customer acts as the coordinator of the service process.

Finally, the process might become fully integrated by physically bringing processes together and performing part or all the communication and coordination on behalf of the customer (Quadrant 4: A cruise ship that provides restaurants, sleeping accommodations, entertainment and concierge service to link the customer to places outside the resort if needed and MHI, which combines the services of the mental health provider, PCP, and care manager in one office to provide integrated and coordinate care); these services coordinate and co-locate, making them integrated in use and in design.

### 3.2.1 Quadrants Detailed

*Quadrant 1, modular in design and modular in use: Services in this quadrant do not physically bring modules together or coordinate communication between modules. All organizing and structuring of service process is left in the hands of the customer.*

Service processes, which can be defined as modular in design and modular in use, usually focus on a single service provision, offered quickly and efficiently. If the service provides any ancillary offerings at all, the offerings usually complement the main service process by adding additional revenue opportunities without requiring excessive costs or additional staff. For example, a service station might sell convenience goods in addition to gasoline because it requires little extra labor for the attendant to collect revenues from gas and convenience items at the same time. Likewise, Jiffy Lube technicians examine lights and air filters while changing a car's oil, and if either needs to be replaced, Jiffy Lube offers the service at an enhanced price.

Quadrant 1 service processes treat every transaction as a separate and distinct transaction and give the customer the greatest latitude in service process design. A visit to a particular gas station last week has no bearing on transactions this week at the same station or any other station. If a customer needs multiple service processes such as gas and a car wash, the responsibility to coordinate services between disparate service processes relies fully on the design skills of the customer.

*Quadrant 2, modular in design and integrated in use: Services in this quadrant do not bring the service modules physically together, but they coordinate communicates between service modules on behalf of the customer.*

Many times the choices facing customers with multiple needs are overwhelming in their scope and options; services modular in design and use do nothing to streamline a customer's overwhelming and difficult choice options, much less assist in finding the optimal or even a palatable outcome. Modular in design and integrated in use services fill in the gaps for the more complex needs of these customers. Service providers in this quadrant literally provide the integration process in behalf of the customers, thus they have titles like real estate agent, insurance agent, travel agent and marketplace. These service providers do not offer true integration because the heterogeneous nature of demand in their market place would make integration exceptionally expensive. For example, an airline that purchased hotel chains and rental car agencies in an attempt to integrate services in behalf of customers would become an expensive alternative for customers not needing all of those assets. Recognizing the high cost of integration through ownership, service processes in this quadrant act as bundlers of services ("virtual service providers") for customers who are overwhelmed by the difficulty of bundling all their service needs. For example, a customer may feel comfortable independently contracting with all the service providers she needs (flights, hotels, rental cars, and dining options) when returning to visit her parents in Illinois, but when traveling to Indonesia or experiencing her first cruise, she might feel overwhelmed at her options and prefer to meet with a travel agent. Likewise, marketplaces like eBay offer meeting places for disparate buyers and sellers, thus facilitating and streamlining the transaction process that would be cost prohibitive otherwise.

Gummesson (1996) discusses these types of services in the marketing literature in terms of imaginary organizations and relationship marketing. Organizations build relationships with customers and bind services together when needed, thus leveraging relationships and only tying services together when needed.

*Quadrant 3, integrated in design and modular in use: Services in this quadrant physically bring service modules together, but because of heterogeneity of demand, they do not coordinate the communication between the service modules. The customer as co-designer or the customer's advocate is in charge of designing which processes and in what order these processes are to be consumed.*

Unlike Quadrant 2 services, the integrated in design and modular in use services actually support multiple service providers in a single location, but these providers leave the designing and coordinating of the service offering in the hands of the customer. This organizational type is an attempt to fully accommodate the customer while still allowing for heterogeneity of demand. Disneyland typifies services in this category: It brings together a multitude of rides, eating establishments, entertainers, and retail shops under one umbrella, thus congregating all the attractions under one management group. Once the customer enters the park, she can mix and match the attractions as she chooses, and how she designs or coordinates the service is entirely up to her; thus once inside Disneyland, the customer experiences a very modular service offering. Many hospitals organize in a similar manner to Disneyland by bringing together disparate service process into a single location but allowing the service to be provided in a very modular fashion (but unlike Disneyland where customers excitedly enter anticipating the experience, hospital customers experience most of their joy when leaving the institutions). Helgheim, Randall and Bo's (2006) research supports this concept by demonstrating how patients with exactly the same diagnosis were treated with such a high degree of variability (as measured by the service processes they received) that it would be very difficult for hospitals to achieve economies of scale even for patients with matching diseases.

A personal experience I had with Primary Children's Hospital in Salt Lake City Utah exemplifies how modular general hospital care can be. A couple of months ago I accompanied my daughter to the hospital to receive outpatient-style tests. We waited for 20 minutes in the lobby before being able to check in with the clerk at the hospital's outpatient desk. Despite my daughter and my other children having been patients at the hospital on previous occasions, the check-in process still required 20 minutes while our personal information was taken and linked to past care. After finishing the check-in process, the clerk handed us our paperwork and gave us verbal directions for navigating the hospital on our own. Since we had never been to that wing of the hospital before, a map much like the one distributed at Disneyland would have been more helpful. We found the x-ray department first, having obliviously passed the blood-drawing department in our search for the nearest service provider. When we arrived at the x-ray department, we handed the staff our paperwork. They asked us who we were and why we were there: basically the same questions reception had asked us 10 minutes earlier. Despite our paperwork from reception, it still required 7 minutes and two employees to find us in their system. We waited an additional 20 minutes for care. After the x-ray exam, we walked to the blood drawing department. Again they did not know who we were, and it took another 5 minutes to find us in the computer system. They again asked us to wait, which we did for another 15 minutes. I want to stress that everyone we met was kind and competent. We received quality care, but I shouldered the responsibility for coordinating my daughter's care. Because of the modular nature of the care, we left the hospital after our second test without anyone taking notice or wondering if we needed more assistance; in this way, the hospital experience mirrored Disneyland, except there was no smiling-faced hand stamper on the way out.

It is important to note that integrating services in design is expensive. It requires massive overhead that is usually not associated with a single service process. Hospitals, theme parks, and universities are top-heavy in overhead and fixed expenses. This is part of the reason why some authors are calling for focused hospitals to correct the runaway costs in healthcare (Herzlinger, 2007), and why Christensen has pointed to healthcare and university education as two industries that are ripe for disruptive business models (Christensen et al., 2009; Christensen, Johnson, & Horn, 2008).

*Quadrant 4, integrated in design and integrated in use: Services in this quadrant physically locate service modules together and coordinate communication between needed service modules in behalf of or in participation with the customer. In this quadrant the customer has the least design control over the service process.*

Services integrated in use and in design coordinate service between multiple service providers and/or between multiple visits in conjunction with the customer. In an integrated environment, the service providers assist the customer in coordinating and communicating service between processes and build complex communication networks that facilitate multiple communication points between disparate service providers and the customer. Additionally, they also co-locate services in one location as much as possible.

Service design in this quadrant requires committed planning and organizational goals aligned with customer needs; thus it is difficult to find service processes that truly match the designation of integrated in design and in use. As a service organization expands and adds additional service processes, it becomes more difficult to synchronize the goals and objectives of all service providers. Tucker, Nembhard, and Edmondson (2007) describe hospitals as complex organizations because hospitals have "interdependent work units whose work must be coordinated to provide customer service, but whose units often have conflicting priorities" (p. 151). Despite the difficulty of integrating services, both Tucker et al. (2007) in neonatal intensive care and Shah, Goldstein, Unger and Henry (2008) in rural cardiac care revealed significant improvement in patient outcomes when service processes were integrated to achieve a particular goal.

*To understand the quadrant design, one has to be aware of the level of focus:*

The description of a service process as either modular or integrated often depends on the level at which one examines the process. For example, if a friend were looking for an integrated treatment option for her hernia, I would recommend Shouldice without reservation as a highly integrated care option. Shouldice hospital seamlessly integrates the three service processes: preoperation, operation, and postoperative recovery. Shouldice plans meals, therapy, patient meetings, surgery, recovery, and support groups all in the same location with massive amounts of coordination (Heskett, 2003). Shouldice's care for hernias fits the definition of integrated care because it integrates care from the moment a patient arrives at the hospital to the point she returns for her 10th reunion. Shouldice physically co-locates these processes and coordinates the communication between them in behalf of the patient. On the other hand, if my friend had multiple co-morbidities, one of which was a hernia, I am confident Shouldice would most likely reject her application on the basis that her case was too complex for their facility. While Shouldice integrates the three parts of hernia care, it purposefully does not expand the facility to include more disparate service offerings. In light of this, most practitioners would define Shouldice as a modular care system when seen in the totality of all healthcare providers. Shouldice, as an integrated facility, offers the “hernia module,” but relies on other modules (i.e., other facilities) to offer complementary treatments to service additional patient needs (i.e., “cancer treatment” module, etc.). This leads to the obvious observation that because customers are co-designers to the service process, their needs are a factor in determining whether a facility is an integral or a modular service provider and in determining which process can best serve their needs.

Schmenner (2004) theorizes that a service process with a swift and even flow produces the more effective outcome than those service processes with choppier and slower delivery. I concur with this theory and hypothesize that integrated service design delivers to complex customers the best possible service because as it coordinates disparate service processes, the customer in need of those processes will have the swiftest and most even flow through the service process. If this hypothesis is true, why don’t all services race to be organized as a Quadrant 4 process, and why are many service businesses in other quadrants successful, profitable, and of high quality? To answer this question I will return to the product modularity literature.

### 3.3 Propositions on the Systems’ Modularity and How They Relate to Service Management

In AMR, Schilling (2000) extensively examines the modularity, integration, and systems literature to create 11 propositions, describing the forces that drive systems to and away from increased modularity. In general, her research propositions are intuitive and precisely written. In an effort to further translate discussion of product modularity and integration into a service environment, I will examine each of her propositions independently and how they relate to service process.

*"Proposition 1: The degree to which functionality is achieved through component specificity will be negatively related to increasing interfirm product modularity"* (Schilling, 2000, p. 322).

The proposition reverses itself in service processes: The more a specific service is needed or desired than other services in the service supply chain, the more likely the service is to be modularized. Highly desired service specialists will be able to financially leverage their position in the service supply chain because the customer is most likely to favor their access to specialty service provider over their convenience of flow through the service system; as the customer, who designs the service supply chain, we yield to the module with the greatest veracity in the chain.

*"Proposition 2: The degree of difficulty customers face in assessing the quality and interactions of components will be negatively related to increasing interfirm product modularity"* (Schilling, 2000, p. 322).

This proposition accurately describes service systems in addition to product systems. The more difficult it is for customers to ascertain the quality of one service process over another, the more likely the customers are to choose the convenience of flow over the variety offered by service modularization. For example, if food and convenience items are seen as having little differentiation in their quality, a customer is more likely to choose a supermarket, which integrates the sale of all products, over more modular specialty shops.

*"Proposition 3: The degree of difficulty customers face in assembling components will be negatively related to increasing interfirm product modularity"* (Schilling, 2000, p. 323).

Again, Schilling's third proposition also applies directly to service integration. The more difficulty a customer has piecing together her service supply chain, the more likely she is to value service integration or to rely completely on it. Travel agencies, guided tours, and other integrated packages are used more often for international travel than for domestic travel.

*"Proposition 4: Greater diversity in technological options available in the market will be positively related to increasing interfirm product modularity"* (Schilling, 2000, p. 323).

This proposition could be restated as, the greater the diversity of service options from diverse firms the more likely the customer is to prefer interfirm service modularity. Customers do enjoy diversity options, but diversity and choices can also cause customers to be overwhelmed. Because the choice of service integration versus modularization comes from the customer, this proposition would need to be reworded for services. For example, the more heterogeneous the customer base, the more likely the customer is to demand increasing interfirm service modularity.

*"Proposition 5: The degree to which firms in the market have different capabilities will be positively related to increasing interfirm product modularity"* (Schilling, 2000, p. 324).

Again this proposition needs to be restated in terms of the service market. In retail, for example, the growth of large grocery stores and super centers have caused small independent (i.e., more modular) service offerings to close. We could restate this option a different way for service modularity. The more diverse the offerings in the service marketplace, the more likely customers will be to seek out a service provider who can integrate the offerings and provide location and organization to service offers to facilitate flow for the customer through the services in the supply chain.

*"Proposition 6: The degree to which firms in the market have differentiated capabilities and the availability of diverse technological options will reinforce each other"* (Schilling, 2000, p. 324).

Restated for service management, the more heterogeneous the customer population the more modular the service offerings that will be demanded, but this will be counteracted because as service offerings become more heterogeneous the number of choices will cause customers to demand the integration and organization of service offerings in their behalf to increase their speed and flow through the service supply chain.

*"Proposition 7: The adoption of increasingly interfirm modular product designs may result in both the further differentiation of firm capabilities and the development of diverse technological options"* (Schilling, 2000, p. 324).

This is basically true as well in services. Restated, as customers become more comfortable with navigating modular service operations, they are more likely to demand and to be able to facilitate movement through greater modular service process design.

*"Proposition 8: Customer heterogeneity in desired function or scale of product will be positively related to increasing interfirm product modularity"* (Schilling, 2000, p. 325).

Customer heterogeneity will produce demand for greater heterogeneity in service options, which will produce service supply chain options from all four quadrants in the service supply chain. It is unclear whether heterogeneity will always push towards greater modularization in services because of structural costs. For example, take a city of 35,000 residents. It may have one central hospital (integrated for healthcare) and multiple stand alone restaurants with one or two stand alone theaters (modular for entertainment). As the city grows and becomes a town of 100,000 it starts to sprout specialty hospitals (increasing modularity in healthcare); it also starts to sprout large joint movie and eating options, creating megaplexes for the masses (increasing integration options in entertainment). In summary, greater heterogeneity in demand can cause growth in multiple service quadrants not necessarily leading to either greater modularity or greater integration.

*"Proposition 9: Heterogeneous inputs (diversity in technological options and differentiation in firm capabilities) and heterogeneous demands (customer heterogeneity) will each reinforce the effect of the other"* (Schilling, 2000, p. 326).

This proposition, which restates and combines propositions 7 and 8, differs slightly for service operations. In services, as capabilities become more diverse and customers become more heterogeneous, the demand for increased diversity not only increases the number of modular offerings, it also increases the amount and the deepness of the integrated service options.

*"Proposition 10: If there are pressures to increase or decrease the interfirm modularity of a product system, the speed of technological change will increase the likelihood of such a change"* (Schilling, 2000, p. 328).

Technology is an enabler of service supply chain change and does not necessarily increase or decrease pressure to move towards increasing modularity or increasing integration. On one hand, technology gives customers the power to choose supply chain design with greater control and confidence. For example, in the past a customer traveling to a distant location employed a travel agent to integrate the needed modular services. The internet now gives customers the confidence and ability to snap together their own modular offerings. Thus from the customer perspective, technology allows greater modularity. On the other hand, technology also allows modular service firms greater ability to offer a more integrated experience to customers. For example, Southwest Airline now offers car rental and hotels to its flying customers through its web site, and the Hackensack NJ medical center uses technology to more tightly integrate its services, leading to higher profits and better patient outcomes (Mullaney & Weintraub, 2005).

*"Proposition 11: If there are pressures to increase or decrease the interfirm modularity of a product system, competitive intensity will increase the likelihood of such a migration"* (Schilling, 2000, p. 328).

The service literature is extensive about the copycatting that happens in services because they are so difficult to patent (Tsai et al., 2007). For example, when IH, the leading healthcare provider in Salt Lake City, announced a specialty orthopedic hospital, the University of Utah medical system quickly followed with a facility of their own. But because service supply chains are so easy to manipulate, competitive intensity in service supply chains also spawns competing systems. One system will often be more modular, while the other system will offer greater integration in the presence of customer heterogeneity. A third hospital system in the Salt Lake Area, St. Mark's, separated their orthopedic unit, but kept it as part of the main hospital campus and not as a fully separate facility.

In services, customers are the designers of the service supply chain, and their heterogeneity often ends up allowing firms on both ends of the integration spectrum to be successful. This is often the case because modular and integrated service firms attract different customer segments and often have radically different cost structures and opposing effects of the complexity of process management. Because costs and complexity play a large role in the balance between service modularization and integration, it is now time to address both topics and how they pressure service supply chains to offer either integration or modularization.

### 3.3.1 Cost

Service processes that accommodate complex customers through integration face increases from two basic categories of costs within a service supply chain: server costs and relationship costs. Adding servers and service processes to the basic service process increases server costs, which includes direct labor for additional specialists, overhead from additional building design and space requirements, additional equipment purchases, and additional billing and HR costs. Integrating relationship aspects into a process increases relationship costs, which arise as patient needs are tracked and responded to in an individualized manner. Customized care across service visits requires either a smaller staff-to-customer ratio, which gives the provider the ability to intimately know its customer base, or it requires investments in database processes to more efficiently track, contact, and provide services to customers over time. This is one of the reasons why service typologies single out service customization as a defining service factor (Baumol

& Bowen, 1996; Lovelock, 1983; Schmenner, 1986): because to truly customize a service usually requires a substantial investment in relationship costs.

In the presence of demand uncertainty, precisely matching the level of the patient's complexity with the level of integration in the supply chain is difficult. Market costs of not correctly matching service supply chain design to customer needs includes customer waiting costs (patients wait months to receive care and may become worse or customers spend long periods of time waiting for dinner or attractions), wasted capacity when supply exceeds demands (missed appointments, waiting for a psychologist, empty tables in a restaurant), and the cost of lost sales when demand exceeds supply (a patient not served ends up in the ER or at another clinic or customers who wait too long in line go elsewhere for dinner).

In manufacturing, all three market costs caused by mismatching supply and demand directly affect the profits of the producer. But in services when a mismatch occurs, only the cost of too much capacity falls directly on the primary provider (thus producers are particularly sensitive to wasted capacity). The market costs of waiting lines or of patients who are left to piece together services by themselves only indirectly affect the provider. In some cases where the provider is the customer's only option, the market costs of waiting lines do not affect the provider at all. Ryan and Wittkins (1977) entitle this situation "trapped commitment." The waiting costs and the burden costs of a self-integrating modular service process usually fall directly on the customer (a vital supplier to the service production process). For some customers these costs are more burdensome than for others, and for the complex customer these costs can be almost overwhelming to shoulder.

While integrating services to respond to customer complexity in the service process increases server costs, relationship costs, or both, different types of complexity have different relative influences on server costs and relationship costs, depending on the level and severity of needs underling the complexity. Hence, the association between customer complexity and service supply chain structure depends on the relative impact of service demand on server costs and relationship costs. For conceptual clarity, one can distinguish between two types of customer complexity: *server-dominated complexity* and *relationship-dominant complexity*. Complexity is server-dominant if the increases in server costs associated with increased customer complexity outweigh the increase in relationship costs. For example, customer/patient complexity that requires multiple expert servers to work in close proximity to fully serve a co-morbid patient requires large investments in overhead, hiring costs, billing, equipment, and planning. The University of Utah Orthopaedic Hospital has lower overhead and a faster average turnaround time than the University of Utah's general hospital for orthopedic surgeries, yet at-risk patients or patients with multiple co-morbidities often find their surgeries are scheduled at the general hospital instead of the orthopedic center because the orthopedic center is not staffed with the necessary specialists and equipment to serve patients with potentially adverse surgical outcomes. The orthopaedic center would exponentially increase its server cost if it staffed servers to care for all the potential negative outcomes severely co-morbid patients could experience because these severely co-morbid patients represent a small portion of their patient population. Conversely, customer/patient complexity is relationship-dominant if the increase in relationship costs associated with increased customer/patient complexity outweighs the increase in server costs. For example, customer/patient complexity that requires repeat visits to the same provider for a chronic illness has minimal impact on overhead but a significant impact on the relational and organizational impact of the service provider. Server-dominant customer complexity typically requires substantial investments in fixed costs for each variant, and relationship-dominant customer complexity is often associated with a high degree of effort to build and support relationships. While separating these costs, it should be noted that the vast majority of complex customers/patients need both server and relationship support. Very few complex customers/patients need only one or the other, and empirically the costs are very difficult to isolate.

Integrating services always increases costs for the server, but the integration may result in lower costs for the consumer, which will increase service value and increase revenue purchases above the increased costs to the server. For example, if a patient were admitted to an ICU it would be dangerous and expensive for her care to be spread across multiple locations even if each silo offered the lowest possible cost, and so while full level-3 trauma hospitals are expensive to run and operate, they drastically reduce costs for customers who need their services.

Community and research hospitals are often attractive because of the range of services and diagnostic procedures they co-locate, but by offering a multitude of heterogeneous services, hospitals increase their server costs because of the additional expenses (equipment, overhead, hiring costs, etc.), which are required to support such a disparate group of service offerings. In grouping all of these specialists together, hospitals often assume that they can achieve economy of scale, but as costs continue to escalate, the assumption is proving less and less viable. Helgheim, Randall, and Bo (2006) found no pattern of consistent care among patients with the same diagnosis at the same hospital. Patients' wide variation in treatment caused them to conclude it would be difficult for the hospital to gain economies of scale by including more services.

Schmenner's (2004) theory of swift and even flow claims that more is needed than co-location to increase productivity: For a hospital to achieve faster flow, the process would have to be arranged to integrate service processes according to the complex service needs of the patient. In support of this concept, Dr. Provonost (Gawande, 2007) studied hospitals staffed with internists and found these hospitals produced better outcomes in safety and efficiency for patients because, in effect, the internist coordinated care for patients in the modular environment of the hospital. The relational care can also be facilitated by technology; the digital integration of medical and information systems in a hospital in Hackensack, NJ, led to a drop in mortality of 16%, a shortening of the average length of stay by 24% (increased the swift and even flow), and an increase in the hospital's operating margins from 1.2% to 3.1% (Mullaney & Weintraub, 2005).

### 3.3.2 Increasing Complexity in the Service Process

Because integration increases either the number of servers or the number of and quality of interactions with the customer or both, it increases the complexity of the service processes, and unless this added complexity is managed, it will increase costs and slow down the flow of customers through the service process. Through observation of the service integration process and through an examination of service typology research, I have delineated seven types of endogenous service complexities that need to be considered and managed when services are integrated (step complexity, path complexity, definitional complexity, skill complexity, relearning complexity, handoff complexity, and incentive complexity). I entitle these complexities as endogenous because unlike Frei's (2006) five types of variability, which come from including exogenous customers in the service process, these endogenous complexities are the result of choices service providers make in designing and positioning their service processes. *(Note: to see a detailed discussion on the seven types of complexity and how mental health integration at IH attempts to manage these complexities, see Appendix B.)*

### 3.4 Chapter Summary and Discussion

Modular services require customers to locate and organize service offerings whereas integrated service offerings lift some or all if the burden of service process organization from the customer. Integration can come for co-location, service organization, or both. Integrated services require greater overhead and greater complexity management from the service provider, which often makes them expensive unless they can increase scale; on the other hand, integrated services increase the flow of customers through the service process and often decrease complexity management for the customer.

In this chapter, the choice between a modular versus an integrated service system has been treated as a customer preference or a decision about convenience, thus the choice becomes nothing more than a marketing tool for service providers to differentiate themselves from other providers. On the other hand, if the choice between modular and integrated design affects the quality of the service offering for certain customer groups, the choice becomes a vital design issue for those service providers who must or chose to serve these niche customer groups. For example, recent studies (Bisognano & Boutwell, 2009) on hospital readmissions uncovered 12 billion dollars in unneeded readmission expense because customers were unable to manage the home care portion of their service process. Unlike Shouldice, which integrates the after-surgery care process with their surgical procedure, most hospitals modularize and leave the integration of postoperative care in the hands of patients. Studies seem to indicate that a large portion of patients find their supplier role in this process is overwhelming (Bisognano & Boutwell, 2009). While this chapter has attempted to broaden the discussion of service integration beyond healthcare, it is important to remember that integration is more than a simple convenience choice: It is also a quality choice. Because the study of modularization and integration in services requires customers to have multiple needs (this is further developed in the next section), it also foretells high amounts of customer heterogeneity and variation (Frei, 2006). This variation allows service operations in every corner of the quadrant to be successful in the market place when correctly positioned with customers. Customers' heterogeneity in demand and heterogeneity in ability to piece together service supply chains will always demand from the market an ebb and flow between service modularity and integration.

### 3.4.1 Future Research

Future research in this area includes the examination of the benefits of service coordination in comparison to service performance. For example, many privately practicing doctors perform surgeries on hernias using the Shouldice methods. An experiment could be performed, holding constant patients' acuity, comparing surgery outcomes between the modular and integrated service designs.

Research could also answer questions about the advantages gained from co-location compared to the advantages of coordination, to see which is more important or cost effective. For example, if we simply locate specialists in the same office complex will we have the same resulting care as coordinating care? And would care coordination without co-location provide an equivalent level of care without the added costs?

Additionally, questionnaires about a customer's perceived burden in care coordination might also be revealing to understand the burden customers feel they are under in modular care. Similar questionnaires could be distributed to college freshman to understand the burden they feel in their coordination responsibilities.

CHAPTER 4

# COMPLEX CUSTOMERS AND THEIR EFFECT ON THE SERVICE SUPPLY CHAIN

## 4.1 The Complex Customer and How This Customer Shapes Our Understanding of the Service Supply Chain

### 4.1.1 Chapter Preview

This chapter will define the complex customer and describe how this customer redefines how the service management literature understands the service supply chain. The complex customer opens the door to the customer as co-designer of the service supply chain, and as co-designers, these customers receive benefits from service integration because it assists them in their role as designer. This chapter builds specifically on Sampson (2000), and it adds dimension to customer/supplier duality. This chapter, like Chapter 3, is an attempt to broaden the concepts in the main study to the entire service operations field; thus MHI will not be explicitly used. There will be medical examples into which MHI could be inserted because these ideas were generated from the process of going through the main study. This paper is meant to eventually become a stand-alone theoretical article. It details the managerial implications of serving complex customers and possible future research.

### 4.1.2 Introduction

Sampson and Foehle (2006) in the their unified services theory define a service process as a process "where the customer provides significant inputs into the production process" (p. 331). In other words, a service is a service because of direct customer inputs, and these inputs are a necessary and sufficient part of the process for it to be labeled as a service.

The theme of how customer inputs define and affect the service process experience permeates the literature. Frei (2006) describes five distinct types of variability that customers introduce into service processes (arrival, request, capability, effort, subjective preference), and multiple authors (Chase, 1978; Kellogg & Chase, 1995; Mersha, 1990; Schmenner, 1986; Verma & Young, 2000) demonstrate how the amount of customer contact (or intensity of inputs) affects the efficiency and management of a service process. Additionally, the literature has also focused heavily on the level of customer involvement and the level of customer discretion within the service process, and how these levels affect service process efficiency (Lovelock, 1983; Mills & Morris, 1986; Schmenner, 1986; Wemmerlov, 1990). In summary, it is clear that having a service means dealing with customer inputs.

Most services consist of a single transaction, such as eating out at the Olive Garden or having one's oil changed at Jiffy Lube. In these simple transactions, what one orders or does not order during a previous visit has little to no influence on the process or experience of the following visit to the Olive Garden; thus for the Olive Garden to provide a customer with a quality service, there is no need to transfer customer information between visits or between other service providers.

Jiffy Lube, the Olive Garden, and a million other service settings act as the genesis for the majority of our service supply chain research questions. The research, generated from the view of the firm, examines the process the firm goes through to deliver a service to its customer. While this examination has produced excellent research, it misses the unseen portion of the service supply chain, discounting and dismissing the full role customers play in the supply chain when they bring multiple inputs into the service process. To capture the intricate role the customer plays requires moving past the role of the firm to examine fully the role of the "complex customer."

This chapter contributes three main items to the literature of service management and service supply chains. First, it provides a clear definition of the complex customer. In addition, it examines the role of the complex customer in the service supply chain, and how an understanding of this role changes the dynamics of the role of services. Finally, this chapter will address the management implications of servicing the complex customer.

### 4.1.3 Defining the Complex Customer

"A service is a process where the customer provides significant inputs into the production process" (Sampson & Froehle, 2006, p. 331). The basic customer is one who has a simple need, and this customer provides a single input into a process. A customer arrives at Jiffy Lube and simply needs her oil changed. This simple customer provides a single input—her car—to the system, and she receives a quick and efficient oil change. Similarly at the Olive Garden, the customer gives her single input, her dinner order, and she is served an authentic Italian meal. On the other hand, the dynamics change and the customer moves from being simple to being complex if the customer needs a car wash in addition to her oil change or is looking for a night out on the town and not only authentic Italian pasta.

> *A complex customer is defined to be one who: 1) demands multiple processes, 2) experiences interactions between these processes, and 3) could benefit from assistance in managing the interactions and interfaces between these processes. Customer complexity increases with the number of processes, the extent of interactions, and the degree of customer ineptness in managing service interactions and interfaces.*

Why is this definition important?

Recent studies have shown that 88% of Americans over 65 have more than one chronic disease and 25% have more than four (Wagner, 2001), demonstrating the extent to which service providers deal with complex customers. Customers with chronic and multiple diseases need their care coordinated between multiple service providers and across time, defining them as complex customers. By their very nature, they demand a new paradigm in the way we view the creation of service supply chains. It is actually through this new lens of seeing the obviously complex medical patients/customers, that we can also view less obviously complex customers (the Jiffy Lube customer who needs an oil change and a car wash and the Olive Garden customer who really wants a complete night out) as complex customers.

## 4.2 The Complex Customer in the Service Management Literature

Despite the role of the customer permeating the service management literature, the bulk of the literature focuses on the customer interaction in a single transaction and not across multiple visits; the one exception is what Cook, Goh, and Chung (1999) call the commitment literature (Goodwin, 1986; Lovelock, 1983; Ryans & Wittink, 1977; Wilson, 1972). Yet even the commitment literature is unsatisfactory in this area. For example, Lovelock (1983) delineates services by those whose service processes require memberships versus those whose service processes do not (attending Gold's Gym versus listing to the radio). This delineation lumps the service I received as a college freshman in with the service I receive from my car insurance company. Both services require a membership, yet as a freshman, I committed myself as an input into the service process on a daily basis. In contrast, as a customer of State Farm, I provided significant inputs at the inception of my policy, but since inception, the extent of my input has been to write checks every 6 months. The nature of these constant inputs into the service process of education makes it an inherently more difficult process to manage and to scale than an insurance process. The other writers in this area focus more on the level of commitment or relative power inherent in customer relationships as a defining factor (Goodwin, 1986; Ryans & Wittink, 1977; Wilson, 1972), and again they are unsatisfactory in their ability to address the customer who supplies information at multiple points in the service process.

### 4.2.1 Three Streams of Service Management Literature

To approach the issue of the complex customer, this study will relate to three streams of research in the service management. The customer as co-producer, the service supply chain literature, and the customer/supplier duality.

#### 4.2.1.1 Customer as Co-Producer

The customer as co-producer literature engages the customer as a "partial" employee because of the customer's role in performing the service (Mills & Morris, 1986). Customers often gather information for lawyers to assist in the service provided by the law firm or engage in activities suggested by their doctors; thus Mills and Morris

(1986) suggest that service providers need to provide a level of training to customers. The role customers play is so important it was developed into a typology by Mills and Newton (1980) to rank customers according to personal interactiveness in the process. Indeed, the literature has gone so far as to recommend ways to satisfy and motivate these personal employees (Kellogg, Youngdahl, & Bowen, 1997; Mills, Chase, & Margulies, 1983). More recently, Frei (2006) warned service providers to be aware of variation these employees cause to the system.

The fault of this literature is that it does not expand outside the current service process. The customers are simply seen as an employee of the current process. The literature pays scant attention to customers' multiple needs that may take them outside the service area except for their role in forming and sustaining relationships (Mills & Morris, 1986; Ryans & Wittink, 1977).

#### 4.2.1.2 Service Supply Chains

Despite the important role the customer plays in a service process, the service process supply chain literature has failed to go into great depth about how the customer's needs affect the design of the service supply chain. The frameworks and the descriptions of service supply chains seem to start from the current manufacturing perspective and then gravitate towards services while pointing out the difference in service supply chains. The differences are built off of the traditional differentiating factors in services, and researchers use those contrasts to differentiate service supply chains from traditional supply chains (Baltacioglu, Ada, Kaplan, Yurt, & Kaplan, 2007; Ellram, Tate, & Billington, 2004; Sengupta, Heiser, & Cook, 2006). This approach extends manufacturing concepts into the service realm; for example, Akkermans and Vos (2003) demonstrated amplification in the telecom service environment, and Ellram, Tate, and Billington (2004) extended the ideas of executive purchasing into the procurement of professional services. But when it leaves the traditional supply chain design and incorporates "pure services" like education and healthcare, most of the literature and attempts to use the term "supply chain" seem forced at best. The service supply chain literature tries so hard to model itself after product supply chains that it likewise gives scant attention to the customer, who mainly becomes the final link in the chain, excepting feedback loops.

#### 4.2.1.3 The Customer Supplier Duality

Sampson and Froehle (Sampson & Froehle, 2006) make a notable addition to both the customer as co-producer and the service supply chain literature by combining their elements. Sampson creates a term he calls the customer supply chain duality (Sampson, 2000). Sampson quotes Lovelock to set the stage for his argument (Lovelock, 1983, 1996). Sampson (2000) describes how all services can fit into one or more of four categories:

> (1) services that act on people's minds (e.g., education, entertainment, psychology);
> (2) services that act on people's bodies (e.g., transportation, lodging, funeral services);
> (3) services that act on people's belongings (e.g., landscaping, dry cleaning, repair);
> (4) services that act on people's information (e.g., insurance, investments, legal services).
>
> To summarize, all services act on something which is provided by the customer. This is true. The implication is that all services have customers as primary suppliers of inputs. In other words, *customers are suppliers in all service businesses, which is the customer-supplier duality.* (p. 351)

Or in other words, the service supply chain differs from manufacturing supply chains because the customer is both the customer and a supplier of inputs. Because the customers supply their inputs to the service supply chain, they are suppliers (i.e., a Jiffy Lube customer supplies her car), but they are also recipients of the service so they are customers as well.

Sampson (2000) continues on to explain that in services there are two basic types of service supply chains:

> The simplest form of a bidirectional supply chain is for the customers to provide their inputs to the service provider, who converts the input into an output which is delivered back to the customer. [This single-level bidirectional supply chain is depicted in Figure 13.]
>
> Things get more complicated when the service provider employs another service provider to assist with the processing of customer inputs. For example, some electronics retailers offer television repair but outsource the actual repair process. The result is a two-level bidirectional supply chain: customers supply broken televisions to the retailer who then supplies them to the repair contractor. [Such a two-level bidirectional supply chain is depicted in Figure 14.]
>
> Finally, the service firm needs to select the supplier based on relevant criteria. The consideration of service suppliers in two-level bidirectional supply chains is not markedly different from the decision processes for manufacturers. Finally, supplier selection is usually not an issue under customer-supplier duality, since it is the customers who choose to be input suppliers to the service provider, not the service provider who chooses the customers. (p. 354)

Sampson closes his discussion on the customer-supplier duality by arguing that service supply chains rarely become more complicated than the two basic structures because services must be just in time (JIT).

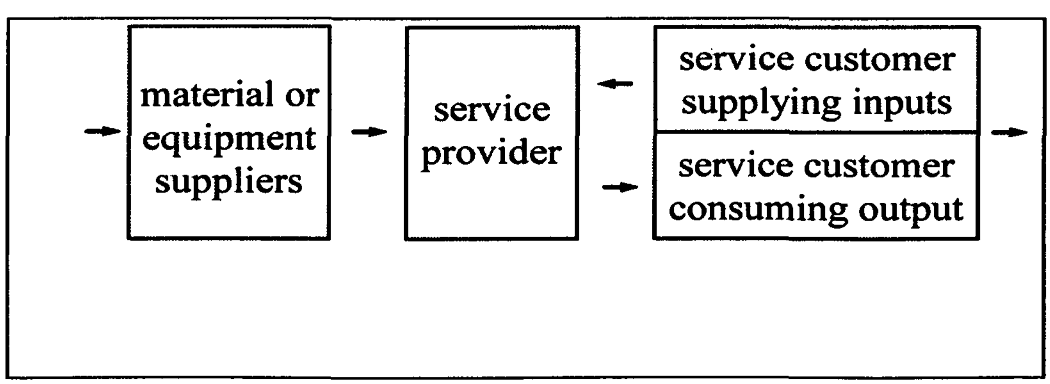



Figure 13: Sampson supply chain design 1

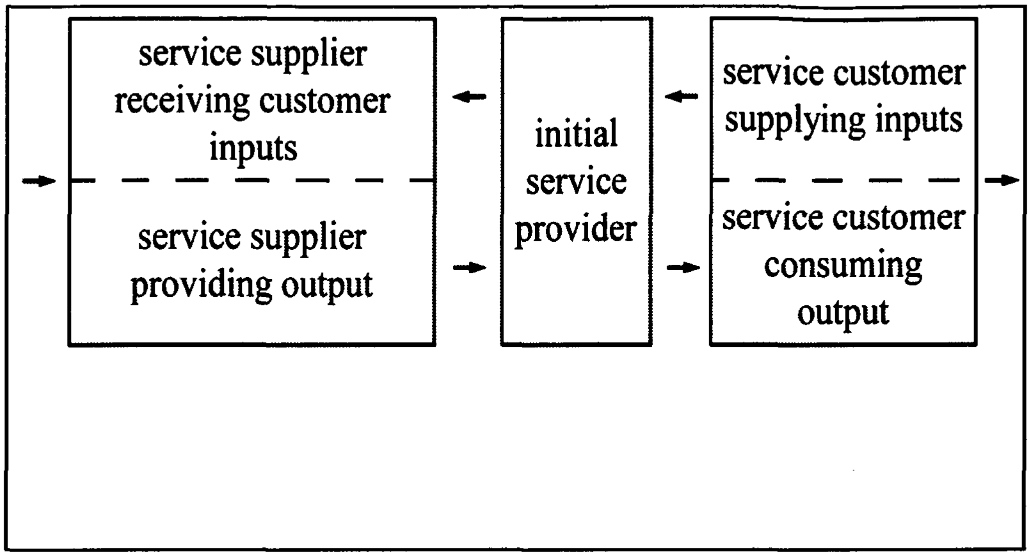



Figure 14: Sampson supply chain design 2

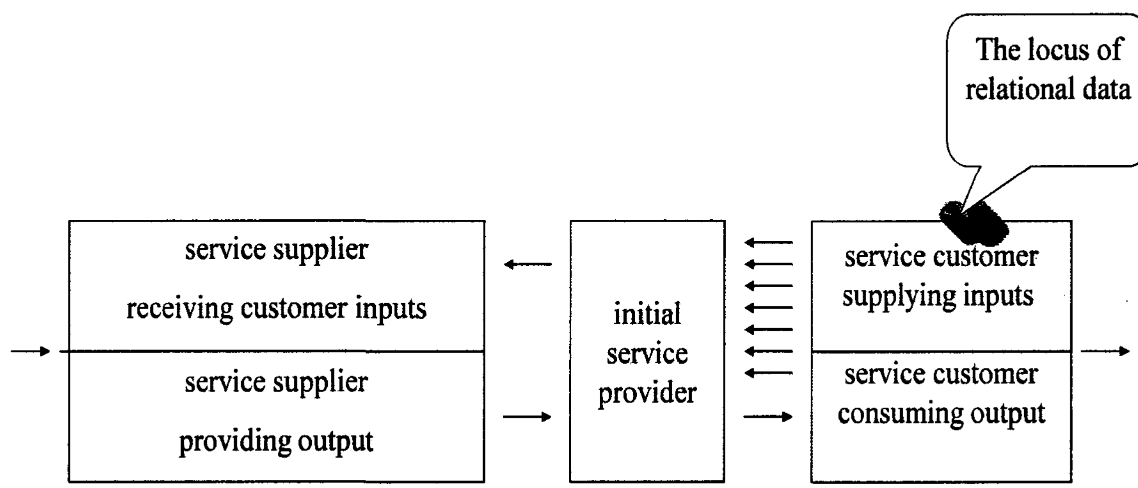
**4.3 The Complex Customer as Co-Designer**

While Sampson's theory well describes typical customers, it is inadequate to explain the role of the complex customer, which also includes the customer-designer duality. For example, visiting Jiffy Lube is a typical example of the first most basic service supply chain (see Figure 13). The total service process is finished in a single location, by a single provider, at one point in time, and the customer provides one input into the process. It would seem that the service supply chain ends after the customer leaves the Jiffy Lube garage. But what if the customer also needed her car washed: is the service supply chain finished? In this example the customer has two options: She can go to two separate service providers—one that provides an oil change (Jiffy Lube) and one that provides a car wash (Spray and Wash)—or she can go to her local Lube and Wash, which provides both services at the same location. In this instance, the customer needs two disparate service offerings and in her customer-designer role she chooses how to configure her service supply chain; thus customers not only play the additional role of supplier to the service chain, they also play the role of co-designer.

The previous example of a customer needing an oil change and car wash is relatively trivial when compared to how customers with chronic diseases and co-morbidities need to see multiple specialists or repeatedly enter the service system. Patients diagnosed with diabetes, a chronic disease, will require multiple specialists and a life-time of vigilance and doctor visits to keep the disease under control (Herzlinger, 2007). Consequently, the service they need for their diabetes cannot simply be obtained in a single visit or with a single given input. Additionally, many of these patients have co-morbidities such as heart disease, depression, or asthma. To effectively treat these co-morbidities, a number of different specialists are required, and only treating one of the co-morbidities leaves the entire care incomplete. For example, if co-morbid depressed patients are treated for their depression and not for their diabetes, their depression will rarely improve. On the other hand, if their diabetes is treated and their depression is ignored, it is unlikely that the patient will effectively regulate her diet, causing her diabetes to worsen. Additionally, unlike a visit to a car wash where the amount or timing of the last service has no bearing on the service received at the current visit, in the case of both the co-morbid and chronically ill patients, what transpired during their last visit to the doctor relates directly to the care they need to receive during the current visit. So unlike the Jiffy Lube example, the customer designs major and sometimes life-altering supply chain designs depending on how she exercises her role as co-designer of the supply chain.

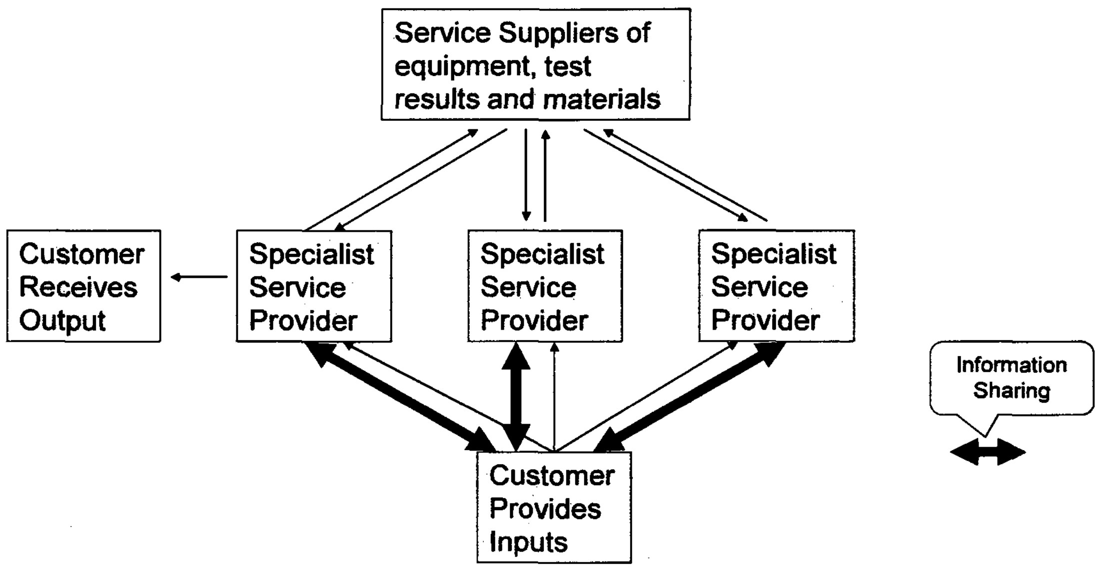
Healthcare may be a fertile area to find complex customers, but other service industries, such as education, also house complex customers as a rule. Most educational services, because of their repetitive nature and multiple disciplines, by definition deliver goods to complex customers. Take for example a college freshman attending her first semester far from home. To receive the services of a 100-level English class, she will attend the class more than 20 times during the semester (much like a chronically diseased patient), and during the same semester she will also require services from multiple specialists such as those in chemistry, math, and arts (much like the co-morbid patient).

Because of the complex customer's role as customer and designer, I propose two additional service supply chain designs (Figures 15 and 16), which are derivations of the two previous basic service supply chain designs suggested by Sampson (Figures 13 and 14). These two new supply chains can have two alternate shapes (see Figures 17 and 18).




Modular design where the customer, a supplier, retains all the relational data and coordinates multiple visits over time to obtain the needed service.

Figure 15: Modular service supply chain for the complex customer - 1

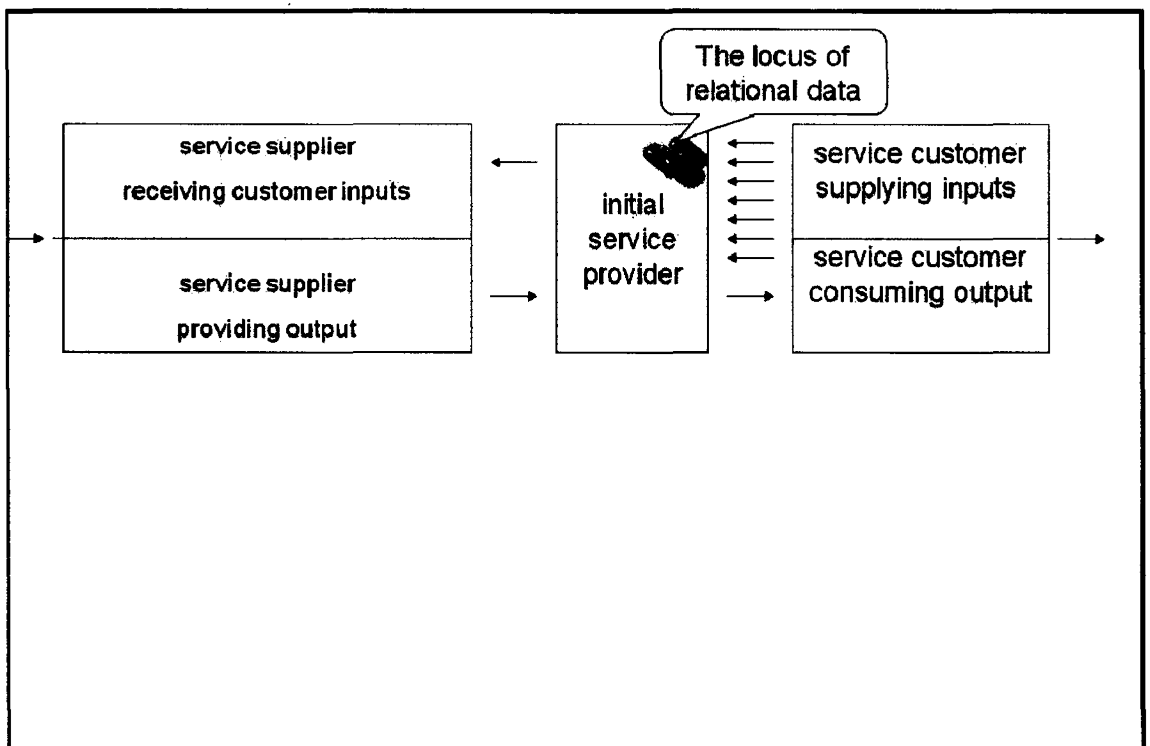



Modular Service System, where the service supplier (customer) is expected to control and communicate service needs between the different specialties.

Figure 16: Modular service supply chain for the complex customer – 2

In the first set (Figures 15 and 16), the customer takes full control of the design of the supply and configures disparate visits and service providers to create a complete service chain (a modular design). In the second set of supply chains (Figures 17 and 18), the service provider takes on the role of service coordinator in behalf of the customer (an integrated design).

Note that Figure 14 and Figure 15 are variants of the two original service supply chains proposed by Sampson (2000) in Figures 12 and 13. The main differences in these supply chains are the continual inputs received from the customer over the extended service process. For example, Figure 15 models a patient who needs to see multiple




**Integrated design where the service provider retains the relational data and coordinates multiple visits over time to obtain the needed service.**

Figure 17: Integrated service supply chain for the complex customer – 1

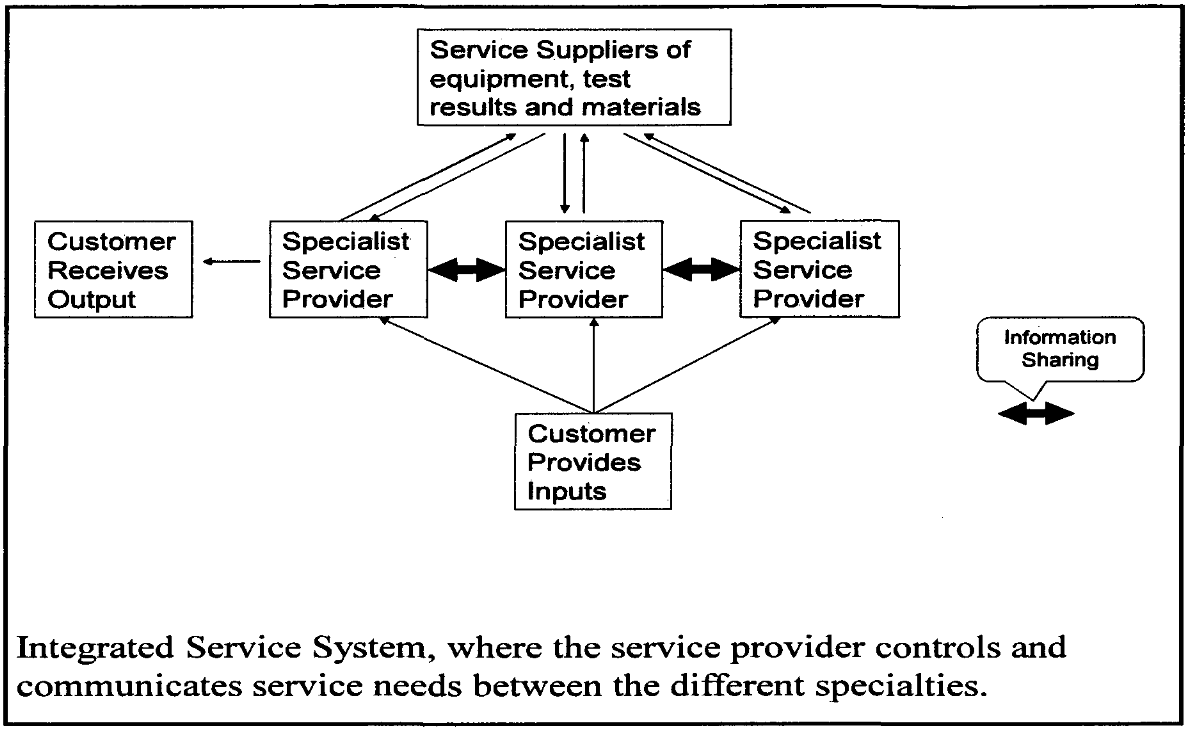



Figure 18: Integrated service supply chain for the complex customer – 2

specialists before she is completely served; thus she must give inputs herself for every step in the process. This differs from customers dropping their cars off at a dealerships.

Even though the car needs to be seen by multiple specialists within the dealership to be completely repaired, the customer is not complex because the customer only provides one input to the process upfront. After the initial inputs the dealership can work much like a manufacturer completing the remainder of the service on the car without input. In fact, recent literature suggests that services in dealerships and insurance agencies (Brunt & Kiff, 2007; Swank, 2003) benefit greatly by using lean management principles to organize, increase quality, and drive out waste in these noncustomer input areas. These improvements most notably affect service processes that occur after the customer input has been received, such as the processing of insurance policies or the actual repair of the automobile. The service management literature trumps the separation of back office (parts where the customer does not supply inputs) and front offices (areas where customers do supply inputs) services as an area where efficiencies in services can be gained (Chase, 1996; Metters & Vargas, 2000). To summarize, it is important to note the complexity caused by the customer either giving multiple inputs into the same process (Figure 14) or across multiple processes (Figure 15).

The service supply chains represented in Figures 14 and 15 are designed to be experienced by the customer in a modular fashion. The customer takes all the responsibility for the information shared across visits and between providers. Under these conditions, while the customer requires multiple visits to be fully served, the design of the service essentially requires the designer/customer to carry all the burdens of the needed relational interaction and needed coordination activities in the service process. Essentially, this means the customer in Figure 14 is complex, but she appears or is treated by the service provider as a Figure-12 customer or noncomplex customer. The same can be said about the Figure-15 customer; although she has complex needs, she is essentially treated by every server as a Figure-13 customer. It is the modular nature of most services that requires customers to carry most of the burden of information transfer between providers and relationship support across visits. Customers as co-designers of the service process often choose to design their supply chain of services in this manner.

On the other hand, the customer as co-designer could enter a service process similar to the two service supply chains in Figures 14 and 15 but differing in that the service provider coordinates the disparate service offerings and the relationship support, thus constituting an integrated design as opposed to the modular ones presented earlier (see Figures 17 and 18).

The integrated approach almost always allows the customer to move through the service supply chain faster because it contains a seamless service package that resolves all of their purchase needs and decreases "designer" related costs to the customer.

On the other hand, the integrated approach significantly increases costs for the service provider. If the service provider is unable to pass the costs on, they might abandon the integrated approach and return to the modular approach. If the service provider can pass the costs along to the customer, most likely a certain set of complex customers will be better off under modularity because managing of their own "designer" costs is less expensive than the increased price passed on to them by the service provider, despite the benefits of integration. A recent article (Shah et al., 2008), studying cardiac service supply chain issues in rural Minnesota, documented all these issues, demonstrating increased speed as services were integrated, resulting in higher costs to providers, which found it difficult to pass costs along.

The idea of integrating service supply chains to increase service for the most complex customers has a corollary in the physical supply chain domain as manifested in the migration of major manufacturers and companies to 3PL and 4PL logistic companies. A survey of Fortune 500 manufactures has found they are outsourcing a greater percentage of their supply chain and budgets to 3PL and 4PL providers (Lieb & Miller, 2002). Another study details how the attractiveness of these providers stems from their ability to integrate (or in the case with 4PL providers by owning sections of supply chain) numerous aspects of the supply chain process, syncing warehousing to transportation, combing trucking with rail, facilitating imports and exports (Tyan, Wang, & Du, 2003). As global supply chains become more complex, the value of integrating processes in the supply chain as offered by 3PL and 4PL providers increases as witnessed by purchasing behaviors of large manufactures. Likewise, as service supply chains become more complex for customers to navigate, the value of service supply chain integration will also create greater value to customers seeking to purchase a wide range of services.

In summary, the customer is not only a supplier to the process, but the customer is also a co-designer in the service supply chain. In manufacturing products, the entity that holds the most sway in the supply chain is often its chief architect and can coordinate portions of the supply chain to achieve better outcomes; the customer as co-designer and supplier in the service supply chain shares this responsibility, but often complex customers are overwhelmed or unsure of how to optimally perform their duty as designer of the supply chain. Service providers will increase customer service as they recognize customers' shortcomings as designers, provide support to the designer, and relieve the integration costs exacted from the customer.

### 4.3.1 Management Implications and Future Research

Complex customers offer new challenges and new opportunities for service providers; providers who recognize the needs of these customers and offer ways to facilitate their way through the total service supply chain can increase customer service. Educators and parents who act as service integrators for students can generate better results (Lewis, 2006). Healthcare providers who integrate care for complex patients have demonstrated dramatic improvement of care (Gawande, 2007; Shah et al., 2008; Tucker et al., 2007).

Managers also need to be aware that they do not need to fully integrate to assist complex customers. Location can assist. For example, a Jiffy Lube set up next to a car wash assists customers with the design of that particular chain, or the Olive Garden in Times Square that assists customers look for the totality of a night out are assisted by its location. Additionally, service providers can virtually integrate to assist the complex customers. Southwest Airlines sells car rental and hotel rooms on its web site to assist travelers with complex travel needs. As service managers take the time to understand the service design burdens of their customers, they can better assist them by easing their burdens and in so doing increase service and customer satisfaction.

Questions to be probed by future additional research include tests to find out how customers who have service supply chain design competence differ from those who need extra assistance. What role does price pay in the design role customers choose and the supply chain structures they select? Can co-location or virtual integration provide customers with a similar service quality level and a decreased price when compared to fully integrated alternatives? By how much and in what ways do customers benefit from service supply chain integration? Under what conditions do complex customers benefit more from integrated supply chains and under what conditions do they benefit more from modular service supply chains? Are there ways to diagnose the supply chains customers are trying to build quickly?

As service supply chain providers acknowledge they are often a small part of the customer's service supply chain, they can better fulfill their role and can better assist customers.

# APPENDIX A

# HOW THE IDEAS OF THE COMPLEX CUSTOMER AND SERVICE INTEGRATION INTEGRATE WITH THE IDEAS OF SERVICE DESIGN

## A.1 Abstract

The New Service Design literature does not discuss integration or the needs of the complex customer. It does focus on the role of the customer, and in this section I demonstrate how the role of the customer could be better understood by examining the service process through the eyes of the complex customer, which would make a case for integration or for modularity depending on the strategic position of the service provider. The key to being able to see opportunities for integration depends on seeing services through the eyes of the job the customer wants to accomplish and examining thoroughly all the service processes required to complete that job.

## A.2 Introduction

To give this section form, I will draw from Tsai, Verma, and Schmidt's (2007) chapter on service design.

(I encourage the reader to study this chapter on service development: its treatment of the topic is the most comprehensive I have seen; its summary instructs and teaches as it narrows the wide literature into singular points.) The outline they use and the major points they derive are all relevant to the discussion of how understanding the complex customer and integration will enhance service design. I will begin with a discussion of new service development (NSD) typologies because it is important to recognize the beginnings of the literature. Next, I will highlight how the four differences between NSD and new product development (NPD) relate to serving the complex customer. Finally, I will use the concepts of the complex customer and integration to build upon Tsai, Verma, and Schmidt's (2007) five *D*s: discover, define, design, deliver, and debug.

## A.3 New Service Development Typologies

Typologies in NSD are often developed empirically or as contrasting elements of NPD, and they tend to consist of steps or lists. Following are five examples listed chronologically.

Bowers (1987) used a survey of hospital administrators and an NPD model (Booz-Allen & Hamilton, 1982) to develop a suggested eight-step process: 1. Business Strategy (consider the producer's mission) 2. New Service Strategy (only accept those services that support the mission) 3. Idea Generation (providers should have a task force to develop and consider new ideas) 4. Concept Development and Evaluation (surveys sent out to test positives and negatives) 5. Business Analysis (concerns about profitability and capacity addressed) 6. Service Development and Evaluation (detail the service blueprint and develop supporting tools) 7. Market Test (pilot test the new service) 8. Commercialization (introduction to the public on a wider scale).

Scheuing and Johnson (1989), like Bowers, studied the financial industry and its new service development processes. Scheuing and Johnson (1989) have the largest number of steps of any researchers: new service objectives and strategy formulation, idea generation, idea screening, concept development, concept testing, business analysis, project authorization, service design and testing, process and systems design testing, marketing programming design testing, personnel training, service testing and pilot run, test marketing, full-scale launch, postlaunch review. The financial industry's population of larger, more stable firms makes its development process more structured and easier to study, and possibly the detail and number of steps would decrease drastically with smaller and newer firms. Alam and Perry (2002) show significant evidence that the process decreases with size.

Ramaswamy's (1996) eight stages are more parsimonious than Scheuing and Johnson's 15 stages, but despite cutting down on the number of steps, their steps remain descriptive and do not yet get into more prescriptive, operations, or time saving strategies. Ramaswamy's steps are defining service design attributes, specifying performance standards, generating and evaluating design concepts, developing design details, implementing the design, measuring performance, assessing customer satisfaction, and improving performance.

Alam and Perry (2002) studied the financial service process for developing new service process at multiple companies in Australia, approaching the process with an empirical bent. They developed 10 stages: strategic planning, idea generation, idea screening, business analysis, formation of cross-functional team, service design and process/system design, personnel training, service testing and pilot run, test marketing, and commercialization.

Interestingly, companies considered test marketing as the least important stage, while idea generation and idea screening were two of the most important stages. This coincides with what Scott Sampson once said to me in a personal conversation: "Everyone has experienced a service, so it is intuitively understood and usually uninteresting to observe." It could be that service providers are so confident in their ability to project the value proposition of a service because they all intuitively understand the process; they feel they can confidently do away with test marketing the service as long as they properly screen the idea first.

Additionally, Alam and Perry (2002) found differences between small and large organizations in the process development process, but all companies valued customer input, particularly in the beginning stages. Large organizations tended to follow the steps in order, while smaller organizations tended to do steps concurrently, and uniformally across organizations, input in the idea stage was valued as helping the development processes proceed at a faster pace.

Froehle and Roth (2007) reveal the need for resource-oriented practices to be included in the service design process, which in the previous literature was wholly devoted to process practices. Froehle and Roth argue that service providers need to seek out new competencies and tools to develop service practices and not simply examine service offerings and ideas they could provide with their knowledge base. They segment practices into four main process-oriented NSD practices (design stage, analysis stage, development stage, launch stage) and into three main resource-oriented NSD practices (intellectual resources, organizational resources, physical resources). They strengthen their theoretical argument by combining it with an empirical survey to demonstrate NSD is incompletely understood without the inclusion of resource development practices.

### A.3.1 Summary of Typologies

The current typologies, while differing on the finer points of the process, almost universally cover the same ground in NSD, and their differences seem only minor when compared side by side. Thus I have chosen for the remainder of the paper to examine the summary points brought out by Tsai, Verma, and Schmidt (2007); for example, while all the typologies make homage to the role of the customer in the process, they lack a process for developing and understanding the tasks customers are trying to accomplish by hiring them. Johnson, Menor, Roth, and Chase (2000) claim the typologies presented to date are mainly descriptive; thus they lack a prescriptive process that examines customer purposes, making businesses who follow the existing descriptive processes blind to customers who are currently struggling within their system and blind to ways they can integrate to improve service processes for complex customers. For example, if Froehle and Roth had added the idea of service integration to their typology they might have been able to focus service providers on what new resources should be developed to increase customer flow and not just the need for the concurrent development of resources.

The creation of the mental health integration process at IH has been very iterative, and truthfully at times it has been loosely organized, giving clinics wide latitude on how they will implement the integration processes, but the one constant has been a passionate desire to assist the most complex customers in their quest to receive total care. The entire MHI process organizes resources to increase patients' accessibility to receive total care of both body and mind by bringing mental healthcare specialists into the clinic, tying them to the PCP through communication processes and institution support. This vision to integrate patient care to include both body and mind has energized outside organizations like NAMI and created efforts to bring the patients' families into the center of the care process. While the role of supporting individuals and groups had previously been considered important in primary care, it was never explicitly made part of the care process until the family's role in integrating the service process was considered. IH could learn from the service management literature how to formalize the service development process, but through the process of integration, it has demonstrated a way to build upon these typologies by adding the vision of the patient/customer to service design process. Services could include this vision by asking questions such as, "What previous steps before my service and future steps after my service will my customer take, and how can I relieve their supplier/designer burden through the design of their service process?" The real key for this type of design is the ability of the care provider to step out of their primary service process and concentrate on previous and future customer steps, a role not currently found in service development typologies.

### A.3.2 The Four Contrasting Differences of NSD Versus NPD

Because Operations and Service Management sprouted out of manufacturing and product development, literature searches in services are incomplete without making contrasting arguments against product development and manufacturing. The contrast is important because surveys done by Griffin (1997) demonstrate NSD is statistically significantly shorter than NPD but also much less formal, with 60% of respondents saying they have no NSD processes at all. To give the contrasting points structure, I will use Tsai et al. (2007), who make four basic claims of differentiation between NSD and NPD. I will cover those four points and further demonstrate how thoughts about integration and modularity further differentiate the new service development process.

A.3.2.1 The Customer Remains at "Center Stage"

Chase and Dasu (2001) highlight how behavioral characteristics matter in services because customers are part of the process, unlike in production where they only receive the final product. For example, when a customer purchases an automobile, details about the production process such as the car's doors being painted before assembly to the car body versus afterwards are unimportant, but in a service, the order of service processes can significantly change the outcome of the service process. Chase and Dasu (2001) point out how providing bad experience up front and good experiences at the end of a process changes perceptions of the process. For example, in a routine checkup with a pediatrician, placing difficult experiences, such as a shot to a toddler, at the beginning of the process and positive experiences, such as choosing a toy from a gift box, at the end of the process leads to an increased positive perception of the doctor's visit in the mind of the toddler.

Because customers are part of service processes, the service process will be iterative and nonlinear. Pointing out the nonlinear and iterative nature of NSD processes, Menor, Tatikonda, and Sampson (2002) labeled them as process cycles. The description of the NSD process as a cycle matches the formation of MHI exactly. In meetings I attended where the discussion described the formation of MHI, I was struck by how clear the vision of mental health integration was, and how starkly that clarity contrasted with the lack of clarity on the other operational details. The process cycled for nearly a year in the original clinic until it became part of the fabric of the clinic. The lead doctor in the clinic said, "My clinic would fall apart" when he was asked, "What would happen if MHI were removed from your clinic?"

The service process integration paradigm adds to this first contrast by demonstrating that clarity of patient/customer needs must move beyond the primary service process to processes not always considered in the purview of the primary service provider. For example, while working on my MBA, I took a night class in economics at the University of New Mexico. The professor began the first lecture with a calculus math review because he realized that the majority of the students needed assistance in bridging their previous service from the math department to his economics course. His effort in the first lecture paid dividends for the remainder of the semester because it increased student understanding and allowed the lectures to flow smoothly. This particular professor has received the gratitude of multiple students as shown by the numerous teaching awards he has received.

#### A.3.2.2 Greater Heterogeneity in the Way the Product Is Produced and Viewed

> The customer-centric focus of services and the heterogeneity in customer inputs and demands suggest a market environment that is less predictable, and one that can change over time as customer perceptions change and as new customers are acquired. Iansiti and McCormack (1997) suggest such an environment calls for a flexible product development process. They too stress the necessity of overlapped activities, continual feedback and early launch; offering the examples of how Netscape and Yahoo! Handled beta testing. (Tsai et al., 2007, p. 435)

Integration decreases the amount of heterogeneity in demand that is allowed into a service process as assets become more specified and more difficult to coordinate. Thus for integration to work properly there must be tools to focus the service on the correct demand streams and to place the service in an environment where homogenous demand is high enough to cover the exceptional overhead. MHI has taken this to heart and developed the cascade model to separate demand streams into treatment pathways so as to not over serve those patients who do not need the extra care and coordination.

A.3.2.3 Innovative Services Are not Patentable Due to Their Intangibility

Services are often pushed to the market. Researchers have commented on this phenomenon, saying services' intangibility and inability to be patented may be the cause of this behavior. Tufano (1989) suggests the first mover advantage comes not from patent protection but also from larger market share and early entry. Integrated processes are difficult to copy because they are expensive to set up, and so while they may not be patentable, their design and set up can be sold. Intermountain Healthcare has shown this ability by selling the MHI format to other healthcare organizations. Intermountain assists them in setting up model clinics and invites them to visit and interview mature Intermountain clinics. In a way, well-performed and orchestrated integration can lead to possible consulting or franchising type activities. While firms may not be able to patent the process, they can sell their ability to orchestrate and synchronize services.

A.3.2.4 The Activities of Service Design Are Used to Account for
Service Perishability Because Service Capacity Is Time-Sensitive

Given that customer demand patterns affect the allocation of resources in services (Verma, Thompson, Moore, & Louviere, 2001), one would expect that integrated service processes, which increase cost and complexity, would guard the perishability of resources with greater tenacity. MHI exemplifies the issues dealt with in service perishability because the margins on providing mental healthcare are so thin that to break even on salaries, mental health professionals must be constantly busy. The more integrated a service offering, the less it can afford to have its capacity empty. Certain researchers have suggested that creating extra capacity is the key to reining in costs and improving quality in production, but in integrated services it may well be the undoing of the service to have unused capacity; this may be another reason why copying an integrated service design is so difficult.

## A.4 The Five *D*s of New Service Design

Tsai et al. (2007) has boiled the numerous points in the previous typologies into five main points, clarifying the important steps in NSD, and paring away the parts that muddy understanding and clarification. Again I will follow their outline, and I will address each one of the five *D*s in NSD and show how a view of service integration for the complex customer can build upon and clarify our understanding of the principle.

### A.4.1 Discover

The literature has been all over the map on classifications of new services. Johnson et al. (2000) segment services from a customer perspective, distinguishing services as either incremental innovations or radical innovations, a segmentation often used in NPD (Chandy, Prabhu, & Antia, 2003). In contrast, Menor et al. (2002) use a company perspective to distinguish services on the basis of external versus internal newness. Again, I prefer the new typology of Tsai et al. (2007), which distinguishes service by company capability versus customer perception. Company capabilities are considered the supply side of the equation or similar to Froehle and Roth's (2007) perspective on developing resources in order to offer new services, asking which resources may be needed to deliver this service, and being cognizant of resource constraints and capacities in the firm. Customer perceptions of the innovativeness of the new service are the demand side of the equation, understanding the level of novelty that will bring in new customers or drive old customers away.

My contribution to discovery will not be to add a new typology but to add a tool for finding new services. This project is similar to that of Sawhney, Balasubramanian, and Krishnan (2004), who recommend looking at the edge of service delivery to discover additional services that could be offered in natural succession. In the HBR article they tout Kodak's online printing and GM's OnStar service as processes that successfully grew by leveraging products to induce services in related arenas. Better examples may be the current wind-generated power stations in Iowa and southern Minnesota, where John Deere realized farmers, to whom they already offered financing through farm equipment, had an abundant natural resource in their wide-open land. John Deere stepped in and offered these same farmers financing and a business model that would allow them to take advantage of tax subsidies and incentives to build profitable wind farms (Hargreaves, 2007). In part because of John Deere's efforts, Iowa is now one of the country's top producers of electricity produced from wind.

Likewise, service integration is a task that concentrates on integrating nearby services, but it stems more from a customer perspective than a company perspective. The question that needs to be asked is: What in the total service process does the customer find difficult? IH answered this question by concluding that customers find it difficult to receive total care for both mind and body; thus by integrating they hoped to make the process easier for the customer. It is similar to Christensen, Anthony, Berstell and Nitterhouse (2007) who asked the question, "What job is a customer trying to accomplish with this product?" They give the example of the McDonald's milkshake, which many people were consuming as an extended breakfast during a long, boring commute. By understanding how and why people were ordering the milkshake, McDonald's was better able to market the product. While Christensen et al. (2007) asks a similar question, it is not exactly the same. The integration for the complex customer asks, Which process might customers find difficult performing on their own, and how can I help them accomplish the task? This question takes a process view of services from the customer's perspective. Recent research has shown that hospitals have high and needless readmission rates (Bisognano & Boutwell, 2009). The readmissions are a symptom of customers finding delegated to them a process step which is difficult to manage and in need of greater integration. Car dealerships long ago found many customers had difficulty navigating the financing side of purchasing, and financing has become an integral part of automobile sales to the point that Ford and GM have often made more money off financing cars than producing them. In a similar fashion, retail, education, healthcare and multiple other industries can find growth through integration by asking themselves, Where are my customers having difficulty in the process?

### A.4.2 Define

Goldstein, Johnston, Duffy, and Rao (2002) alerted the NSD community to the fact that NSD service design was missing the idea of the service concept. What outcomes and benefits are offered to the customer, what service is delivered by employees, and how do the services strategically align to the service concept? New services are often contemplated without considering the service concept, and I agree with Goldstein et al. (2002) but widen their concern to current service offerings.

An excellent educator may have the service concept to be a superior math teacher to high school students, but despite the educator's skills in teaching math there will be a number of students the teacher will find it difficult to reach because these students need assistance bridging their educational gaps between modularized subjects. One such example was "Big" Mike: He was essentially abandoned by his parents and living in poverty with multiple friends who would temporarily shelter him. He was failing in school not because he was not bright enough to understand, but because of his deficiencies in reading. The *New York Times* writes a moving story about a family who took Mike under their wing. The mother essentially became the integrator of Mike's educational services. As she took control of Mike's education, his grades improved, he joined the football team and excelled, he enrolled in college, and was chosen as a first-round pick in the NFL (Lewis, 2006). Multitudes of well-meaning teachers at Mike's school who narrowly defined their service concept led to this complex student failing in the system. Likewise, service integration requires providers to often think beyond their core business to difficulties customers may be having in completing all their objectives in hiring a service.

### A.4.3 Design

Tsai et al. (2007) emphasize six specific types of service design that need to be addressed, which includes both virtual and real facility and information system design:

> *Service features design* refers to the design and prioritization of service attributes to fulfill the service concepts. *Service operations design* refers to the conversion of the new service concept into an operational entity, i.e., the development of the operational details of the service itself. *Service facility design* refers to the design of the physical layout of the facility (including virtual facility) where the service is delivered. *Service marketing design* involves formulating and testing the introductory marketing program with prospective users. *Service encounter design*

> pertains to the interactions process between the service provider and the customer. *Service recovery* is designed to help do it right the second time since it is impossible to prevent every possible service failure in all service encounters due to the heterogeneity and simultaneity nature of services. (Tsai et al., 2007, p. 440)

Service integration adds to this research by asking the question, what services should be co-located and what communication pathways need to be developed to integrate the relationship between co-located and other sparsely offered services? These concerns cross the boundaries between features, operations, facility, and marketing design, and it is one of the reasons why integration is such a difficult and expensive task to achieve. During the design phase it may be determined it is most palatable to ignore the complex customer and not offer integrated service because doing so will raise costs significantly for more able customers.

### A.4.4 Deliver

The delivery of new services covers ideas mentioned by all the typology providers such as field and marketing testing, two areas vital to service integration. Alam and Perry (2002) found that testing was one of the least important stages for many service providers. On the other hand, because integration increases costs and complexity, the testing phase will most likely be intertwined with the service development phase. MHI required a number of iterations to develop into a truly integrated service offering, learning and designing processes in tandem with complex customers and new service providers, unable to distinguish between testing and implementation. Integration is more inherently a trial and error process in delivery than other NSD projects because of the additional staff and processes that are now being joined by complex communication patterns.

### A.4.5 Debug

Stewart and Chase (1999) found human error caused a high percentage of the service failure in the delivery of services; thus even integrated services need a way to track service failures and to compensate for these failures. The area where integrated service design can build upon this area is to help managers see service failure as an opportunity to possibly integrate services and improve their quality. Last year the United States spent 15 billion dollars in hospital readmissions (rework), of which 12 billion dollars was preventable (Hackbarth et al., 2007). This service failure is a cue that hospitals need to better integrate postsurgical care into the flow of care.

## A.5 Summary of How My Work Builds on the Service Design Literature

Alam and Perry (2002) stressed the following about NSD:

> Managers should pay most attention to the idea generation stage in the development process, and should strive to develop services that match customers' needs. Managers should look beyond simple market research and develop a planned and formal process of obtaining customer input for their new service development projects. Managers should treat customers as partners in their quest for successful new services. (p. 520)

When managers realize complex customers enter their service processes, they will recognize these customers have additional needs that must be served before they can be fully satisfied. For managers to capture this vision, they will need to look beyond the services they currently offer and to examine the costs of co-location and coordinating different services in behalf of customers. Opportunities for increased integration will often be found by examining customers who fail in the service process. Operationally, the aspects of the service must be seen from the customer's point of view, and only by envisioning all the steps the customer needs to take can integration by fully envisioned.

Integration is an extra opportunity to increase customer service and service offerings, but it is also expensive and the decision can be made to treat all customers as simple customers for cost and management reasons. The concept of the complex customer and service integration add to the already rich literature on NSD by demonstrating areas where managers can take more caution and use extra steps to increase the service quality for their customers. As managers consider all customer types entering their service processes, they will increase service quality by acknowledging different levels of needs and planning processes to accommodate those needs.

APPENDIX B

# THE SEVEN SOURCES OF ENDOGENOUS COMPLEXITY

## B.1 Introduction

We base our analysis of the MHI system at IHC on the "process view" that is prevalent in operations management. This view suggests that any product or service can be thought of as a series of process steps that collectively transform raw materials into finished goods. For example, the production of a Toyota car involves a host of process steps that transform iron ore (and other raw materials) into a drivable vehicle. In healthcare, a series of process steps transforms a sick patient into a (hopefully) cured patient. Each process step is performed by some resource (in some cases the customer herself may be this resource), taking some amount of time. (Of course, a process step may involve multiple resources and be performed concurrently with some other process step.)

In order for Toyota to improve the process of creating a car (i.e., in order to improve its quality and/or reduce its cost), it must develop a better transformation process. That is, it must come up with a better set of process steps, and/or follow its predefined set of process steps more precisely to improve quality, and/or better manage resources to perform the process steps more cost-effectively/efficiently. This is the crux of the Toyota Production System. The same holds for healthcare. Thus our analysis is aimed at examining the MHI system from the "process view."

The well-established field of queuing theory can model the performance of a system of processes, given the system and its parameters. For example, it can describe the distribution of throughput times and the level of inventory in the system given the distribution of process times and arrival times. These output measures (throughput times and inventory levels) can then be compared against targets that must be achieved for the firm to be competitive in its market environment.

But before one can run a performance (queuing) analysis, one has to know what the process steps are, what the resources are that are performing those process steps, what the demand stream is for the jobs arriving for processing, and so forth. In this research we will focus not on the queuing theory analysis itself, but rather on the aforementioned inputs that would go into a queuing system analysis. That is, we explore the extent to which the benefits of MHI (if any) might accrue from the way MHI 1) prescribes the process steps, 2) directs and monitors the flow of a job (i.e., a patient) through the system, and 3) assigns/manages the resources performing each process step.

In particular, we hypothesize that mental health integration increases process "complexity" in that as the number of service process increases it becomes more difficult to manage the three aforementioned elements, i.e., it is difficult to prescribe the process steps, direct and monitor product (patient) flow, and assign/manage the resources performing each process step. We identify seven different factors that might contribute to complexity of any service transformation process.

## B.2 The Seven Sources of Service Complexity

## Summarized

1) Step Complexity (The number of steps in a process. A four-stitch wound is slightly more complex than a three-stitch wound.)
2) Path Complexity (The number of paths or branches a service can follow. All withdrawals from an ATM must be in denominations of $20, thus there is only one very well defined path the service can take to disseminate $100. But when using a teller, there are an almost unlimited amount of paths or monetary combinations that can be requested to disseminate $100.)
3) Definitional Complexity (How definable a service's steps and paths are before the service process begins. Project management for building prefabricated homes in a suburb has a greater percentage of definable steps than project management of a one-time construction project such as the "Big Dig.")
4) Skill Complexity (The skill required to perform a task. It is more difficult to take a last-second 15-foot shot under defensive pressure than it is to hit a 15-foot free throw shot.)
5) Relearning Complexity (This is the complexity caused by time between service events in a continual service process. Treating a chronic disease is made more difficult because the service by its nature must be given over time and not at a single event. When teaching, the longer the time-periods between each class the greater the relearning curves experienced by the students and teachers each time they meet.)
6) Handoff Complexity (Each time a customer is handed off from one server to another, service complexity increases. The transfer process between service providers causes a

loss of information. A nurse from the afternoon shift turns a patient over to a nurse on the evening shift, which can lead to a loss of vital information.)

7) Incentive Complexity (Whenever there are multiple servers in a service environment it is possible for each server to have their own incentives and agendas. Individuals and departments within a firm often seek to maximize their own efficiency because of their incentives, but optimality for an individual often causes suboptimality within the entire system. The goal of the ER department is to cut wait times for patients, but the goal of the janitorial staff is to cut costs by having fewer employees. The ER department becomes frustrated in its attempts partially because a shortage of janitorial staff causes long changeovers, which cuts the capacity of available rooms.)

## B.3 Step Complexity

Sampson (2001) draws from Shostack (1987) to define complexity as "the number and intricacy of the steps in a process. Complex procedures have many steps, and may include a number of process branches. A process branch is a rule that changes the procedure based on a condition" (p. 85).

*Step Complexity is measured by the number of steps in a process. The more steps a process has the more step complexity it has.* Applying stitches to a 3-inch wound is less complex than applying stitches to a 6-inch wound, simply because it requires fewer stitches or steps in the process.

Step Complexity has been intuitively understood for quite some time. The roots of scientific management are deeply imbedded in the attempt to decrease step complexity. Taylorism taught that the responsibility of the "Scientific Manager" was to study the routines of her employees and find the fastest and simplest ways to accomplish their tasks (Taylor, 1911).

Not controlling for or understanding step complexity can be a source of defects in process and product quality. Boeing built the first B-17 bomber in 1935 at the request of the military for a new long-range bomber. During its initial test-flight the B-17 (later called the flying fortress) left the ground briefly only to crash seconds later, killing its experienced test pilot (the pilot failed to disengage the control locks on the plane). The military considered the aircraft too complex to fly for ordinary pilots and gave the contract for production to Boeing's smaller competitor. Despite the military's decision, some engineers and pilots saw the potential of the B-17 bomber and would not abandon the project. They developed a checklist of liftoff protocols for flying the B-17. Pilots with the checklist in hand flew 1.8 million miles in World War II without a similar accident and gave the U.S. air force a superior position in flight range and bombing power in its fight against the Axis (Gawande, 2007).

By integrating mental health services into the primary care clinic, IH has actually increased the number of steps a patient can take in its clinics, thus intuitively increasing process complexity for the clinic. On the other hand, patients needing mental health services experience a decrease in the number steps they must take to receive total care, and thus with mental health integration the complexity of care actually decreases from the patient perspective. These patients no longer have to manage care and coordinate care between two separate care systems and are thus better off.

## B.4 Path Complexity

Service management increases in difficulty when the possible service options or pathways that service steps can take multiply. Sampson (2001) adds to (Shostack, 1987) labels the potential for numerous service pathways as divergence. "Divergence is seen in the nature of the steps: divergent procedures have steps that can be handled any number of ways depending on the circumstances of production" (p. 85). The multiplication of service pathways can quickly become overwhelming even for the best checklist. Expert systems in retail that support decision making can have over 100,000 possible pathways (Sampson, 2001).

*Path Complexity is measured by the number of possible process branches (possible paths) in a process. The more paths a process has the more path complexity it has.* An ATM that offers a $100 withdrawal only in increments of $20 has less path complexity than a teller who offers an unlimited number of denominational choices to a customer seeking a $100 withdraw.

IH intuitively realized the possibilities of treatment plans could be exponentially multiplied by integrating mental healthcare into the clinic, and the MHI team created a cascade treatment model. The cascade model created three basic pathways of treatment, which pathways were triggered by the severity and complexity of the patient. By creating medical pathways, IH controlled path complexity within the MHI service process.

## B.5 Definitional Complexity

Unfortunately, not all step or path complexity can be realistically controlled and dealt with because there are often unknown and indefinable steps and paths. By definition, customers are part of the service process and having customers in the process means there will be as much variation in process as there is variation in the customers in the process. In an example shared below about central line infections, each customer's anatomy is similar enough that each step could be defined and executed in exactly the same manner for every patient, and what the patients defined as an appropriate outcome of central line insertion was always the same; in other service processes customer-induced variation increases definitional complexity. The customers may have a wide variety of demands on the same service system (request variability (Frei, 2006)), or a wide variety of skills they can bring to the service production process (capability variability (Frei, 2006)), or even varying degrees of what they define excellent service to be (subjective preference variability (Frei, 2006)).

In addition to ambiguity that is customer induced, task ambiguity is also common in project-based service management. Companies that bid on large construction projects, software firms developing new programs, and mental health professionals counseling patients operate in environments with healthy doses of ambiguity at the beginning of the task. It is only once the task is in process that all the necessary process paths and steps are even definable.

*Definitional complexity is measured by amount of ambiguity inherent in the service process pertaining to understanding the proper paths and steps that should be considered before the service process begins.* A psychiatrist treating a patient with depression will have more definitional complexity (caused by the ambiguity of the depression's source) than a cardiologist will have performing a coronary angioplasty.

This definition is consistent with that devised by Goldratt, who defined complexity as ambiguity, or in other words, not knowing how certain factors will affect a system. "The more degrees of freedom the system has the more complex the system is" (Goldratt, 2008, p. 41). For example, heart bypass surgery has many steps and thus is high in step complexity, but the steps are definable and can be consistently executed by a well-trained staff. On the other hand, treating depression can be a much more complicated task because of the compounding factor of ambiguity that causes a lack of definition for the steps of care. Patients' backgrounds and chemistry are highly variable, which causes their responses to different therapies to be highly variable. It is interesting to note that treating both the heart bypass patient and the depressed patient requires customization, yet their complexity differs significantly because of known and unknown processes steps.

In the service management literature, high-contact services and the level of customization have been used to segment services (Chase, 1978; Lovelock, 1983; Schmenner, 1986). Chase (1978) said the following: "it follows that service systems with high customer contact are more difficult to control and more difficult to rationalize than those with low customer contact" (p. 138). Thus it would seem that the more time spent with a customer in a service process and the level of customization provided would simply determine the management complexity process and its ability to be improved and streamlined. These typologies, though, have insufficient granularity.

For example, central line insertion is a very customized and high contact service by any measurement, but through the use of a simple checklist, infections received from the procedure have been eliminated (Pronovost et al., 2006). The customization and high contact services typologies examine groups of services at the 10,000 foot level. They make it impossible to differentiate between service providers within an industry (Verma

& Young, 2000) and group the management of disparate industries that have little in common into the same management groupings (Mersha, 1990). Understanding step, path, and definition complexity gives managers a more granular thought tool for making decisions about how to structure services and what steps can be taken to improve them.

Managers who understand these three general forms of service complexity (step, path, and definitional) can take steps to control it and significantly affect quality outcomes:

> In 2001 . . . a critical-care specialist at Johns Hopkins Hospital named Peter Pronovost decided to give checklists a try. He didn't attempt to make the checklist cover everything; he designed it to tackle just one problem: line infections. On a sheet of plain paper, he plotted out the steps to take in order to avoid infections when putting a line in. Doctors are supposed to (1) wash their hands with soap, (2) clean the patient's skin with chlorhexidine antiseptic, (3) put sterile drapes over the entire patient, (4) wear a sterile mask, hat, gown, and gloves, and (5) put a sterile dressing over the catheter site once the line is in. Check, check, check, check, check. These steps are no-brainers; they have been known and taught for years. So it seemed silly to make a checklist just for them. Still, Pronovost asked the nurses in his I.C.U. to observe the doctors for a month as they put lines into patients, and record how often they completed each step. In more than a third of patients, they skipped at least one.
>
> The next month, he and his team persuaded the hospital administration to authorize nurses to stop doctors if they saw them skipping a step on the checklist; nurses were also to ask them each day whether any lines ought to be removed, so as not to leave them in longer than necessary. This was revolutionary. Nurses have always had their ways of nudging a doctor into doing the right thing, ranging from the gentle reminder ("Um, did you forget to put on your mask, doctor?") to more forceful methods (I've had a nurse bodycheck me when she thought I hadn't put enough drapes on a patient). But many nurses aren't sure whether this is their place, or whether a given step is worth a confrontation. (Does it really matter whether a patient's legs are draped for a line going into the chest?) The new rule made it clear: if doctors didn't follow every step on the checklist, the nurses would have backup from the administration to intervene.
>
> Pronovost and his colleagues monitored what happened for a year afterward. The results were so dramatic that they weren't sure whether to believe them: the ten-day line-infection rate went from eleven per cent to zero. So they followed patients for fifteen more months. Only two line

> infections occurred during the entire period. They calculated that, in this one hospital, the checklist had prevented forty-three infections and eight deaths, and saved two million dollars in costs.
>
> Pronovost recruited some more colleagues, and they made some more checklists. One aimed to insure that nurses observe patients for pain at least once every four hours and provide timely pain medication. This reduced the likelihood of a patient's experiencing untreated pain from forty-one per cent to three per cent. They tested a checklist for patients on mechanical ventilation, making sure that, for instance, the head of each patient's bed was propped up at least thirty degrees so that oral secretions couldn't go into the windpipe, and antacid medication was given to prevent stomach ulcers. The proportion of patients who didn't receive the recommended care dropped from seventy per cent to four per cent; the occurrence of pneumonias fell by a quarter; and twenty-one fewer patients died than in the previous year. The researchers found that simply having the doctors and nurses in the I.C.U. make their own checklists for what they thought should be done each day improved the consistency of care to the point that, within a few weeks, the average length of patient stay in intensive care dropped by half.
>
> The checklists provided two main benefits, Pronovost observed. First, they helped with memory recall, especially with mundane matters that are easily overlooked in patients undergoing more drastic events. (When you're worrying about what treatment to give a woman who won't stop seizing, it's hard to remember to make sure that the head of her bed is in the right position.) A second effect was to make explicit the minimum, expected steps in complex processes. Pronovost was surprised to discover how often even experienced personnel failed to grasp the importance of certain precautions. In a survey of I.C.U. staff taken before introducing the ventilator checklists, he found that half hadn't realized that there was evidence strongly supporting giving ventilated patients antacid medication. Checklists established a higher standard of baseline performance. (Gawande, 2007, pp. 90-91)

Pronovost replicated his success using checklists on a larger scale in the state of Michigan when the program rolled out in a statewide program (Pronovost et al., 2006).

Using checklists in hospitals is similar to the science behind standard work at Toyota (Liker, 2004). At Toyota, standard work procedures for each process are so detailed they even describe the order for which bolts are to be put into seats (S. Spear & Bowen, 1999). Standard work like checklists have the ability to control step and path complexity, but they also have the side benefit of increasing memory, which decreases and controls indefinable steps or processes added by or forgotten by employees. Gawande (2007) quotes Levitt as advocating that "discretion is the enemy of order, standardization, and quality" (p. 92).

The MHI team designed a mental healthcare packet to assist primary care doctors in diagnosing the type and severity of mental illness a patient possessed. A physician in Maine, which is partnering with IH, described the mental healthcare packet as the best part of the MHI system. The packet effectively decreases definitional, path, and step complexity for the primary care doctors in the diagnosis of the mental health diseases and in the measurement of its severity.

## B.6 Skill Complexity

*Skill Complexity is measured by the amount of training it takes to perform a service process. The more training a step takes, the greater the skill complexity.* Surgeons usually require 8 years of training beyond medical school before they are approved to operate independently, whereas a "sandwich artist" at Subway can usually be considered fully trained after his first shift. Skill complexity not only addresses the inherent difficulty in a step, but it also encompasses the variation between similarly trained employees performing the same tasks because of natural talent.

Skill complexity is best understood in the terms of a sport such as baseball.

> Regardless of how good a major league batter is, the skill necessary to hit a ball pitched at up to 150 kilometers per hour is phenomenal. A ball pitched at major league speeds takes just half a second to reach the batter. Allowing about a quarter of a second for the swing, the batter may only have a tenth of a second to decide where to swing, and the ball will be over the plate for as little as 0.01 seconds. Given these figures, it's easy to see why most major league batters only manage to hit successfully about one time in four! (Willis, 2000, n.p.)

Is there any doubt as to why Manny Ramirez, a player often vilified for dogging it but a very prolific hitter, is still worth between 20 and 35 million dollars per year (Crasnick, 2008)? The skill of hitting a major league baseball is rare indeed.

Sports offer a unique view of the process problems caused by skill complexity not only because they require immense skill to perform but also because skills vary so widely between players on each team, and managing the variability in skills between players by providing a network in which they can complement each other and thrive as a team is a talent unto itself. The best sports managers, such as the Laker's Phil Jackson, are paid millions to integrate talent. Despite the immense skill of both Michael Jordan and Kobe Bryant, neither won a championship without Phil Jackson. If CEOs can be considered to be managers of skill complexity, then their talent is even more valued in the business world than it is in sports, as witnessed by the precipitous drop in Apple's stock when Steve Jobs was rumored to be extremely ill. Research verifies that skill does not reside fully in independent actors, but also within the system in which the actors work. Huckman and Pisano (2006) found evidence of highly skilled physicians being unable to reproduce the quality of their work at all disparate hospitals with which they contracted. Despite their skill, the hospital processes also weighed heavily upon their outcomes.

The way MHI has managed complexity is though their training processes, automation, and job segmentation. After attending brown bags and experiencing a high level of system support, PCPs at MHI clinics have displayed an increased confidence in dealing with mental health issues. One doctor said that when they first implemented MHI at their clinic they felt they had to have a psychiatrist on the staff, but now that they are more familiar with mental health medications, they are comfortable working with a psychologist to perform the needed counseling while they handle the medication.

## B.7 Relearning Complexity

*Relearning Complexity is caused by elapsed time between steps in a continuous service process. It is measured by the required amount of relearning for both the server and the customer in the next step of the service process. Often the greater the time elapsed between steps, the more relearning is required by the servers and customers in the service process.* Year-round school for grammar school students reduces relearning complexity when compared to traditional school years by reducing the relearning needed for both students and teachers.

Most service delivery happens in a single visit, thus eliminating relearning complexity completely. Often customers will return to a service provider if they are satisfied with its service offering, but customers consider the second visit to be an entirely separate service offering. On the other hand, education and care for chronic diseases exemplify services that require the customer to visit multiple times to complete a single service offering. Because customers are an intimate part of the production process (Sampson & Froehle, 2006), the quality of their inputs will vary over time and separation from the service provider. One colleague mentioned it was easier to teach summer semester classes because the students came to class every day and the semester was compressed. It was easier for students to recall the previous day's discussion than to try and recall items that had occurred a week earlier.

Even in the simulation of service delivery, complexity caused by the elapse of time increases management difficulty. Sterman (1989) used the beer game to challenge students thinking about inventory. He found it was very difficult for the students to gauge the value of choices when time lags were present. The time lags instigated larger orders of inventory than necessary because students were incapable of judging the results of their inventory orders over time.

While relearning complexity in service processes centers on customers who need multiple visits to receive complete care, such as chronically ill patients, the concepts also apply to the actors in the service process. Pisano, Bohmer, and Edmondson (2001) found medical teams that stayed together longer decreased their surgical times drastically when compared to those teams with multiple server configurations. As team cohesion increased, learning and service quality also increased.

MHI at IH uses the position of care manager to bind its relationship with the patients. The care manager provides education, schedules appointments, and tracks the customer in an effort to provide continuous integrated care. By so doing, they control relearning complexity and increase compliance amongst their patients.

### B.8 Handoff Complexity

Tucker et al. (2007) said, "we define a complex service organization as one with interdependent work units whose work must be coordinated to provide customer service, but whose units often have conflicting priorities" (p. 894).

*Handoff complexity is measured by the number of servers involved in delivering the service product and by the amount of information that needs to be handed off between servers.* The more servers there are involved in a process, the higher the cost of orchestrating their movements to supply a service product. The more information that must be exchanged in the handoff, the costlier the handoff will become.

Every time a customer is passed off to an additional server the complexity in the system increases. Tucker's (2004) in-depth study of nursing found that most operational failures stem from breakdowns in the supply of materials and information across organizational boundaries. Her results concur with a 2005 study and other studies that revealed nearly 70% of preventable hospital mishaps occurred because of communication problems, and at least half of such breakdowns occur during handoffs (Naik, 2006).

Woodside, Frey and Daly (1989) documented that for service encounters with multiple acts, quality is judged at each act. Thus a service provision with multiple stops and providers would make quality more difficult to manage.

Although handoff complexity is a service management concept, its roots are found in the production management literature. Bohn (1995) studied the variableness inherent in each of the numerous steps in semiconductor manufacturing. He concluded that it was nearly impossible for all but the best plants to detect small improvements in a single step in the process because of the combined process noise of the entire process. And it may have been an inherent understanding of handoff complexity caused by multiple handoffs that led Japanese manufacturers towards the strategy of fewer suppliers. Chrysler followed this strategy in the mid-1990s by cutting the number of suppliers it worked with and integrating these suppliers into the design and production process. Through this strategy, Chrysler experienced significant increases in quality and efficiency (Dyer, 1996). Unfortunately, a change in leadership at Chrysler caused a move away from these quality initiatives.

Once service providers understand the added complexity that comes with handoffs, they can actively act to manage and decrease errors while increasing throughput. The Great Ormond Street Hospital in London retains a reputation of pediatric cardiac operational excellence. In 1994 one of its brightest surgeons published an unusually forthright paper about quality defects in the surgery process, which he attributed to "suboptimal performance" by himself and his team. Many small mistakes made by his team caused death and hardship for his patients. "At Great Ormond Street Hospital, it prompted doctors to take a harder look at how their teams were working together and transferring patients. 'Our handovers were haphazard,' says Dr. Goldman, the pediatric ICU chief" (Naik, 2006, p. A.1). Blood pressure monitors would go missing and when patients would arrive in the ICU after surgery the ventilator would not be set up properly. On a Sunday afternoon in 2003 the doctors were relaxing by watching a Formula One race after a particularly stressful surgery. As they watched, they were fascinated by how a 20-man pit crew could completely service a car in less than 7 seconds.

> In early 2005, Dr. Elliot, Dr. Goldman and Mr. Catchpole traveled to Ferrari's headquarters in Maranello, Italy, and sat down with Nigel Stepney, the racing team's technical director. As a test car roared around a nearby track, the visitors played a video of a hospital handover and described the process in pictures.
>
> The Ferrari man wasn't impressed. "In fact, he was amazed" at how clumsy and informal the hospital handover process appeared to be, recalls Mr. Catchpole, now a researcher at Oxford University.
>
> In that meeting, Mr. Stepney described how each member of the Ferrari crew is required to do a specific job, in a specific sequence, and usually in silence. By contrast, he noted, the hospital handover was often chaotic. Several conversations between nurses and doctors went on at once. Meanwhile, different members of the team disconnected or reconnected equipment to a patient, but in no particular order.
>
> In a Formula One race, the "lollipop man" with a paddle ushers the car in and signals the driver when it's safe to go. But in the hospital setting, it wasn't always clear who was in charge. Though the anesthesiologist had nominal responsibility to take the lead during a handover, sometimes the surgeon assumed that role–or no one at all.

> The crew at Ferrari trained for the worst contingencies. "If Michael Schumacher comes in five laps early because it's raining and he wants wet-weather tires, they're prepared," says Mr. Catchpole, referring to the Ferrari driver and seven-time world champion, who recently retired. The hospital team dealt with problems as they came up. (Naik, 2006, p. A.1)

After the visit to Ferrari, Dr. Goldman and his associates began to implement the pit crew's suggestions into their process. They submitted a paper to a journal after studying 23 handovers before and 27 handovers after the changes. Their results revealed technical errors per handover fell 42%, information omissions fell 49%, and the handover process was significantly shortened even though that was not the intent of the changes (Naik, 2006).

IH uses their electronic medical record system and co-location of services to combat the problem of handoff complexity. As one doctor described the system, "We rub shoulders in the hallway." This rubbing of shoulders and a commitment to the medical record provides for a seamless handoff between the primary care doctor, the care manager, and the mental health specialist. These communication patterns create a complex web of communication interaction, which increases integration (Ulrich, 2007).

### B.9 Incentive Complexity

Incentive complexity is closely related to handoff complexity because it only surfaces when a service requires multiple handoffs. It usually surfaces when a service operation is large enough that it requires supervision from multiple managers. As quoted earlier, Tucker et al. (2007) said, "we define a complex service organization as one with interdependent work units whose work must be coordinated to provide customer service, but whose units often have conflicting priorities" (p. 894).

*Incentive complexity is measured by the number of incentives separate servers are subject to in the delivery of the service product.* The more disparate the incentives exerted upon service providers, the higher the cost of orchestrating their movements to supply a service product. Competing incentives produce *sub optimality caused by servers acting independently to maximize the "profitability" of their particular process while causing the process as a whole to suffer.*

At Mercy hospital in Missouri, the staff set a goal to lower wait times in the ER to 15 minutes or less. In their attempt to decrease process times they found that the entire hospital community needed to be orchestrated to achieve these process results. Cleaning crews, nursing staffs, and bed openings on all floors had to be orchestrated to achieve the stated goals (PBS documentary on healthcare). It is clear that a cleaning crew attempting to maximize its individual efficiency could seriously affect the efficiency of the entire hospital. Unfortunately, the individual silos approach to healthcare is the norm rather than the exception in the US healthcare system.

Herzlinger's (1997) case study on Humana describes the classic example of incentive complexity. Humana began as an insurance organization. Its profits and size ballooned dramatically, and to extend its growth, Humana began to purchase hospital systems. Although Humana had sizeable managerial skill, it did not plan on the incentive complexity that would accompany this purchase. For example, it was in the insurance arm's best interest to have patients use the hospitals as little as possible, but it was in the hospitals' interest to have the patients use the facilities as much as possible. The strain of these competing priorities led to losses and the eventual spin off of Humana's hospital units.

MHI cuts down on incentive complexity by hiring its mental health workers directly and paying them by the hour. Because the mental health specialists are paid directly from the clinic and are paid whether or not they see patients, their incentives to cooperate and to assist with the patient flow in the clinic are maximized.

APPENDIX C

STATISTICAL TESTS AND

PROGRAMMING OUTPUT

In this section I explicitly write out all the steps I took in my statistical testing procedures. I include the programming language used in Stata, and I include the Stata output. This level of detail was necessary to explicitly demonstrate how I came to my conclusions and to demonstrate the tests and checks I performed. The programming and the output are raw (thus not appropriate for the general dissertation), but in the appendix, it is appropriate to provide full and complete detail of the tests and the order in which they were preformed.

## C.1 Testing Steps

### C.1.1 OLS Regression

I tested the regression model using OLS regression. I used Stata's statistical package for all the data work (see Table 9).

```
reg total_all_er sex age num_como cm_total de_outpsy_total insta_total
clinic_mhi interaction_mhi, cluster (clinic)
Linear regression                                 Number of obs =   2991
                                                  F( 8,   55) =   8.57
                                                  Prob > F    = 0.0000
                                                  R-squared    = 0.0472
                                                  Root MSE    = 3.3023
            (Std. Err. adjusted for 56 clusters in clinic)
```

**Table 9: OLS regression**

| total_all_er | Roust coef. | Std. Err. | t | P>\|t\| | (95% Conf. Interval] | (95% Conf. Interval] |
|---|---|---|---|---|---|---|
| Sex | -.1573155 | .1472387 | -1.07 | 0.290 | -.4523884 | .1377574 |
| Age | -.0053829 | .0032341 | -1.66 | 0.102 | -.0118642 | .0010985 |
| num_como | .6665365 | .1175066 | 5.67 | 0.000 | .431048 | .9020249 |
| cm_total | .1490217 | .0800205 | 1.86 | 0.068 | -.0113429 | .3093863 |
| de_outpsy_~l | .0198253 | .0114848 | 1.73 | 0.090 | -.0031908 | .0428415 |
| insta_total | .2189931 | .0555765 | 3.94 | 0.000 | .1076153 | .3303709 |
| ph2 | -.3184342 | .1471962 | -2.16 | 0.035 | -.613422 | -.0234465 |
| int~e_num_co | -.5858741 | .1652989 | -3.54 | 0.001 | -.9171404 | -.2546077 |
| _cons | 1.14976 | .3101277 | 3.71 | 0.000 | .5282505 | 1.77127 |

Note: both the clinic and interaction effect are significant, but we expect the OLS to be a poor estimator for the count data. Note also that to increase accuracy, I cluster the data on the clinic number and use robust errors. While clustering does not have the same effect as a hierarchal model, it is a conservative regression technique. I must often refrain from using the hierarchal model because postestimation does not work on the hierarchal models.

### C.1.2 Poisson Regression

I tested the data using the Poisson regression.

```
poisson total_all_er sex age num_como cm_total de_outpsy_total insta_total ph2
interaction_five_num_co, cluster (clinic)
Poisson regression                                  Number of obs   =     2991
                                                    Wald chi2(8) =    488.68
Log pseudolikelihood = -6489.3662                   Prob > chi2     =   0.0000
            (Std. Err. adjusted for 56 clusters in locationnumber)
```

| total_all_er | Robust Coef. | Std. Err. | z | P>\|z\| | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| sex | -.1200601 | .1106525 | -1.09 | 0.278 | -.336935 | .0968148 |
| age | -.0061458 | .0025292 | -2.43 | 0.015 | -.0111029 | -.0011887 |
| num_como | .4113772 | .0658912 | 6.24 | 0.000 | .2822328 | .5405216 |
| cm_total | .100822 | .0432346 | 2.33 | 0.020 | .0160837 | .1855602 |
| de_outpsy_~l | .013268 | .0060352 | 2.20 | 0.028 | .0014393 | .0250967 |
| insta_total | .0600949 | .0046857 | 12.83 | 0.000 | .0509111 | .0692787 |
| clinic_mhi | -.2203792 | .1310444 | **-1.68** | **0.093** | -.4772215 | .0364632 |
| interaction | -.2691451 | .1102088 | **-2.44** | **0.015** | -.4851503 | -.0531399 |
| _cons | .3614496 | .2112089 | 1.71 | 0.087 | -.0525123 | .7754115 |

Note: the interaction effect holds but the clinic effect becomes insignificant. At this point I am not using a hierarchal model because those models do not allow for post estimation effects. I will first test for the goodness of fit and then I will apply the hierarchal model once I am sure of fit to increase the accuracy of the model.

### C.1.3 Goodness of Fit

I compare the two models for goodness of fit.

```
Measures of Fit for regress of total_all_er

                           Current            Saved              Difference
Model:                     regress            poisson
N:                         2991               2991               0
Log-Lik Intercept Only    -7884.964           .       .
Log-Lik Full Model         -7812.689          -6489.366          -1323.323
D                          15625.378(2982)    12978.732(2982)    2646.645(0)
LR                         144.549(8)         .(8)               .(0)
Prob > LR                  0.000              .                  .
R2                          0.047             .x                 .
Adjusted R2                0.045              .x                 .
AIC                        5.230              4.345              0.885
AIC*n                      15643.378          12996.732          2646.645
BIC                        -8240.651          -10887.296         2646.645
BIC'                       -80.523            .       .
BIC used by Stata          15697.408          13050.763          2646.645
AIC used by Stata          15643.378          12996.732          2646.645
```

Note: Clearly, as we would expect, the Poisson regression has a better fit to the data than the OLS regression. The count nature of the data makes it nonlinear and thus OLS is a bad fit. The two main tests to examine are the Bayesian information criterion (BIC) (Raftery, 1996) and Akaike's information criterion (AIC) (Akaike, 1973); both tests show the Poisson has a lower score and thus is a better fit (Long & Freese, 2006).

### C.1.4 Hierarchical Model

Now I take the Poisson regression and put it into a hierarchal model to increase its efficiency and accuracy.

```
xtset locationnumber
    panel variable: clinic (unbalanced)
```

The xtset command describes the hierarchal nature of the model. All the patients will now be nested into their respective clinics when an xtregression is run.

```
xtpoisson total_all_er sex age num_como cm_total de_outpsy_total insta_total
ph2 interaction_five_num_co, nolog
Random-effects Poisson regression              Number of obs     =    2991
Group variable: clinic                         Number of groups  =      56
Random effects u_i ~ Gamma                     Obs per group: min =      1
                                               avg =      53.4
                                               max =       547
                                               Wald chi2(8)      =  1130.51
Log likelihood = -6182.9448           Prob > chi2      =  0.0000
------------------------------------------------------------------------------
total_all_er |    Coef. Std. Err. z             P>|z|    [95% Conf. Interval]
-------------+----------------------------------------------------------------
     sex     | -.1389006  .0343636  -4.04       0.000   -.2062521   -.0715491
     age     | -.0062229  .0013724  -4.53       0.000   -.0089128   -.003533
  num_como   |  .3992713  .0307798  12.97       0.000    .338944   .4595985
  cm_total   |  .1068781  .0220234   4.85       0.000    .063713   .1500432
de_outpsy_~l |  .0143983  .0023136   6.22       0.000    .0098638   .0189328
 insta_total |  .0616518  .0021647  28.48       0.000    .0574091   .0658945
  clinic_mhi | -.4045515  .2262478  -1.79       0.074   -.8479891   .0388862
interaction  | -.2676306  .071926  -3.72        0.000   -.4086029   -.1266583
   _cons     |  .5924118  .1176984   5.03       0.000    .3617271   .8230965
-------------+----------------------------------------------------------------
  /lnalpha | -.9414452  .2269372                -1.386234  -.4966564
-------------+----------------------------------------------------------------
    alpha |  .3900637   .08852                   .2500151   .608562
------------------------------------------------------------------------------
Likelihood-ratio test of alpha=0: chibar2(01) =  612.84 Prob>=chibar2 = 0.000
```

Note: Even as the model fit improves, the results are robust, but as stated earlier I predict there will be a problem with Poisson's accuracy because of the large number of 0's and overdispersion.

### C.1.5 Negative Binomial Regression

Next I will test the negative binomial regression

```
nbreg total_all_er sex age num_como cm_total de_outpsy_total insta_total ph2
interaction_five_num_co, nolog cluster (clinic)
Negative binomial regression                   Number of obs   =     2991
Dispersion      = mean                         Wald chi2(8)  =    247.64
Log pseudolikelihood = -4285.7453              Prob > chi2    =    0.0000
                (Std. Err. adjusted for 56 clusters in clinic)
------------------------------------------------------------------------------
             |       Robust
total_all_er |   Coef. Std. Err. z              P>|z|    [95% Conf. Interval]
-------------+----------------------------------------------------------------
     sex     | -.1486131  .1236748  -1.20        0.230   -.3910113  .0937851
     age     | -.0055748  .0026487  -2.10        0.035   -.0107661  -.0003835
   num_como  |  .4271861  .053231   8.03         0.000    .3228553  .5315169
   cm_total  |  .0901633  .0421451   2.14        0.032    .0075605  .1727661
de_outpsy_~l |  .0110417  .0070777   1.56        0.119   -.0028304  .0249139
 insta_total |  .0907443  .0131314   6.91        0.000    .0650072  .1164815
   clini_mhi | -.2803058  .1193422  -2.35        0.019   -.5142122  -.0463994
int~e_num_co | -.2680388  .0915066  -2.93        0.003   -.4473886  -.0886891
      _cons  |  .3079017  .2400392   1.28        0.200   -.1625664  .7783698
-------------+----------------------------------------------------------------
   /lnalpha |  1.036335  .0972022           .8458221  1.226848
-------------+----------------------------------------------------------------
     alpha |  2.818867    .274           2.329892  3.410462
------------------------------------------------------------------------------
Likelihood-ratio test of alpha=0: chibar2(01) = 4407.24 Prob>=chibar2 = 0.000
```

Note: The likelihood ratio test at the bottom of the readout. It tests for overdispersion and the usefulness of the model. Because it is significant we can assume the presence of over dispersion. Also note both the clinic effect and the interaction effect are both supported.

### C.1.6 Fit of Poisson Regression and Negative Binomial Regression

Next, I test the fit of the Poisson regression when compared the negative binomial regression.

```
Measures of Fit for poisson of total_all_er
                             Current              Saved          Difference
Model:                       poisson              nbreg
N:                           2991                 2991          0
Log-Lik Intercept Only       .                    -4350.208          .
Log-Lik Full Model           -6489.366            -4285.745      -2203.621
D                            12978.732(2982)      8571.491(2981) 4407.242(1)
LR                           .(8)                 128.925(8)       .(0)
Prob > LR                    .            0.000          .
McFadden's R2                .            0.015          .
McFadden's Adj R2            .            0.013          .
ML (Cox-Snell) R2            .            0.042          .
Cragg-Uhler(Nagelkerke) R2 .              0.045          .
```

| | | | |
|---|---|---|---|
| AIC | 4.345 | 2.872 | 1.473 |
| AIC*n | 12996.732 | 8591.491 | 4405.242 |
| BIC | -10887.296 | -15286.535 | 4399.238 |
| BIC' | . | -64.898 | . |
| BIC used by Stata | 13050.763 | 8651.524 | 4399.238 |
| AIC used by Stata | 12996.732 | 8591.491 | 4405.242 |

Note how the negative binomial distribution is a much better fit than the Poisson regression. We can even plot the regressions against the actual and see how much better the Negative Binomial performs compared to the Poisson, which was better than OLS.

The visual verdict (see figures in Chapter 2) and the fit tests both demonstrate the negative binomial regression is giving the most accurate reading of our data. The good news is that it supports both the interaction effect and the clinic effect, even when clustering the data and using robust errors.

Note: It is not in the hierarchal format. In any data review, it is important to look at the data before the calculations begin to get a sense for its accuracy and potency. In one tabulated distribution of the data, I got the following results.

```
table phase num_como, contents(mean total_all_er freq )
```

| | num_como | | | | |
|---|---|---|---|---|---|
| Phase | 0 | 1 | 2 | 3 | 4 |
| 0 | 1.19345 | 1.69345 | 2.35385 | 4.58333 | 2 |
| | 1,587 | 336 | 65 | 12 | 1 |
| 1 | 1.12162 | 1.19481 | 1.59091 | | |
| | 814 | 154 | 22 | | |

The ordinary model regression treats all observations as independent, while the hierarchal model correctly accounts for lack of independence. This essentially means the effective sample size (number of independent pieces of information) is bigger in the ordinary model, so there is greater power. This is a great concern because as the number of co-morbidities increases for integrated clinics, our sample size decreases rapidly and will not leave enough power for the interaction effect.

### C.1.7 Hierarchical Negative Binomial Regression

I will run a hierarchal negative binomial regression.

```
xtnbreg total_all_er sex age num_como cm_total de_outpsy_total insta_total ph2
interaction_five_num_co, nolog
Random-effects negative binomial regression   Number of obs    =   2991
Group variable: clinic                    Number of groups   =     56
Random effects u_i ~ Beta                         Obs per group: min =      1
                                                  avg =    53.4
                                                  max =     547
                                                  Wald chi2(8)     =  297.61
Log likelihood = -4255.0887                       Prob > chi2      =  0.0000
------------------------------------------------------------------------------
total_all_er |    Coef. Std. Err. z            P>|z|    [95% Conf. Interval]
-------------+----------------------------------------------------------------
     sex     | -.0850247  .0585562  -1.45      0.146  -.1997928  .0297433
     age     | -.0030069  .0023054  -1.30      0.192  -.0075254  .0015117
  num_como   |  .3279217  .0546347   6.00      0.000   .2208398  .4350037
  cm_total   |  .0996944  .0375828   2.65      0.008   .0260334  .1733554
de_outpsy_~l |  .0108509  .0042834   2.53      0.011   .0024557  .0192461
 insta_total |  .0604172  .0039957  15.12      0.000   .0525858  .0682485
   clinic_mhi| -.3158243  .0921351  -3.43      0.001  -.4964058  -.1352428
int~e_num_co | -.1043318  .1197176  -0.87      0.383   -.338974  .1303105
    _cons    |  -.954856  .1108782  -8.61      0.000  -1.172173  -.7375388
-------------+----------------------------------------------------------------
    /ln_r | 2.264669  .3195515              1.63836  2.890978
    /ln_s | 3.433063  .3352804             2.775925    4.0902
-------------+----------------------------------------------------------------
       r | 9.627938  3.076622              5.14672  18.01092
       s | 30.97136  10.38409             16.05348  59.75186
------------------------------------------------------------------------------
Likelihood-ratio test versus pooled: chibar2(01) =   42.47 Prob>=chibar2 = 0.000
```

As we expected, the interaction effect becomes insignificant because of the small sample size in the hierarchical model for patients with multiple co-morbidities, but the model is still pointing in the right direction. A good check to insure the data predicts an interaction effect is to model it visually (see the figures in Chapter 2).

Clearly the lines cross, predicting an interaction effect. The interaction effect is even clearer when graphed using fractional and quadratic fitted lines.

Because when a nonhierarchal model is used the interaction effect remains, I would suggest the effect is valid and would be consistent if there were greater power in the groups of patients with higher numbers of co-morbidities.

One other item to note about the interaction effect is that it seems to be additive and not multiplicative. This observation is in important because, "When interaction is present for additive models, it is absent for multiplicative model, and vice-versa" (Stoddard, 2008). According to Stoddard, OLS is the best way to capture an additive effect and logistic and count regressions are best for multiplicative effects. Note how in the first regression we tested (OLS), the interaction effect was significant. In linear regression, the outcome changes by the amount of the regression coefficient (slope) for each one unit increase in the predictor variable. That is the same thing as saying that amount is added to the outcome for each one unit change (thus, an additive effect). Since I am dealing with an additive effect, an interaction term in this type of model is an additive interaction. In a negative binomial model, or logistic regression, or Poisson model, the relative risk (RR) or odds ratio is multiplied by itself for each unit increase in the predictor variable. So when the odds ratio increases one unit or RR x RR it would be assumed to double, RR x RR x RR is a three unit increase. This is where the name multiplicative comes from. In this type of model, the regression lines go up in an exponential fashion, rather than linearly. If no interaction is present, the ratio of one line to the other line is RR at each point on the x axis. Thus, a deviation from this would be parallel lines, since the RR pattern is not maintained if the lines are going up. If they were flat, than the RR pattern would be maintained (Stoddard 2008).

### C.1.8 Most Effective Regression

Repeat the most effective regression and perform the two last tests.

```
nbreg total_all_er sex age num_como cm_total de_outpsy_total insta_total ph2
interaction_five_num_co, nolog cluster (clinic)
Negative binomial regression                        Number of obs  =    2991
Dispersion      = mean                              Wald chi2(8) =   247.64
Log pseudolikelihood = -4285.7453                   Prob > chi2    =   0.0000
                (Std. Err. adjusted for 56 clusters in clinic)
------------------------------------------------------------------------------
       |        Robust
total_all_er |   Coef. Std. Err. z            P>|z|    [95% Conf. Interval]
-------------+----------------------------------------------------------------
     sex     | -.1486131  .1236748  -1.20      0.230  -.3910113  .0937851
     age     | -.0055748  .0026487  -2.10      0.035  -.0107661  -.0003835
  num_como   |  .4271861  .053231   8.03       0.000   .3228553  .5315169
  cm_total   |  .0901633  .0421451   2.14      0.032   .0075605  .1727661
de_outpsy_~1 |  .0110417  .0070777   1.56      0.119  -.0028304  .0249139
 insta_total |  .0907443  .0131314   6.91      0.000   .0650072  .1164815
   clinic_mhi | -.2803058  .1193422  -2.35      0.019  -.5142122  -.0463994
inter_mhi    | -.2680388  .0915066  -2.93      0.003  -.4473886  -.0886891
    _cons    |  .3079017  .2400392   1.28      0.200  -.1625664  .7783698
-------------+----------------------------------------------------------------
  /lnalpha |  1.036335  .0972022            .8458221  1.226848
-------------+----------------------------------------------------------------
   alpha |  2.818867    .274           2.329892  3.410462
Likelihood-ratio test of alpha=0: chibar2(01) = 4407.24 Prob>=chibar2 = 0.000
```

Note: the negative binomial regression uses maximum likelihood for an estimator and because it predicts counts, it shares very few of the assumptions with OLS. Long suggests using a Wald test and a Fit test as post estimation techniques after every regression. I have already done the fit test. The Wald test follows:

```
test mhi_clinics =0
 ( 1)  [total_all_er]mhi_clinics = 0
      chi2( 1) =   5.52
     Prob > chi2 =   0.0188
. test interaction_mhi =0
 ( 1)  [total_all_er]interaction_mhi = 0
      chi2( 1) =   8.58
     Prob > chi2 =   0.0034
. test mhi_clinics interaction_mhi
 ( 1)  [total_all_er]mhi_clinics = 0
 ( 2)  [total_all_er]interaction_mhi = 0
      chi2( 2) =  29.71
     Prob > chi2 =   0.0000
```

### C.1.9 Collinearity Diagnostics

Although a test for collinearity not required. I supply the test anyway.

```
                SQRT          R-
 Variable              VIF   VIF  Tolerance  Squared
----------------------------------------------------
    sex                1.00  1.00  0.9958    0.0042
    age                1.15  1.07  0.8717    0.1283
 num_como              1.47  1.21  0.6820    0.3180
 cm_total              1.07  1.04  0.9334    0.0666
de_outpsy_total        1.01  1.00  0.9914    0.0086
insta_total            1.05  1.03  0.9486    0.0514
mhi_clinics            1.24  1.11  0.8074    0.1926
interaction_mhi        1.57  1.25  0.6372    0.3628
----------------------------------------------------
 Mean VIF   1.19
                  Cond
    Eigenval      Index
---------------------------------
  1    3.9650      1.0000
  2    1.2978      1.7479
  3    0.8850      2.1167
  4    0.8809      2.1216
  5    0.7494      2.3002
  6    0.6148      2.5394
  7    0.3373      3.4285
  8    0.2262      4.1867
  9    0.0436      9.5372
---------------------------------
 Condition Number      9.5372
 Eigenvalues & Cond Index computed from scaled raw sscp (w/ intercept)
 Det(correlation matrix) 0.5155
```

Even with the interaction term, the collinearity is quite low.

### C.1.10 Format Results

The final step is to express the results in a readily interpretable format.

C.1.10.1 Examination of Hypothesis 1

```
listcoef sex age num_como cm_total de_outpsy_total insta_total mhi_clinics
interaction_mhi, percent help
nbreg (N=2991): Percentage Change in Expected Count
 Observed SD: 3.3785904
----------------------------------------------------------------------
total_all_er |    b        z     P>|z|         %       %StdX    SDofX
-------------+--------------------------------------------------------
         sex |  -0.14861  -1.202           0.230  -13.8    -6.8   0.4723
         age |  -0.00557  -2.105           0.035   -0.6    -7.2  13.4116
    num_como |   0.42719  8.025            0.000   53.3    24.7   0.5161
    cm_total |   0.09016  2.139            0.032   9.4    5.6   0.6084
de_outpsy_~l |  0.01104  1.560             0.119   1.1    6.1   5.3946
 insta_total |  0.09074  6.910             0.000   9.5    30.7   2.9523
 mhi_clinics | -0.28031  -2.349            0.019  -24.4   -12.4   0.4706
interactio~i | -0.26804  -2.929            0.003  -23.5    -7.1   0.2767
-------------+--------------------------------------------------------
    ln alpha |   1.03633
       alpha |  2.81887  SE(alpha) = 0.27400
----------------------------------------------------------------------
 LR test of alpha=0: .  Prob>=LRX2 =    .
----------------------------------------------------------------------
       b = raw coefficient
       z = z-score for test of b=0
   P>|z| = p-value for z-test
       % = percent change in expected count for unit increase in X
   %StdX = percent change in expected count for SD increase in X
   SDofX = standard deviation of X
```

**Hypothesis 1 is supported with both the main effect and interaction effect.** The main effect will decrease ER visits by 24% over 3 years, and as co-morbidities increase there is an extra additive effect of decreasing ER visits of 23.5%.

C.1.10.2 Examination of Hypothesis 2

The next set of tests was done in exactly the same manner as the first set. For the sake of brevity, I will simply state the ending following results. In this set of tests, I examine Hypothesis 2 to determine the clinic and interaction effect on visits the PCP.

```
nbreg pcp_total sex age num_como  cm_total de_outpsy_total  insta_total
mhi_clinics interaction_mhi, nolog cluster(clini)irr
Negative binomial regression                      Number of obs   =       2991
Dispersion           = mean                       Wald chi2(8)    =     448.01
Log pseudolikelihood = -9374.5694                 Prob > chi2     =     0.0000
                                (Std. Err. adjusted for 56 clusters in clinic)
------------------------------------------------------------------------------
             |               Robust
   pcp_total |        IRR   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         sex |   1.250766   .0377534     7.41   0.000      1.178917   1.326994
         age |   1.003354   .0009815     3.42   0.001      1.001433    1.00528
    num_como |   1.282326   .0409243     7.79   0.000      1.204573   1.365098
    cm_total |   1.074588   .0274472     2.82   0.005      1.022117   1.129752
de_outpsy_~l |   1.003141    .003016     1.04   0.297       .997247    1.00907
 insta_total |   1.025319   .0045154     5.68   0.000      1.016507   1.034207
 mhi_clinics |   .9539932   .0461916    -0.97   0.331      .8676224   1.048962
interactio~i |    .915948   .0553086    -1.45   0.146      .8137141   1.031026
-------------+----------------------------------------------------------------
    /lnalpha |  -1.049104   .0871417                     -1.219898  -.8783092
-------------+----------------------------------------------------------------
       alpha |   .3502515   .0305215                      .2952602   .4154848
```

Note: both the main effect and interaction effect are insignificant. The literature supports dropping the interaction effect when it is not significant from the regression model as it confuses interpretation (Box, Hunter, & Hunter, 1978). As seen below, removing the interaction effect improved the main effect, but it is still insignificant, pointing the right way.

```
nbreg pcp_total sex age num_como  cm_total de_outpsy_total  insta_total
mhi_clinics, nolog cluster(clinic)irr
Negative binomial regression                      Number of obs   =       2991
Dispersion           = mean                       Wald chi2(7)    =     391.17
Log pseudolikelihood = -9375.8411                 Prob > chi2     =     0.0000
                                (Std. Err. adjusted for 56 clusters in clinic)
------------------------------------------------------------------------------
             |               Robust
   pcp_total |        IRR   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         sex |   1.250032   .0379123     7.36   0.000      1.177891   1.326592
         age |   1.003365   .0009801     3.44   0.001      1.001446   1.005288
    num_como |   1.255608   .0397089     7.20   0.000      1.180143   1.335899
    cm_total |   1.068173   .0253246     2.78   0.005      1.019673    1.11898
de_outpsy_~l |   1.003207   .0029814     1.08   0.281      .9973802   1.009067
 insta_total |   1.025273   .0046069     5.55   0.000      1.016284   1.034343
 mhi_clinics |   .9366568   .0381444    -1.61   0.108       .864801   1.014483
-------------+----------------------------------------------------------------
    /lnalpha |  -1.048022   .0875445                     -1.219606  -.8764383
-------------+----------------------------------------------------------------
       alpha |   .3506305   .0306958                      .2953464   .4162629
------------------------------------------------------------------------------
```

**Hypothesis 2 is not supported for either the main effect or the interaction effect.**

C.1.10.3 Examination of Hypothesis 3

The third set of tests was performed in exactly the same manner as the first set, but for the sake of brevity, I will simply state the ending following results. In this set of tests, I examine Hypothesis 3 to determine the clinic and interaction effect on visits to central psych from patients attending MHI clinics.

```
nbreg  centeral_psych  sex age num_como  cm_total insta_total mhi_clinics,
nolog cluster(clinic)irr
Negative binomial regression                      Number of obs   =       2991
Dispersion           = mean                       Wald chi2(6)    =      55.59
Log pseudolikelihood = -4078.651                  Prob > chi2     =     0.0000
                                (Std. Err. adjusted for 56 clusters in clinic)
------------------------------------------------------------------------------
             |               Robust
centeral_p~h |        IRR   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         sex |    1.02571   .1417068     0.18   0.854      .782397     1.34469
         age |   .9743896   .0055247    -4.58   0.000     .9636213    .9852782
    num_como |    1.11919   .1467298     0.86   0.390     .8655819    1.447103
    cm_total |   .9627157    .177443    -0.21   0.837     .6708243    1.381616
 insta_total |   1.050627   .0177134     2.93   0.003     1.016476    1.085924
 mhi_clinics |   .8203613   .1180547    -1.38   0.169      .618746    1.087672
-------------+----------------------------------------------------------------
    /lnalpha |   2.377567   .0772339                      2.226191    2.528943
-------------+----------------------------------------------------------------
       alpha |   10.77864   .8324773                      9.264511    12.54024
```

I dropped the interaction term because it was insignificant when running through the test.

**Hypothesis 3 is not supported for either the main effect or the interaction effect.**

C.1.10.4 Examination of Hypothesis 4

The fourth set of tests was performed in exactly the same manner as the first set, but for the sake of brevity, I will simply state the ending following results. In this set of tests, I examine Hypothesis 4 to determine the clinic and interaction effect on use the use of medications by patients.

```
. nbreg  rx_script_total sex age num_como  cm_total insta_total mhi_clinics,
nolog cluster(clinic) irr
Negative binomial regression                      Number of obs   =       2991
Dispersion           = mean                       Wald chi2(6)    =     902.89
Log pseudolikelihood = -15418.358                 Prob > chi2     =     0.0000
                                (Std. Err. adjusted for 56 clusters in clinic)
------------------------------------------------------------------------------
             |               Robust
rx_script_~l |        IRR   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         sex |   1.224219   .0524139     4.73   0.000     1.125682    1.331382
         age |   1.017902   .0015749    11.47   0.000      1.01482    1.020993
    num_como |   1.461431   .0358336    15.47   0.000     1.392859    1.533378
    cm_total |   1.018698   .0273107     0.69   0.490     .9665517    1.073657
 insta_total |   1.040262   .0039985    10.27   0.000     1.032455    1.048129
 mhi_clinics |   .9144105   .0548284    -1.49   0.136      .813023    1.028441
-------------+----------------------------------------------------------------
    /lnalpha |   .0310647   .0515643                     -.0699994    .1321288
-------------+----------------------------------------------------------------
       alpha |   1.031552   .0531912                      .9323944    1.141255
```

I dropped the interaction term because it was insignificant when it was run through the previous set of tests.

**Hypothesis 4 is not supported for either the main effect or the interaction effect.** I hypothesized MHI patients would have a greater use of Rx than their nonintegrated compatriots. While it is impossible to gather any conclusions to nonsignificant data, it is interesting to note the sign is negative as if the direction the results were leaning towards was the use of fewer medications.

### C.2 The Confirmation Group

The first set of tests were performed on a homogeneous group of patients all insured by Select Health for an entire 3-year period. To confirm the results found in the first set of patients, we broadened our sample to include all payer types. The danger with including all payer types is a loss of data points because we are no longer drawing from the insurance roles. Data are now being drawn from facility and doctor usage, which means the usage of non-IH providers will not be captured. This could be a loss of up to 40% of the patient's data. This is why the larger sample size could not be used to do the original tests, but can only used in a confirmatory and exploratory capacity. The regressions are essentially the same except insurance providers are dummy coded into three groups. Medicare, all private providers (Blue Cross, Select Health, United, etc.), Medicaid, and all self-payers. The comparison group is Medicare patients. Note all the similar steps as in the first regression, starting with OLS:

```
reg er_all sex age num_como care_num instacare a_psy all_commercial
medicaid_self mhi_clinic interaction_mhi, cluster (clinic)
Linear regression                                     Number of obs =    11096
                                                      F( 10,     55) =    19.75
                                                      Prob > F      =   0.0000
                                                      R-squared     =   0.1165
                                                      Root MSE      =   3.7658
                                   (Std. Err. adjusted for 56 clusters in clinic)
------------------------------------------------------------------------------
             |               Robust
      er_all |      Coef.  Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         sex |   .0471883   .0724886     0.65   0.518    -.0980822    .1924588
         age |  -.0338687    .004397    -7.70   0.000    -.0426805   -.0250569
    num_como |   .4871152   .0789462     6.17   0.000     .3289035    .6453269
    care_num |   .0453336   .0248157     1.83   0.073    -.0043981    .0950654
   instacare |   .1594226    .041039     3.88   0.000     .0771787    .2416666
       a_psy |   .0255697   .0088512     2.89   0.006     .0078314    .0433079
all_commer~l |  -1.501049   .2016035    -7.45   0.000    -1.905072   -1.097027
medicaid_s~f |   1.328555   .2330751     5.70   0.000     .8614621    1.795648
  mhi_clinic |  -.6563349   .1517627    -4.32   0.000    -.9604741   -.3521957
interactio~i |  -.0283556   .1183345    -0.24   0.812    -.2655032     .208792
       _cons |   3.601472   .4118488     8.74   0.000     2.776108    4.426835
```

Only the main effect is significant.

```
poisson er_all sex age num_como care_num instacare a_psy all_commercial
medicaid_self mhi_clinic interaction_mhi, cluster (clinic)nolog
Poisson regression                                 Number of obs   =     11096
                                                   Wald chi2(10)   =    750.83
Log pseudolikelihood =  -25947.11                  Prob > chi2     =    0.0000
                                (Std. Err. adjusted for 56 clusters in clinic)
------------------------------------------------------------------------------
             |               Robust
      er_all |      Coef. Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         sex |   .0439315   .0481723     0.91   0.362    -.0504845    .1383474
         age |   -.025391   .0021417   -11.86   0.000    -.0295886   -.0211933
    num_como |   .2957563   .0367028     8.06   0.000     .2238201    .3676924
    care_num |   .0268674   .0096355     2.79   0.005     .0079822    .0457526
   instacare |   .0198617   .0029489     6.74   0.000     .0140819    .0256415
       a_psy |   .0136994   .0029191     4.69   0.000     .0079781    .0194206
all_commer~l |  -1.115922   .1079362   -10.34   0.000    -1.327473    -.904371
medicaid_s~f |   .2068442   .0997117     2.07   0.038     .0114129    .4022755
  mhi_clinic |  -.4164444   .1198696    -3.47   0.001    -.6513845   -.1815042
interactio~i |   .0507657   .0635616     0.80   0.424    -.0738127    .1753442
       _cons |   2.018408   .1932346    10.45   0.000     1.639675    2.397141
```

The Poisson is consistent; thus it has the same mean as the negative binomial model, but it is less accurate.

```
. fitstat, using(nas) force
Measures of Fit for poisson of er_all
                                Current             Saved          Difference
Model:                          poisson           regress
N:                                11096             11096                   0
Log-Lik Intercept Only                .        -31139.480                   .
Log-Lik Full Model           -25947.110        -30451.995            4504.885
D                         51894.219(11085) 60903.990(11085)   9009.771(0)
LR                                 .(10)     1374.969(10)                .(0)
Prob > LR                             .             0.000                   .
McFadden's R2                         .                .x                   .
McFadden's Adj R2                     .                .x                   .
ML (Cox-Snell) R2                     .                .x                   .
Cragg-Uhler(Nagelkerke) R2            .                .x                   .
AIC                               4.679             5.491              -0.812
AIC*n                         51916.219         60925.990           -9009.771
BIC                          -51355.239        -42345.468           -9009.771
BIC'                                  .         -1281.826                   .
BIC used by Stata             51996.677         61006.448           -9009.771
AIC used by Stata             51916.219         60925.990           -9009.771
xtpoisson er_all sex age num_como care_num instacare a_psy all_commercial
medicaid_self mhi_clinic interaction_mhi,nolog
Random-effects Poisson regression               Number of obs      =     11096
Group variable: clinic                          Number of groups   =        56
Random effects u_i ~ Gamma                      Obs per group: min =         2
                                                               avg =     198.1
                                                               max =      1212
                                                Wald chi2(10)      =   9404.50
Log likelihood  = -25011.908                    Prob > chi2        =    0.0000
------------------------------------------------------------------------------
      er_all |      Coef. Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         sex |   .0482969   .0171542     2.82   0.005     .0146753    .0819186
         age |  -.0247389   .0006285   -39.36   0.000    -.0259708   -.023507
```

```
    num_como |   .2907005   .0141232    20.58   0.000     .2630196    .3183814
    care_num |   .0369305   .0044093     8.38   0.000     .0282883    .0455726
   instacare |     .02253   .0004426    50.90   0.000     .0216624    .0233975
       a_psy |   .0135359   .0008014    16.89   0.000     .0119652    .0151067
all_commer~l |  -1.041984   .0252489   -41.27   0.000    -1.091471   -.9924968
medicaid_s~f |   .2019569   .0268754     7.51   0.000     .1492822    .2546317
  mhi_clinic |  -.5260134   .1513125    -3.48   0.001    -.8225803   -.2294464
interactio~i |  -.0133252   .0263048    -0.51   0.612    -.0648817    .0382313
       _cons |   2.120774   .0774688    27.38   0.000     1.968938     2.27261
-------------+----------------------------------------------------------------
    /lnalpha |  -1.701406    .193133                      -2.07994   -1.322872
-------------+----------------------------------------------------------------
       alpha |   .1824269   .0352326                      .1249377    .2663691
------------------------------------------------------------------------------
Likelihood-ratio test of alpha=0: chibar2(01) =  1870.40 Prob>=chibar2 = 0.000
nbreg er_all sex age num_como care_num instacare a_psy all_commercial
medicaid_self mhi_clinic interaction_mhi, cluster clinic)nolog
Negative binomial regression                      Number of obs   =      11096
Dispersion          = mean                        Wald chi2(10)   =     770.40
Log pseudolikelihood = -16658.687                 Prob > chi2     =     0.0000
                                (Std. Err. adjusted for 56 clusters in clinic)
------------------------------------------------------------------------------
             |               Robust
      er_all |      Coef. Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         sex |  -.0228961   .0489741    -0.47   0.640    -.1188837    .0730915
         age |  -.0197234    .002011    -9.81   0.000    -.0236649   -.0157819
    num_como |   .3189089   .0383784     8.31   0.000     .2436887    .3941292
    care_num |   .0179932   .0104756     1.72   0.086    -.0025386    .0385251
   instacare |   .0880055   .0104147     8.45   0.000      .067593     .108418
       a_psy |   .0189309   .0059814     3.16   0.002     .0072075    .0306543
all_commer~l |   -.935682   .0804292   -11.63   0.000     -1.09332   -.7780438
medicaid_s~f |   .3890355   .0984594     3.95   0.000     .1960586    .5820124
  mhi_clinic |  -.5203316   .1329282    -3.91   0.000     -.780866   -.2597972
interactio~i |     .06298   .0773828     0.81   0.416    -.0886874    .2146474
       _cons |   1.512497   .1844257     8.20   0.000     1.151029    1.873964
-------------+----------------------------------------------------------------
    /lnalpha |   .7391368   .0567301                      .6279478    .8503257
-------------+----------------------------------------------------------------
       alpha |   2.094127   .1188001                      1.873761    2.340409
------------------------------------------------------------------------------
fitstat, using(nas) force

                                  Current             Saved         Difference
Model:                            poisson             nbreg
N:                                  11096             11096                  0
Log-Lik Intercept Only                  .        -17622.239                  .
Log-Lik Full Model             -25947.110        -16658.687          -9288.423
D                         51894.219(11085)  33317.374(11084)    18576.846(1)
LR                                  .(10)      1927.104(10)              .(0)
Prob > LR                               .             0.000                  .
McFadden's R2                           .             0.055                  .
McFadden's Adj R2                       .             0.054                  .
ML (Cox-Snell) R2                       .             0.159                  .
Cragg-Uhler(Nagelkerke) R2              .             0.166                  .
AIC                                 4.679             3.005              1.674
AIC*n                           51916.219         33341.374          18574.846
BIC                            -51355.239        -69922.770          18567.531
BIC'                                    .         -1833.960                  .
BIC used by Stata               51996.677         33429.146          18567.531
AIC used by Stata               51916.219         33341.374          18574.846
```

Note how the negative binomial scores better than the Poisson by a wide margin.

```
table phase num_como, contents(mean er_all freq)
------------------------------------------------------
          |                  num_como
    PHASE |        0         1         2         3         4
----------+-------------------------------------------
        0 |   1.6759   1.75204   2.35737     2.925       1.5
          |    5,702     1,351       319        80        10
          |
        1 |  1.13398   1.28293   1.88496   3.08108   .666667
          |    2,866       615       113        37         3
```

Note how, as in the last dataset, a clear interaction effect is not seen here.

```
xtnbreg  er_all sex age num_como care_num instacare a_psy all_commercial
medicaid_self mhi_clinic interaction_mhi,nolog irr
Random-effects negative binomial regression     Number of obs      =     11096
Group variable: clinic                          Number of groups   =        56
Random effects u_i ~ Beta                       Obs per group: min =         2
                                                               avg =     198.1
                                                               max =      1212
                                                Wald chi2(10)      =   1378.47
Log likelihood  = -16862.009                    Prob > chi2        =    0.0000
------------------------------------------------------------------------------
      er_all |        IRR   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         sex |   .9972365   .0292927    -0.09   0.925      .9414453    1.056334
         age |   .9851658   .0010839   -13.58   0.000      .9830436    .9872925
    num_como |   1.311573   .0318665    11.16   0.000       1.25058    1.375541
    care_num |   1.028362   .0080444     3.58   0.000      1.012715     1.04425
   instacare |   1.017382   .0009162    19.14   0.000      1.015588     1.01918
       a_psy |   1.012265   .0014232     8.67   0.000      1.009479    1.015058
all_commer~l |   .4854279   .0215223   -16.30   0.000      .4450259    .5294979
medicaid_s~f |   1.144851   .0588079     2.63   0.008      1.035202    1.266114
  mhi_clinic |   .7701707   .0390797    -5.15   0.000      .6972615    .8507037
interactio~i |   1.003729   .0444298     0.08   0.933      .9203189    1.094699
-------------+----------------------------------------------------------------
       /ln_r |    2.09746   .2279297                       1.650726    2.544194
       /ln_s |   3.401197   .2313606                       2.947739    3.854656
-------------+----------------------------------------------------------------
           r |   8.145451   1.856591                       5.210759    12.73296
           s |         30   6.940818                        19.0628    47.21236
------------------------------------------------------------------------------
Likelihood-ratio test versus pooled: chibar2(01) =   297.79 Prob>=chibar2 =
0.000
```

The hierarchal model supports the normal model with a main effect but no interaction effect.

```
nbreg er_all sex age num_como care_num instacare a_psy all_commercial
medicaid_self mhi_clinic, cluster (clinic)nolog ir
> r
```

```
Negative binomial regression                      Number of obs   =      11096
Dispersion           = mean                       Wald chi2(9)    =     762.76
Log pseudolikelihood = -16659.284                 Prob > chi2     =     0.0000
                                (Std. Err. adjusted for 56 clusters in clinic)
------------------------------------------------------------------------------
             |               Robust
      er_all |        IRR   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         sex |   .9767169   .0480786    -0.48   0.632     .8868875    1.075645
         age |   .9804877   .0019685    -9.81   0.000      .976637    .9843536
    num_como |   1.400848   .0529706     8.91   0.000     1.300781    1.508613
    care_num |   1.019394   .0107832     1.82   0.069     .9984769    1.040749
   instacare |   1.092049   .0113333     8.48   0.000      1.07006    1.114489
       a_psy |   1.019163   .0061101     3.17   0.002     1.007257    1.031209
all_commer~l |   .3922877   .0315523   -11.63   0.000     .3350744      .45927
medicaid_s~f |    1.47594   .1455597     3.95   0.000     1.216527    1.790671
  mhi_clinic |   .6057196   .0776599    -3.91   0.000     .4711273    .7787625
-------------+----------------------------------------------------------------
    /lnalpha |   .7393385   .0567918                      .6280287    .8506484
-------------+----------------------------------------------------------------
       alpha |    2.09455   .1189532                      1.873913    2.341164
------------------------------------------------------------------------------
```

I dropped the interaction effect because it was insignificant.

```
. test mhi_clinic
 ( 1)  [er_all]mhi_clinic = 0
           chi2(  1) =   15.29
         Prob > chi2 =    0.0001
collin sex age num_como care_num instacare a_psy all_commercial medicaid_self
mhi_clinic
  Collinearity Diagnostics
                        SQRT                   R-
  Variable      VIF     VIF    Tolerance    Squared
----------------------------------------------------
       sex      1.01    1.01    0.9890      0.0110
       age      1.97    1.40    0.5079      0.4921
  num_como      1.19    1.09    0.8395      0.1605
  care_num      1.02    1.01    0.9758      0.0242
 instacare      1.04    1.02    0.9641      0.0359
     a_psy      1.01    1.01    0.9888      0.0112
all_commercial      2.46    1.57    0.4069      0.5931
medicaid_self      2.08    1.44    0.4806      0.5194
mhi_clinic      1.04    1.02    0.9655      0.0345
----------------------------------------------------
  Mean VIF      1.42
                           Cond
        Eigenval          Index
---------------------------------
    1     4.3728          1.0000
    2     1.0349          2.0555
    3     1.0065          2.0843
    4     0.9368          2.1605
    5     0.8549          2.2616
    6     0.7422          2.4273
    7     0.5699          2.7699
    8     0.2657          4.0569
    9     0.1976          4.7044
    10     0.0186         15.3377
---------------------------------
 Condition Number        15.3377
 Eigenvalues & Cond Index computed from scaled raw sscp (w/ intercept)
```

```
 Det(correlation matrix)    0.3087
listcoef sex age num_como care_num instacare a_psy all_commercial medicaid_self
mhi_clinic, percent help
nbreg (N=11096): Percentage Change in Expected Count
 Observed SD: 4.0047308
----------------------------------------------------------------------
      er_all |      b         z     P>|z|      %       %StdX      SDofX
-------------+--------------------------------------------------------
         sex |  -0.02356   -0.479   0.632     -2.3      -1.1     0.4592
         age |  -0.01971   -9.815   0.000     -2.0     -29.2    17.5565
    num_como |   0.33708    8.914   0.000     40.1      22.5     0.6014
    care_num |   0.01921    1.816   0.069      1.9       2.6     1.3297
   instacare |   0.08806    8.485   0.000      9.2      46.2     4.3167
       a_psy |   0.01898    3.166   0.002      1.9      13.2     6.5479
all_commer~l |  -0.93576  -11.634   0.000    -60.8     -36.0     0.4765
medicaid_s~f |   0.38930    3.947   0.000     47.6      14.1     0.3386
  mhi_clinic |  -0.50134   -3.910   0.000    -39.4     -21.0     0.4693
-------------+--------------------------------------------------------
    ln alpha |   0.73934
       alpha |   2.09455   SE(alpha) = 0.11895
----------------------------------------------------------------------
 LR test of alpha=0: .      Prob>=LRX2 =     .
----------------------------------------------------------------------
       b = raw coefficient
       z = z-score for test of b=0
   P>|z| = p-value for z-test
       % = percent change in expected count for unit increase in X
   %StdX = percent change in expected count for SD increase in X
   SDofX = standard deviation of X
```

### C.2.1 Confirmation Results Against Hypothesis 1

Hypothesis 1a (testing the confirmation group) is partially supported. The main clinics main effect still decreases ER visits by depressed patients, but the interaction effect is not significant in this expanded but less complete data set.

### C.2.2 Confirmation Results Against Hypothesis 2

The second set of tests were performed in exactly the same manner as the first set, but for the sake of brevity, I will simply state the ending following results. In this set of tests, I examine Hypothesis 2a to determine the clinic and interaction effect on visits to see ones PCP.

```
nbreg a_pcp sex age num_como care_num instacare a_psy all_commercial
medicaid_self mhi_clinic interaction_mhi, cluster (clinic)nolog
Negative binomial regression                      Number of obs   =      11096
Dispersion           = mean                       Wald chi2(10)   =     517.89
Log pseudolikelihood = -36088.517                 Prob > chi2     =     0.0000
                                (Std. Err. adjusted for 56 clusters in clinic)
```

| a_pcp | Coef. | Robust Std. Err. | z | P>\|z\| | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| sex | -.008052 | .0241003 | -0.33 | 0.738 | -.0552877 | .0391836 |
| age | .0085152 | .001345 | 6.33 | 0.000 | .0058791 | .0111514 |
| num_como | .1850963 | .0228622 | 8.10 | 0.000 | .1402872 | .2299053 |
| care_num | .0348006 | .01007 | 3.46 | 0.001 | .0150638 | .0545373 |
| instacare | .0187472 | .005492 | 3.41 | 0.001 | .007983 | .0295113 |
| a_psy | -.0066635 | .0034707 | -1.92 | 0.055 | -.013466 | .000139 |
| all_commer~l | -.2904383 | .0534685 | -5.43 | 0.000 | -.3952346 | -.1856419 |
| medicaid_s~f | .0413749 | .0536245 | 0.77 | 0.440 | -.0637271 | .1464769 |
| mhi_clinic | .0252255 | .1205234 | 0.21 | 0.834 | -.2109959 | .2614469 |
| interactio~i | -.0033197 | .0354311 | -0.09 | 0.925 | -.0727634 | .0661239 |
| _cons | 1.929581 | .1137374 | 16.97 | 0.000 | 1.70666 | 2.152503 |
| /lnalpha | -.3893287 | .2196844 | | | -.8199023 | .0412448 |

Hypothesis 2a (testing the confirmation group) is unsupported for both the main and interaction effects. In fact the main effect, while insignificant, points in the positive direction.

Mirroring hypotheses for the central psych and for RX cannot be run because this second data set lacks complete data on out of network psychiatrists and RX fulfillment at non-IH facilities, but we have no reason to believe the results would be different.

### C.2.3 Another Test to Exactly Match Clinic Demographics to Ensure Accuracy

In one of my discussions with researchers at IH, the concern was brought up that the demographics of the clinics might be a deciding factor in the results. To be conservative we decided to control for demographics by matching clinics. In an earlier study with a separate group of data, IH researchers had matched four non-MHI clinics to four MHI clinics by size, insurance mix of patients, rural versus urban, and size of doctor staff. Using the data set from the Select Health draw, I selected the four non-MHI clinics and the four MHI clinics singled out by IH in their previous study. The sample size dropped from 2,991 to 589, which offers plenty of power except for the interaction effect. I used the same process to check results and received the following results for Hypotheses 1–4.

```
nbreg   total_all_er sex age num_como  cm_total  de_outpsy_total  insta_total
mhi_clinics interaction_mhi, nolog cluster (clinic)irr
Negative binomial regression                      Number of obs    =        589
Dispersion              = mean                    Wald chi2(5)     =          .
Log pseudolikelihood = -782.00687                 Prob > chi2      =          .
                                  (Std. Err. adjusted for 8 clusters in clinic)
------------------------------------------------------------------------------
             |               Robust
total_all_er |        IRR   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         sex |   .7658628   .0623835    -3.27   0.001     .6528541    .8984332
         age |   1.000447   .0031486     0.14   0.887     .9942949    1.006637
    num_como |   1.868227   .4838073     2.41   0.016     1.124598    3.103573
    cm_total |   1.098482   .0587456     1.76   0.079     .9891716    1.219872
 de_outpsy_~l |  1.035119    .011324     3.16   0.002     1.013161    1.057553
  insta_total |  1.128159   .0467804     2.91   0.004     1.040098    1.223675
  mhi_clinics |  .5452315    .155767    -2.12   0.034     .3114595    .9544658
 interactio~i |  .6103424    .162574    -1.85   0.064      .362112    1.028736
-------------+----------------------------------------------------------------
    /lnalpha |   .7140015   .2481836                      .2275705    1.200432
-------------+----------------------------------------------------------------
       alpha |   2.042147   .5068273                      1.255546    3.321553
```

The main effect for ERs is still significant and interaction effect is approaching significance.

```
nbreg pcp_total sex age num_como  cm_total de_outpsy_total  insta_total
mhi_clinics, nolog cluster(clinic)irr
Negative binomial regression                      Number of obs    =        589
Dispersion              = mean                    Wald chi2(5)     =          .
Log pseudolikelihood = -1807.5731                 Prob > chi2      =          .
                                  (Std. Err. adjusted for 8 clusters in clinic)
------------------------------------------------------------------------------
             |               Robust
   pcp_total |        IRR   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         sex |   1.199509   .1044814     2.09   0.037     1.011255    1.422807
         age |   1.006488   .0030951     2.10   0.035      1.00044    1.012573
    num_como |   1.214405   .0570641     4.13   0.000     1.107557    1.331561
    cm_total |   1.036674   .0159157     2.35   0.019     1.005944    1.068342
de_outpsy_~l |   1.005165   .0050504     1.03   0.305     .9953149    1.015112
 insta_total |   1.035571   .0071819     5.04   0.000      1.02159    1.049743
 mhi_clinics |   .7923677   .0424225    -4.35   0.000     .7134349    .8800335
-------------+----------------------------------------------------------------
    /lnalpha |  -1.201157   .0710361                     -1.340385   -1.061928
-------------+----------------------------------------------------------------
       alpha |    .300846   .0213709                      .2617449    .3457883
------------------------------------------------------------------------------
```

The main effect for PCP visits is significant as predicted, but the interaction effect was dropped because it was insignificant.

```
nbreg  centeral_psych  sex age num_como  cm_total insta_total mhi_clinics
interaction_mhi, nolog cluster(clinic)irr
Negative binomial regression                      Number of obs   =        589
Dispersion          = mean                        Wald chi2(5)    =          .
Log pseudolikelihood = -721.53275                 Prob > chi2     =          .
                                  (Std. Err. adjusted for 8 clusters in clinic)
------------------------------------------------------------------------------
             |               Robust
centeral_p~h |        IRR   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         sex |   1.052601    .173355     0.31   0.756      .7622149    1.453616
         age |   .9614035   .0051803    -7.30   0.000      .9513038    .9716105
    num_como |   .8197867   .3154647    -0.52   0.606      .3856092    1.742828
    cm_total |   .1753403   .0650367    -4.69   0.000      .0847533    .3627495
 insta_total |   1.052574   .0242487     2.22   0.026      1.006105     1.10119
 mhi_clinics |   .9610414    .273435    -0.14   0.889      .5502483    1.678516
interactio~i |   1.736636   .7994788     1.20   0.231      .7044486    4.281229
-------------+----------------------------------------------------------------
    /lnalpha |   2.412634   .1435174                       2.131345    2.693923
-------------+----------------------------------------------------------------
       alpha |   11.16333   1.602132                       8.426193    14.78958
```

Both the main effect and interaction effect are insignificant for central psych uses.

```
nbreg  rx_script_total sex age num_como  cm_total de_outpsy_total  insta_total
mhi_clinics, nolog cluster(clinic)irr
Negative binomial regression                      Number of obs   =        589
Dispersion          = mean                        Wald chi2(5)    =          .
Log pseudolikelihood = -3028.7412                 Prob > chi2     =          .
                                  (Std. Err. adjusted for 8 clusters in clinic)
------------------------------------------------------------------------------
             |               Robust
rx_script_~l |        IRR   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         sex |   1.171899   .0972799     1.91   0.056      .9959358    1.378951
         age |   1.022462   .0033849     6.71   0.000      1.015849    1.029118
    num_como |   1.530695   .1552279     4.20   0.000      1.254782    1.867279
    cm_total |   1.057184   .0185457     3.17   0.002      1.021453    1.094166
de_outpsy_~l |   1.016345   .0030637     5.38   0.000      1.010358    1.022367
 insta_total |   1.050429   .0067363     7.67   0.000      1.037309    1.063715
 mhi_clinics |   .8827221   .0576074    -1.91   0.056      .7767364    1.003169
-------------+----------------------------------------------------------------
    /lnalpha |   -.217116   .0925784                      -.3985664   -.0356657
-------------+----------------------------------------------------------------
       alpha |   .8048366   .0745105                       .6712817    .9649628
```

In the larger test sample the main effect was also negative, but insignificant. This smaller sample lends support to the supposition that it could actually be negative.

These more conservative retests are actually stronger than the original results because they also demonstrate a main effect for PCP usage at the clinic level. This is encouraging that the results strengthen even when the populations and demographics at individual level clinics are strictly matched.

### C.3 Test Two: Testing the Cascade Model

Because the mental health resources, even within the MHI clinics, constitute a scarce resource, I hypothesized that those clinics who more efficiently sorted patients to the proper care would perform better. Because primary care services a wide variety of patients, physicians' ability to direct patients into appropriate care pathways is a vital skill. Studies have demonstrated MHI-type programs increase access for patients to care, but other studies have shown that more care does not equal better care (Gawande, 2009). Often better care results are found in areas where less is spent on healthcare (Gawande, 2009); thus, to insure medical benefit to patients when access to care is increased, medical staff must be sufficiently trained to direct the correct patients towards these resources and the incorrect patients away from them.

The goal of the IH's cascade tool is to properly segregate customers into medical pathways so as to not over serve or under serve patients. The difficulty with this study, even before implementation, has always been a lack of data. For example, the only available data I could obtain from medical records were PHQ9 scores (a validated instrument to test the severity of depression) and the number of co-morbidities a patient had. The cascade model actually triggers off those two data points and the following six data points: family style, sleep patterns, mental health co-morbidities, medical co-morbidities in control or out of control, suicidal tendencies and chemical dependency.

Additionally, there are also very few patient PHQ9's coded in the system. This means patients were most likely given mental health packets, but the data were never coded into the medical record from the paper copy recorded in the clinic. Out of the larger cohort of 11,096 patients, only 2,276 actually have at least one coded PHQ9 in their medical record. Despite not having full data, I believed the partial markers would still be sufficient to separate the better clinics from the poorer clinics by the way they sorted patients.

I sorted patients into four categories (as prescribed by IH's clinicians) according to their score on the PHQ9 and the presence of co-morbidity. Because it was necessary to have a PHQ9 for the patients to be sorted, the majority of patients in the sample were from the MHI patient group, where the packets are used most regularly. This was expected. The plan was to use this method to differentiate between the performances in these clinics. I sorted the patients as follows:

Remission = PHQ9 score of 0-9 and no co-morbidities

Mild = PHQ9 score of 10-14 and no co-morbidities/PHQ9 0-9 and co-morbidities

Moderate = PHQ9 score of 15-19 and no co-morbidities/PHQ9 10-14 and co-morbidities

Severe = PHQ9 score of 20-30/PHQ9 15-19 and co-morbidities

After my initial results were completed, the patients were sorted with a number of different permutations, including the dropping of co-morbidities, but even with more conservative sorting techniques, the results stayed consistent. Table 10 describes the results across all clinics:

| Table 10: Patient care across clinics | | | |
|---|---|---|---|
| **Sorted Category** | **Number of Patients** | **Number Receiving appropriate care** | **Percent Receiving appropriate care** |
| Remission | 778 | 658 | 84.6% |
| Mild | 564 | 369 | 65.4% |
| Moderate | 545 | 26 | 4.8% |
| Severe | 419 | 13 | 3.1% |

It is easy to see from the table how when I split the data out between clinics, it quickly becomes statistically insignificant. Appropriate care is defined as receiving neither too much nor too little care. For example, if a patient in remission had a mental health inpatient stay, the patient received too much care for the severity of their condition. And if a severe patient did not visit a mental health specialist, the patient received too little care. I hoped to see separation between clinics in the way they treated moderate and severe patients because care for these patients required the activation of the entire MHI team. Unfortunately, when I separated the 39 correctly-seen patients into their respective clinics, the numbers per clinic became so small as to remain statistically indistinguishable.

When I shared these results with the MHI team at IH, these results quickly became the most important results from my entire study for their work, and the results have prompted detailed searching through medical records and spurred interviews with physicians and care managers at the clinics. While the team is continuing to examine the results, so far they have determined the five following items are all at least partial causes of the results.

1. The two data points I used to sort the patients are insufficient, thus giving an inaccurate picture. Some doctors do not rely on the PHQ9 to sort patients; they feel other data points are more accurate and important for sorting patients into treatment pathways, such as the family stability score.

2. While these clinics have embraced the MHI program, the way individual clinics and physicians implement the program varies significantly.

3. The process for capturing the data electronically at the clinics needs drastic improvement if further studies are going to be made using only the electronic medical record. In other words, many of the happenings at the clinic are not recorded electronically, and my study failed to capture the paper trail or other nonrecorded items.

4. There is a great deal of variation in the way care managers at different clinics define their responsibilities and in the criteria physicians use to refer patients to their care. This variation is not all negative; most of it derives from the clinic's individual characteristics.

5. My study was also unable to capture patients' unwillingness to follow suggested guidelines. For example, if a physician referred a patient to a mental health specialist and the patient chose not to meet the specialist, my study would have shown the patients as having received inappropriate care.

One of the dangers of using secondary data is finding the data incomplete or insufficient to answer the study question. The data I used were the best IH had in its medical records, but there were both incomplete and insufficient to enable me to statistically rank the clinics by performance.

APPENDIX D

# UNLEASHING THE POWER OF STORYTELLING TO BRING CONCEPTS FROM SERVICE MANAGEMENT RESEARCH INTO THE MINDS AND MEMORIES OF OUR STUDENTS

## D.1 Abstract

As we teach, most of us tell stories to illustrate our points. Storytelling brings concepts straight into the hearts, minds, and memories of our students as few other tools in the arsenal of teaching techniques can, yet often even when we tell a fascinating story, we miss the opportunity to facilitate real learning in our students. By making clear to our students a story's objective, context, and applicability, we enhance our teaching effectiveness. Creating succinct process-level objectives from service management typologies, which are suitable for storytelling, can be difficult, so to facilitate this process, we present a technique for creating process-level objectives from service typologies using theory development. Being a prepared storyteller is not enough; we must also use tools to involve our students in the storytelling process. We must combine our prepared storytelling with bidirectional storytelling from our students to capture fully the learning power of storytelling.

## D.2 Introduction

"It was the best of times, it was the worst of times" (*The Tale of Two Cities* (Dickens, 2003)). "All Children, except one, grow up." (*Peter Pan* (Barrie, 2003)). "Call me Ishmael" (*Moby-Dick* (Melville, 2002)). Just as the first lines of these novels have imprinted themselves on the consciousness of our society, so too do good stories make an indelible impression upon the memories of our students.

For example, during a rather boring lecture in a required business class outside my undergraduate major, the professor droned on about disparate topics, but stopped on the topic of lifelong learning to tell the following story:

> A new regional manager of a large retail chain took notice of one of the stores he visited during his introductory tour because it stood out above and beyond all the other stores in appearance and performance. The end-caps, the specials, and the in-store displays looked as though they had jumped straight off the page of a marketing campaign in a high-end magazine. The area manager's respect deepened as he realized the manager of this store was the only one in the region without a college degree; the store manager's management training had come entirely at the hands of the U.S. Marine Core. After touring the store, the area manager made a pilgrimage to the store manager's office at the back of the store, and he confronted the store manager. "How did you learn to manage a retail operation like this in the Marines?" The store manager did not reply; he simply went to his desk and opened its bottom drawer. The drawer was filled with industry-leading retail management magazines. The store manager simply said, "Everything I know I learned from these magazines."

Three years after graduation, I received a promotion from internal auditor to manager of transportation, and to say I knew nothing about trucking would be an understatement, but, remembering my professor's narrative, I filled my office drawer with industry-leading trucking magazines. In less than a year, the unit had turned from a loss to a profit, and I became the company's expert in trucking-related issues. Most of us can likely cite similar stories that have formed our education and shaped our decisions. By sharing with our students the stories that impressed us, we offer them a vivid way to remember the lessons we teach.

Storytelling demonstrated its effectiveness as a vehicle for teaching operations concepts when Goldratt's book *The Goal* (1986) became a runaway bestseller. At the time of its publication, *The Goal* was a novelty because of its ability to teach the theory of constraints while telling the story of how Alex learned how to increase throughput, save his factory, and resurrect the love in his marriage all in the same novel. Since *The Goal*, other authors have also used storytelling with great success: examples include *Leadership and Self-Deception* (Institute, 2002), *If You Want it Done Right, You Don't Have to Do it Yourself!* (Genett, 2003), and most recently, *The Gold Mine* (Balle' & Balle', 2005), which was written to teach the principles of lean management. These books all take the approach of using a novel to teach basic business and human management principles. The story is the vehicle for making what might be a mundane subject meaningful for the reader.

But while stories can easily capture a class's attention, sometimes they do little more than entertain: Storytelling can be simply fascinating or it can rise to the level of powerful teaching. By using storytelling effectively, service management researchers can unlock the pathway to the minds and hearts of students (Harris, 2000). In the first section of this article we will highlight the three essential principles of stories required to produce learning within students. In the penultimate section we will describe a technique for finding teaching objectives in the service management literature, and we will demonstrate how to go from teaching objectives to storytelling. Finally, we emphasize that true leaning is based in the students, and to achieve the full purpose of learning from storytelling it must be bidirectional, or in other words the students must also tell stories to us.

### D.3 How to Use Storytelling in Teaching Services

Many key concepts are lost on students when they are not illustrated by a story. Take, for example, one of the least interesting, simplest, and yet exquisitely powerful quality tools: the lowly and simple checklist. The checklist can increase process control and improve quality in almost any environment that might confront our students upon graduation. Additionally, it is virtually costless and easy to implement, yet many managers fail to use this powerful tool because they fail to see how it will solve their problems or improve their systems. A teacher trying to share this simple concept could show a checklist on a power point slide or recommend its usefulness in a lecture, and students would likely forget it before they leave the room. But use a story/narrative , and they might never be able to forget it.

> On October 30, 1935, at Wright Air Field in Dayton, Ohio, the U.S. Army Air Corps held a flight competition for airplane manufacturers vying to build its next-generation long-range bomber. It wasn't supposed to be much of a competition. In early evaluations, the Boeing Corporation's gleaming aluminum-alloy Model 299 had trounced the designs of Martin and Douglas. Boeing's plane could carry five times as many bombs as the Army had requested; it could fly faster than previous bombers, and almost twice as far. A Seattle newspaperman who had glimpsed the plane called it the "flying fortress," and the name stuck. The flight "competition," according to the military historian Phillip Meilinger, was regarded as a mere formality. The Army planned to order at least sixty-five of the aircraft.
>
> A small crowd of Army brass and manufacturing executives watched as the Model 299 test plane taxied onto the runway. It was sleek and impressive, with a hundred-and-three-foot wingspan and four engines jutting out from the wings, rather than the usual two. The plane roared down the tarmac, lifted off smoothly, and climbed sharply to three hundred feet. Then it stalled, turned on one wing, and crashed in a fiery explosion. Two of the five crew members died, including the pilot, Major Ployer P. Hill.

> An investigation revealed that nothing mechanical had gone wrong. The crash had been due to "pilot error," the report said. Substantially more complex than previous aircraft, the new plane required the pilot to attend to the four engines, a retractable landing gear, new wing flaps, electric trim tabs that needed adjustment to maintain control at different airspeeds, and constant-speed propellers whose pitch had to be regulated with hydraulic controls, among other features. While doing all this, Hill had forgotten to release a new locking mechanism on the elevator and rudder controls. The Boeing model was deemed, as a newspaper put it, "too much airplane for one man to fly." The Army Air Corps declared Douglas's smaller design the winner. Boeing nearly went bankrupt.
>
> Still, the Army purchased a few aircraft from Boeing as test planes, and some insiders remained convinced that the aircraft was flyable. So a group of test pilots got together and considered what to do.
>
> They could have required Model 299 pilots to undergo more training. But it was hard to imagine having more experience and expertise than Major Hill, who had been the U.S. Army Air Corps' chief of flight testing. Instead, they came up with an ingeniously simple approach: they created a pilot's checklist, with step-by-step checks for takeoff, flight, landing, and taxiing. Its mere existence indicated how far aeronautics had advanced. In the early years of flight, getting an aircraft into the air might have been nerve-racking, but it was hardly complex. Using a checklist for takeoff would no more have occurred to a pilot than to a driver backing a car out of the garage. But this new plane was too complicated to be left to the memory of any pilot, however expert.
>
> With the checklist in hand, the pilots went on to fly the Model 299 a total of 1.8 million miles without one accident. The Army ultimately ordered almost thirteen thousand of the aircraft, which it dubbed the B-17. And, because flying the behemoth was now possible, the Army gained a decisive air advantage in the Second World War which enabled its devastating bombing campaign across Nazi Germany. (Gawande, 2007, p. 89)

The idea of a simple operations tool saving a major company like Boeing and giving a strategic advantage to allied forces in World War II is intoxicating, but despite the power and entertainment value in this story, it is still not enough to promote change and checklist use within our students. Without a teacher to give framework to the narrative, some students would simply be fascinated by the military history presented; other students would assume the pilots were missing the obvious and discount the checklist;

and finally others might conclude that the checklist was a neat trick, but has no applicability to the circumstances they face. This is where the power of focus and the power of a well-prepared teacher can take a fascinating narrative and turn it into a learning opportunity. As we go through this article, we explore the concepts that can raise this story from the level of simply being fascinating to the level of memorable teaching.

### D.3.1 Release the Power of Storytelling Through Objective, Context, and Applicability

Storytelling must have an objective to rise above the level of simply being fascinating. Before the storytelling begins, a teacher should start with a teaching objective. For example, Abraham Lincoln has gained mythical status in the United States partially because of his ability to communicate. One of his favorite communication modes was storytelling. His stories were not simply entertaining tales of small towns in Minnesota with strong women, good looking men, and above-average children; they became legendary and memorable because they had specific teaching objectives.

> Abraham Lincoln had no love for favor seekers, especially when they took his time away from the duties of the presidency during the Civil War. On one occasion, he gathered together a number of would-be office-holders and told them this story:
>
> "There was once a King who wished to go out hunting, so he asked his weather minister if it was going to rain. The minister assured him that it would not. On the way to the woods, the King passed a farmer who was working the land with his donkey. The farmer warned the King that it would rain soon, but the King just laughed and continued on. A few minutes later it was pouring, and the King and his companions were soaked to their skin. Upon return to the castle, the King dismissed his weather minister and sent for the farmer. He asked the man how he knew it was going to rain.
>
> "'It was not me, your Majesty. It was my donkey. He always droops one ear when it is going to rain.'
>
> "So the King bought the donkey from the farmer and gave him the position of weather minister at court. This was where the King made his mistake.

> "'How was that?' asked several people in the audience.
>
> "'Because ever since then,' Lincoln continued, 'every jackass wants an office. Gentlemen, leave your credentials and when the war is over you'll hear from me' (Lincoln, 1862).

At the conclusion of this story, Abraham Lincoln's audience was left with no doubt about his feelings in regard to their attempts to petition him for an appointed office. In this story, President Lincoln demonstrates how we begin the story selection process by first being clear about what our teaching objective is. We lose our audience, or at least our ability to teach our audience could be described as tenable if we are unsure of our own objective in telling a story.

Next in importance to having a firm objective in good storytelling is context, which can be defined the story's setting having the ability to give the audience an experience they can personally relate to their own lives or circumstances. Note how in the previous story Abraham Lincoln used the context of a king making political appointments to carry his message to the presidential office-seekers. The context clearly set the stage for the listeners who were hoping for a political appointment. By using the skill of context development we can convey our objectives as clearly as President Lincoln. One of the major roadblocks to teaching services comes from OM's roots in manufacturing, which is a foreign environment for most of our students; thus we can exponentially increase our teaching ability with storytelling as we take ideas from manufacturing and contextually encapsulate our stories in service processes.

For an example of the power of context and for a lead into our third principle of storytelling for teaching, we need no further than *The Goal*. *The Goal's* sequels—*It's Not Luck* (Goldratt, 1994), *The Critical Chain* (Goldratt, 1997), and *Necessary But Not Sufficient* (Goldratt, Ptak, & Schragenheim, 2000)—are similar, story-based management novels, but combined their sales have paled in comparison to *The Goal*. *The Goal* has two advantages over its sequels: context and applicability.

First, context: *The Goal* plays out not only in a factory, but also in cub-scout hike with Herbie, a particularly slow cub scout. Herbie's story has been vital to the success of *The Goal* because it deliverers a context with which everyone can relate: Even those who have never been in a factory can relate to Herbie. In a very subtle way, Herbie releases the power of context to all the readers unfamiliar with factories and has contributed to the book's runaway success. In contrast, *Necessary But Not Sufficient* attempts to showcase the power of combining the theory of constraints with ERP software, but the entire book is written in the context of the ERP installers, thus making it less than helpful to those having the software installed, which group comprises the largest population that might find the book relevant.

Second, applicability: *The Goal* not only tells a story, but also succinctly summarizes the learning that is to be taken away and how that learning can be directly applied. Goldratt's other books are good, but they leave the reader often wondering what the central point of the book was, or how to apply the learning obtained in the book. *The Goal*, on the other hand, specifically shows the reader the process for finding a bottleneck elevating the bottleneck once it is found. Applicability anchors *The Goal* in minds and hearts of its readers (it is for this reason that we never teach an introductory operations class without *The Goal*). *It's Not Luck* in contrast, introduces Goldratt's revolutionary "Evaporating Cloud" thinking technique, but its explanation about how to apply or use it effectively is scarce at best. Thus the book, while good, is very forgettable.

Other excellent examples in management literature of using context and applicability in storytelling are *Good to Great* (Collins, 2001) and *The Toyota Way* (Liker, 2004). They use stories like the building of the first Lexus, the creation of the Prius, and the rise of Walgreens to teach very specific and simple ideas. Until one reads the story of the ubiquitous Walgreens chain taking advantage of the Internet more effectively than its dot-com competitors, one cannot really understand how the "Crawl, Walk, Run" principle applies to Collins' wider "Hedgehog" concept.

> On July 28, 1999, drugstore.com—one of the first Internet pharmacies—sold shares of its stock to the public. Within seconds of the opening bell, the stock multiplied nearly threefold to $65 per share. Four weeks later, the stock closed as high as $69, creating a market valuation of over $3.5 billion. Not bad for an enterprise that had sold products for less than nine months, had fewer than 500 employees, offered no hope of investor dividends for years (if not decades), and deliberately planned to lose hundreds of millions of dollars before turning a single dollar of profit....
>
> At the high point of this frenzy, drugstore.com issued its challenge to Walgreens. At first, Walgreens' stock suffered from the invasion of the dotcoms, losing over 40 percent of its price in the months leading up to the drugstore.com public offering. Wrote *Forbes* in October 1999: "Investors seem to think the Web race will be won by competitors who hit the ground running—companies like drugstore.com, which trades at 398 times revenue, rather than Walgreen, trading at 1.4 times revenue." Analysts downgraded Walgreens' stock, and the pressure on Walgreens to react to the Internet threat increased as nearly $15 billion in market value evaporated.
>
> Walgreens' response in the midst of this frenzy?
>
> "We're a crawl, walk, run company," Dan Jorndt told *Forbes* in describing his deliberate, methodical approach to the Internet. Instead of reacting like Chicken Little, Walgreens executives did something quite unusual for the times. They decided to pause and reflect. They decided to use their brains. They decided to think!
>
> Slow at first (crawl), Walgreens began experimenting with a Web site while engaging in intense internal dialogue and debate about its implications, within the context of its own peculiar Hedgehog Concept. "How will the Internet connect to our convenience concept? How can we tie it to our economic denominator of cash flow per customer visit? How can we use the Web to enhance what we do better than any other company in the world and in a way that we're passionate about?"....

> Then a little faster (walk), Walgreens began to find ways to tie the Internet directly to its sophisticated inventory-and-distribution model and—ultimately—its convenience concept. Fill your prescription on-line, pop into your car and go to your local Walgreens drive-through (in whatever city you happen to be in at the moment), zoom past the window with hardly a moment's pause picking up your bottle of whatever. Or have it shipped to you, if that's more convenient. There was no manic lurching about, no hype, no bravado—just calm, deliberate pursuit of understanding, followed by clam, deliberate steps forward.
>
> Then, finally (run!), Walgreens bet big, launching an Internet site as sophisticated and well designed as most pure dot-coms.... Precisely one year after the *Forbes* article, Walgreens had figured out how to harness the Internet to accelerate momentum, making it just that much more unstoppable.... From its low point in 1999 at the depths of the dot-com scare, Walgreens' stock price nearly doubled within a year.
>
> And what of drugstore.com? Continuing to accumulate massive losses, it announced a layoff to conserve cash.... It has lost nearly all of its initial value. While Walgreens went from crawl to walk to run, drugstore.com went from run to walk to crawl. (Collins, 2001, pp. 144-146)

Jim Collins's use of storytelling trumps Goldratt's later books because he uses the narrative to highlight the principle being taught and to give it context, but then thoroughly explains the principle and displays its application so that the reader is not lost in the story. For example, Collins objective is to demonstrate how having a simple strategy, a "Hedgehog Concept," guided one of his sample "Good to Great Companies," Walgreens (which is also the context), during a turbulent technological revolution. In the paragraph describing Walgreens' crawl phase, Walgreens' executives ask specific questions about how the internet will relate to their hedgehog concept: "How will the Internet connect to our convenience concept? How can we tie it to our economic denominator of cash flow per customer visit?" In this way, Jim weaves his objective into the story's fabric. Finally, Jim demonstrates applicability of the hedgehog concept by using Walgreens' crawl, walk, run principle as an example for how the hedgehog concept can be applied to other industries, and just in case a reader misses the application portion of the story, he summarizes the learning at the end of each chapter. We encourage the reader to read *Good to Great* and learn from Jim Collins's style.

### D.4 What to Teach: Reaching Our Students With Service Management Research Through Stories

Boje (1991a) highlighted that all good stories have three points in common: context, story parts, and relevance to the readings. (We highly recommend this article to all who would like to become better at the art of storytelling, and who would like to become better at teaching the art of storytelling to their students.) We have hit upon context and upon relevance (applicability). Intuitively, it is simple to see their importance in storytelling, yet many times we have a hard time making them fit with the "story parts." Story parts are the details of the story that allow the objective of the story to come out and impress the minds of our students. To be able to get the story parts right, we ask the following question, "How can we bring service management research into the classroom through succinct objectives?"

Powerful books like *Good to Great*, *The Toyota Way*, and *The Goal* narrow large amounts of information into clear and concise points. Collins (2001) says good to great companies have a "hedgehog concept," a simple concept that drives their corporate vision. Likewise, effective stories narrow down service management concepts to a process level in a context that students can understand them and achieve applicability. While the previously told story about the checklist saving the B17 program is illustrative, it is incomplete until we tie objectives and application of the story to service management principles on a level our students can understand. And we can only do this if we are very granular in the way we interpret service management principles to our students.

Remember the old saying: "Don't be so clear that people can understand: be so clear that they cannot misunderstand."

### D.4.1 Granularizing Service Typologies

To tell a story with teaching potential, we need to start with a goal to help our students understand service management's granular principles. When succinct and granular principles such as a "bottleneck," a "hedgehog concept," or the "bullwhip effect" are identified, teaching objectives become clear because the principles can be used to distinguish between similar processes in the same industry. For example, the bottleneck principle can be used to explain why the service process at sandwich stand A can produce more sandwiches than the service process at sandwich stand B. Two recent examples of articles that have succeeded in bringing service ideas down to a succinct and granular level have been (Frei, 2006) and (DeHoratius & Raman, 2008). For example, Frei (2006) granularizes customer induced variation into five distinct types: arrival, request, capability, effort, and subjective preference variability; she then demonstrates how each type of variability affects services on the process level. She tells the following story to illustrate how Starbucks institutionalized the control of customer induced capability variability:

> Starbucks provides an excellent example of the deft handling of capability variability. The coffee shop chain allows customers to choose among many permutations of sizes, flavors, and preparation techniques in its beverages. In the interests of filling orders accurately and efficiently, Starbucks trains its counter clerks to call out orders to beverage makers in a particular sequence. It is all better when the customers themselves can do so. Therefore, Starbucks attempts to teach customers its ordering protocol in at least two ways. It produces a "guide to ordering" pamphlet for customers to peruse, and it instructs clerks to repeat the order to the customer not in the way it was presented but in the correct way. The tone is not one of rebuke, but nevertheless most customers learn to avoid the implied correction by stating their order in the way that helps Starbucks's

> operations–with no hit to the service experience. Indeed, for some customers, getting the order right is an aspiration, a small victory on the way to the office. It's a clever solution, achieving an uncompromised reduction of variability. (p. 97)

Frei's successful teaching in this story lies in her ability to take a service management principle down to the process level. At this level, the principle can be processed and compared by companies in the same industry. Unfortunately, because service management literature is fairly new, the majority of our research is linked to high-level typologies.

Typologies usually do not make process to process comparisons, but instead compare processes across industry. Lovelock (1983), for example, uses a network of four 2 x 2 matrices to segment services between industries such as healthcare and banking because healthcare is tangible and done to people while banking is intangible and done to things. Such high-level comparisons are common to fields in their infancy; the physical sciences also began with categorizations or typologies because until one animal or one process can be separated from another for systematic reasons, it is difficult if not impossible for learning to begin. As it grows increasingly sophisticated, science allows us to become more and more specific, or granular. For example, the first segregation or typology of animals one learns about in grammar school science divides animals into groups of fish, fowls, mammals, amphibians, and reptiles. While these categorizations start learning on a base level, they do little to help on the granular level. This typology teaches that both whales and squirrels are mammals, but the typology does little to help in understanding the behavior of either creature. It is only through the progression of science that useful specificity is eventually gained.

The beginning of service sciences started in a similar manner with high-level typologies that set the base for learning. For example, Chase (1978), who created one of the earliest typologies, focused on how the amount of customer contact in a service either increases or decreases the efficiency of the service process. In the article Chase categorizes hotels and healthcare as both being high contact services. Again this is useful at the 50-foot level, but like the classification of whales and squirrels as mammals, it does little to explain process differences between surgery and staying a night at the Marriott.

As service science has progressed, successive typologies have been produced in the effort to become increasingly granular on the process level. (Our purpose is not to list and detail all the many useful service typologies that have been presented over the past 3 decades, but to demonstrate a method for granularizing the concepts to create clear and concise objectives for storytelling. We encourage readers to examine Cook, Goh and Chung's (1999) extensive and thoughtful article for a full review of service typologies.) While successive typologies have incrementally contributed to our understanding of service management, many still contain the same flaw: They tend to group industries using wide swaths. Verma and Young (2000) suggest that groupings such as Schmenner's (1986) where all airlines, trucking, and hotels are service factories; all hospitals and repair services are service shops; all retail businesses are mass service; whereas all doctors, lawyers, accountants and architects are professional service providers are fine for theoretical development, but are too broad for practical application. Verma and Young (2000) go on to demonstrate that there are distinct service strategies and groupings even within a single low contact industry such as car repair. Because operations is process oriented, we all inherently understand the need for our research to become more relevant on the process level, but our typologies for the most part are not granular enough yet to focus on process differences in a single industry, and without succinct process level principles it is difficult to create clear objectives that give storytelling its power. The challenge for teaching services through storytelling is to take the higher-level comparisons across industries and bring them down to the more granular level of comparing services across service processes so that we can have clear objectives to inform our storytelling.

In the next section we demonstrate the process of granularizing a typology and using it to teach storytelling in one of our healthcare management classes.

### D.4.2 Using Theory Building Theory to Draw Out the "Objective" in the Typology

As editor of AMR, Whetten (1989) proposed the building blocks of theory development as "what," "how," "why," and "who, where, when." We have co-opted the theory building blocks to create tools for transforming across industry comparisons found in typologies to the across process level comparisons useful in generating succinct objectives. Each of Whetten's questions can be used as a key to the next step in creating clear objectives. We used this process to examine all the service process typologies found in (Cook et al., 1999), and in doing so we have drawn out a number of endogenous and exogenous factors that increase or decrease complexity in managing services at the process level, but for brevity we will demonstrate the process on a single paper.

We will demonstrate our process using (Shostack, 1987). We would like to note that this process is one we found useful, but certainly not the only useful process available for drawing out objectives in the service management literature. Some research such as (DeHoratius & Raman, 2008; Frei, 2006) may already be granular enough to use in storytelling at publication, and other papers will contain parts that are granular and parts that are not. The important item to remember is that when principles are granular they allow for clear objectives and better storytelling.

#### D.4.2.1 "What" are the Main Constructs?

Every typology has anchoring constructs that create the delineation between high level service process groupings. We propose the first step to take in creating granular process steps is to identify the primary constructs by definition. Whetten (1989) labels the primary constructs the "What" of theory building. We identified Shostack's (1987) two most prominent constructs as complexity and divergence. They are defined as follows: Complexity is defined as "the number and intricacy of the steps in a process. Complex procedures have a lot of steps, and may include a lot of process branches. A process branch is a rule that changes the procedure based on a condition" (Sampson, 2001, p. 85). Divergence is defined as unknown "nature of the steps: divergent procedures have steps that can be handled any number of ways depending on the circumstances of production" (Sampson, 2001, p. 85).

#### D.4.2.2 "How" Could the Constructs Be Used to Differentiate Between Different Service Processes?

Once the main constructs are succinctly listed and defined, the next step requires the drivers of the constructs to be listed. In or around the definitions of the constructs authors usually provide the drivers of the constructs; the drivers are the characteristics that either increase or decrease the constructs' potency. The drivers provide the key to unlocking the "How" or more granular aspects of the service process. For example, in the complexity definition, Shostack lists an increased number of steps and branches as the leading cause to increased complexity, while divergence is increased by the unknown nature of the processes steps. We have taken literary license and labeled each driver as a type of complexity.

After identifying the drivers, we define them by demonstrating "how" the drivers will either increase or decrease process complexity. A succinct "how" definition facilitates the granularization of service management principles and the creation of objectives.

Step Complexity: the number of steps in a process.

Path Complexity: the number of paths or branches a service can follow.

Definitional Complexity: how definable a service's steps and paths are before the service process begins.

D.4.2.3 "Why" Would Change in These Drivers Be Important in Service Process Management?

Tight "how" statements give rise to "why" statements; and why statements create delineation between service processes on the process level. For example, heart bypass surgery has many steps and thus is high in step complexity, but the steps are definable and can be consistently executed by a well-trained staff. On the other hand, treating depression might have less step complexity, but it has exponentially more definitional complexity because of the ambiguity in treatment steps caused by a lack of definition in the steps of care. Patients' backgrounds and chemistry are highly variable, which causes their responses to different therapies to be highly variable. The "why" statement's power of delineation finalizes a well thought out objective.

Writing a "why" statement requires the contrasting of each "how" statement in a measurable way. The "why" statement allows the drivers to delineate between service processes on a granular level. The "why" statement asks, why does measurably changing this driver affect the service process? The "why" statement is not a question; it is a statement that demonstrates the application of the "how" statement and in so doing answers the question "why" is this important. To insure we are granular enough we add to the "why" statement the sandwich shop statement because "why" statements that can be understood in the context of a sandwich shop exemplify objectives that are clear and comprehendible. Following are some "why" statements.

**Step Complexity.** The number of steps in a process. (Dave's wound was more complex than Steve's because it required four stitches to Steve's three stitches. / Dave's sandwich was more complex to fix than Steve's because he required three different types of cheese to Steve's singular choice.)

**Path Complexity.** The number of paths or branches a service can follow. (All withdrawals from an ATM must be in denominations of $20, thus there is only one pathway to withdraw $100. But when using a teller there are an almost unlimited amount of pathways or branches that could be used to satisfy the request to withdraw $100. / Subway's sandwich process is more complex than Quiznos' because its menu is larger, and thus customer choices can direct servers down a larger variety of pathways.)

**Definitional Complexity.** How definable a service's steps and paths are before the service process begins. (Surgeons in the 21$^{st}$ century confront less definitional complexity than earlier surgeons because imaging technology has decreased the number of unknowns a surgeon confronts before operating on a patient. / At Dave's "your way sandwich shop," a customer is promised the sandwich of her choice made any way she likes it. Dave's servers must have the ability to respond to a number of unknown requests and are paid more because they experience more definitional complexity than Subway's servers, who are trained specifically on all 15 types of sandwiches the menu specifies.)

#### D.4.2.4 "Who, Where, When" – Who Else Uses These Principles, Where and Why?

The process of writing the "why" statement completes the process of creating an objective usable in storytelling, but understanding increases as one also asks the questions "who, where, and when." Whetten (1989) uses the first three questions (what, how, why) to demonstrate the building of a theory. He further explains the last three questions (who, where, when) set boundaries around the theory explaining when or when not it might be applicable.

We have found asking the "who, where, and when" questions increases our classroom readiness because they increase our understanding of the objective's boundaries; we ask questions such as:

When might allowing increased definitional complexity increase customer service?

Where are the boundaries of human capacity to efficiently handle increased path complexity and how might technology assist in reshaping these boundaries?

And who else uses these underlying principles in their typologies?

For example, treating both the heart bypass patient and the depressed patient requires customization and high contact, two important parts of previous typologies (Chase, 1978; Lovelock, 1983; Schmenner, 1986), yet it seems clear on the granular level the source of their complexity differs significantly because of known and unknown processes steps.

### D.4.3 Taking Objectives From the Research and Using Them in Storytelling

Researchers in education frequently highlight the value of clear objectives (McKeachie & Svinicki, 2006). Most educators try to follow this advice by using clear objectives in their course syllabi; popular OM textbooks are extending this practice by starting each discussion by detailing distinct learning objectives before beginning of each chapter (Jacobs & Chase, 2008; Russel & Taylor, 2009). Likewise, to enhance student learning, teachers should state clear objects obtained from their research before they begin storytelling.

#### D.4.3.1 Examples of Presenting Objectives to Students

For example, we would take the objectives we previously drew out of the service management research and present them to our class in a power point format:

**Step Complexity.** The number of steps in a process. (Dave's wound was more complex than Steve's because it required four stitches to Steve's three stitches.)

**Path Complexity.** The number of paths or branches a service can follow. (All withdrawals from an ATM must be in denominations of $20, thus there is only one pathway to withdraw $100. But when using a teller there are an almost unlimited amount of pathways or branches that could be used to satisfy the request to withdraw $100.)

**Definitional Complexity.** How definable a service's steps and paths are before the service process begins. (Surgeons in the 21$^{st}$ century confront less definitional complexity than earlier surgeons because imaging technology has decreased the number of unknowns a surgeon confronts before operating on a patient.)

D.4.3.2 Teaching With Objectives

Once the classroom clearly understands the objectives, we turn the power point off and begin the storytelling portion of the lesson. As stated in the first section, once the objective is clearly understood a narrative needs to be chosen from within service management that has sufficient context and applicability to enhance learning within our students. In *The Goal*, Goldratt uses the stories of the plant and of Herbie to teach one objective; likewise it may take multiple stories to cover the needed objectives or provide the needed context or applicability.

In one of our lectures on healthcare management, we chose to share the following story to convey the previous three complexity objectives. Notice how this story's context can be grasped by both medical and nonmedical students; additionally, notice how the application of the solution directly addresses step, path, and definitional complexity on the process level.

> In 2001, though, a critical-care specialist at Johns Hopkins Hospital named Peter Pronovost decided to give checklists a try. He didn't attempt to make the checklist cover everything; he designed it to tackle just one problem: line infections. On a sheet of plain paper, he plotted out the steps to take in order to avoid infections when putting a line in. Doctors are supposed to (1) wash their hands with soap, (2) clean the patient's skin with chlorhexidine antiseptic, (3) put sterile drapes over the entire patient, (4) wear a sterile mask, hat, gown, and gloves, and (5) put a sterile dressing over the catheter site once the line is in. Check, check, check, check, check. These steps are no-brainers; they have been known and taught for years. So it seemed silly to make a checklist just for them. Still, Pronovost asked the nurses in his I.C.U. to observe the doctors for a month as they put lines into patients, and record how often they completed each step. In more than a third of patients, they skipped at least one.

The next month, he and his team persuaded the hospital administration to authorize nurses to stop doctors if they saw them skipping a step on the checklist; nurses were also to ask them each day whether any lines ought to be removed, so as not to leave them in longer than necessary. This was revolutionary. Nurses have always had their ways of nudging a doctor into doing the right thing, ranging from the gentle reminder ("Um, did you forget to put on your mask, doctor?") to more forceful methods (I've had a nurse bodycheck me when she thought I hadn't put enough drapes on a patient). But many nurses aren't sure whether this is their place, or whether a given step is worth a confrontation. (Does it really matter whether a patient's legs are draped for a line going into the chest?) The new rule made it clear: if doctors didn't follow every step on the checklist, the nurses would have backup from the administration to intervene.

Pronovost and his colleagues monitored what happened for a year afterward. The results were so dramatic that they weren't sure whether to believe them: the ten-day line-infection rate went from eleven per cent to zero. So they followed patients for fifteen more months. Only two line infections occurred during the entire period. They calculated that, in this one hospital, the checklist had prevented forty-three infections and eight deaths, and saved two million dollars in costs.

Pronovost recruited some more colleagues, and they made some more checklists. One aimed to insure that nurses observe patients for pain at least once every four hours and provide timely pain medication. This reduced the likelihood of a patient's experiencing untreated pain from forty-one per cent to three per cent. They tested a checklist for patients on mechanical ventilation, making sure that, for instance, the head of each patient's bed was propped up at least thirty degrees so that oral secretions couldn't go into the windpipe, and antacid medication was given to prevent stomach ulcers. The proportion of patients who didn't receive the recommended care dropped from seventy per cent to four per cent; the occurrence of pneumonias fell by a quarter; and twenty-one fewer patients died than in the previous year. The researchers found that simply having the doctors and nurses in the I.C.U. make their own checklists for what they thought should be done each day improved the consistency of care to the point that, within a few weeks, the average length of patient stay in intensive care dropped by half.

The checklists provided two main benefits, Pronovost observed. First, they helped with memory recall, especially with mundane matters that are easily overlooked in patients undergoing more drastic events. (When you're worrying about what treatment to give a woman who won't stop seizing, it's hard to remember to make sure that the head of her bed is in the right position.) A second effect was to make explicit the minimum, expected steps in complex processes. Pronovost was surprised to discover how often even experienced personnel failed to grasp the importance of certain precautions. In a survey of I.C.U. staff taken before introducing the

> ventilator checklists, he found that half hadn't realized that there was evidence strongly supporting giving ventilated patients antacid medication. Checklists established a higher standard of baseline performance. (Gawande, 2007, pp. 90-91)

By starting with clear process level objectives, and by providing context (healthcare management), and by using a story that applies directly to the objectives, we set the stage for dramatic learning in our students. Notice how the objectives, our context, and the applicability of principles enhance the learning power of this narrative when compared to the previous story of checklist use by B17 pilots. First students will understand why a check list is needed (to control, step, path, and definitional complexity), second they see its applicability to even highly trained service providers, and finally they will see its value in the operating room as well as in mundane tasks.

At this point our students' hearts, minds, and memories have been opened because of our careful preparation; now we need to fill them using bidirectional storytelling. By encouraging our students to tell stories to us and their classmates, we complete the learning process.

## D.5 The Student's Role: Using Bi-Directional Storytelling to Draw Out Applicability and Relevance From the Hearts and Minds of Our Students

### D.5.1 Why Bidirectional Storytelling Is Important

Oftentimes as teachers we put the majority of our effort into preparing what the students will receive from us, and thus consequently we spend very little time considering what our students will do in the classroom (Packer 1996). Steven Covey, one of the most well known management consultants, always teaches the students of his seminars to return home and teach the principles they have learned during the seminar to others because he knows that through the process of teaching the material to others his students will begin to internalize the material. Boje's (1991b) research confirms Covey's approach as it demonstrates storytelling is a vital skill for managers to possess if they want to communicate effectively and generate results. Additionally, research has shown that the act of storytelling itself is a powerful pedagogical tool (Jones, 2001). Like Steven Covey, we want to enhance the teaching power of our storytelling and to do so we need to encourage our students tell us and their classmates stories. In other words, after our stories are told to the students in one direction and their stories come back to us in the opposite direction, we create the dynamic we label bidirectional storytelling.

As our students tell stories, the objectives, context, and application of our original story all become internalized on a level that listening can never reach. Confucius' remark on doing applies here: "I hear and I forget. I see and I remember. I do and I understand" (Confucius, 2009).

Service management has a clear advantage over other OM topics because unlike high-tech manufacturing, supply chain design, project management, or product design, services are something everyone has had experiences with. (This is why one colleague mentioned that the international business trips popular in executive education almost exclusively visit manufacturing sites and rarely visit service sites because everyone has experienced a service.) Thus we can be confident that almost every student will have a story to tell about services as either a service customer or service producer.

We use the following three techniques to draw storytelling out of our students: questioning for large groups, structured sharing for small groups, and small stakes writing for individual work.

**D.5.2 Using the Structure of Questions to Engage Large Groups in Bidirectional Storytelling**

Either directly after the conclusion of the narrative or directly after a summation of the story's main takeaways, the professor should generate large group discussion about the story in the form of three types of interpretation questions: search, analyze, and apply. Solomon, Rosenburg, and Bezdek (1964) were some of the pioneers who proved that teachers who used interpretation questions produced gains in student comprehension (McKeachie & Svinicki, 2006). Interpretation questions engage students on a deeper level. We suggest that this question-asking segment take no longer than 5 or 10 minutes to keep the class flowing smoothly.

D.5.2.1 Search Questions

Search questions ask students to participate in storytelling by asking them to search their memories for stories to share. Search questions help students to connect with the story as they realize their experiences have elements in common to the service processes in the story. Examples of search questions used in teaching the previous story include:

Describe to me a time when you experienced a drastically different level of service from one visit to the next at same venue or drastically different level of service when compared to that of a friend or relative who visited the same venue? - Follow up question: What role did definitional complexity play in the varying service levels?

Tell us of a time when you or a relative were subject to a medical error? – Follow up: Was the error related to one of these three complexities, and could a check list or mistake proofing device have prevented the error?

### D.5.2.2 Analyze Questions

Analyze questions cause students to examine the story itself and confront the actions of its participants by asking why they took the actions they did and what the consequences were. Examples of analyze questions used in teaching the previous story include:

Why did Dr. Provonost have the nurses simply measure the process for the first month of the implementation? – Follow up question: How would creating measurements of results change the service processes where you currently work?

Why was it important for Dr. Provonost to seek the administration's approval for nurses to stop doctors who missed a step in the central line insertion process? - Follow up: Can anyone share with the class an experience where a nurse or other front line employee was in a better position to control quality than higher skilled employees such as doctors?

### D.5.2.3 Apply Questions

Apply questions require students to make connections between the current class material and material taught on previous occasions. As students synthesize the class material, they begin to see how the material connects between class periods and they form new stories in their minds. Examples of apply questions used in teaching the previous story include:

Remembering our previous discussion on the seven forms of waste (Rother & Shook, 1999), what forms of waste did the simple checklist prevent? – Follow up question: Describe a current service process you are a part of and tell us who in that process should be the owner of the checklist and why?

From queuing theory, we learn variability increases the length of time spent in a line. What effect would you expect Dr. Provonost's list to have on ICU's throughput and why? - Follow up question: Describe a situation where you felt you experienced a service script, in your opinion did the service script increase or decrease process throughput?

### D.5.3 Structured Small Group Sharing for Bidirectional Storytelling

Certain students often tend to monopolize conversations in large classroom settings, cutting down on the participation level for large sections of the classroom; having students meet in small groups facilitates participation in storytelling by the entire class. We have found small group breakout sessions increase not only the number who can participate, but also (when they are structured) the quality of the participation. Unless the class is populated by highly motivated executive education students, most students will need structure and a time limit to encourage readiness and to facilitate storytelling.

Our approach consists of telling the student they have 5 to 7 minutes to share stories amongst themselves. The students break into groups of three or four grouped by where they are sitting in the classroom. Next we project questions (similar to the ones asked in the previous section) in the front of the classroom. We ask each student to respond to one of the questions and share experiences with others in the group. We warn students that at the end of the 5- to 7-minute period certain groups will be called upon to share their stories. The time limit, in addition to the thought of sharing stories with the entire class, creates an animated environment of abundant storytelling.

Small group sharing creates the opportunity for the majority of students to share stories and creates an environment that allows students to engage each other and experience dynamic learning.

### D.5.4 Low-Stakes Writing for Bidirectional Storytelling

Low-stakes writing consists of short papers written for the students' benefit and usually not graded (Elbow & Sorcinelli, 2006). We like this third option because it requires all students to participate in the storytelling process. While we usually do not grade these papers for content, often they are graded for submission. Low-stakes writing encourages thoughtful application of the objective principles without exponentially increasing the workload of the professor. Below we provide an example of a low-stakes writing assignment linked to the previous story; notice how we link the search, analyze, and apply questions to the assignment.

Using checklists in hospitals is similar to the science behind standard work at Toyota (Liker, 2004). At Toyota, standard work procedures for each process are so detailed they even describe the order for which bolts are to put into seats (S. Spear & Bowen, 1999). Standard work, which manages step complexity and eliminates path and definitional complexity, is the basis for all quality improvement at Toyota. Describe on one page one service process you were involved in as a provider and one service process you were involved in as a customer that was plagued by one or all of the three complexities (step, path, definitional). Next using the concepts of standard work and checklists detail how using these tools could have been used in these processes to improve their consistency and quality.

### D.5.5 Summary of Bidirectional Storytelling

Bidirectional storytelling derives its importance from its engagement of the students, and not from specific methods we have presented as recommendations. We are not suggesting that every story told in class needs to be followed up by a certain amount of questions, group activities, or writing assignments, but we are highlighting the importance of involving students in the storytelling process to increase their learning and to enliven the classroom environment.

## D.6 Conclusion

In this article, we purposefully do not focus on the delivery of the story itself, but rather on how to make storytelling more powerful, which requires the use objectives, application, and context. We have also demonstrated how to derive objectives from service management typologies using Whetten's (1989) theory building method, and how to then combine those objectives with context and application to open the minds and hearts of students. And finally, we described tools for encouraging students to participate in bidirectional storytelling.

We purposefully embedded storytelling within the text of this article; our objective in doing so was to facilitate the article's teachability. Each story had an objective, which facilitated learning within that section of the article. We encourage you to do the same in your teaching. Use stories to highlight objectives using context and applicability to increase learning.

We have taken two different approaches to increasing the storytelling in our classes, and each approach seems equally effective. One approach consists of finding stories first and then marrying them to objectives. In the search for stories we have found *The Harvard Business Review*, *The Wall Street Journal*, and *Business Week Magazine* to be excellent sources of material, but often our most powerful stories have been personal stories. Students are eager to learn more about their teachers, and by sharing personal experiences with services we humanize ourselves to our students. The second approach starts with objectives, and then moves towards finding stories to accompany the objectives. Objectives of service management are abundant in our literature, and when they seem obscured we recommend using the theory questions posited by Whetten (1988) to draw them out. As long as the objectives and the stories finally merge, we have found it matters little which one is collected first.

The Ute Indians used to choose their best story teller as their chief (Boje 1991a). They valued storytelling as medium for communicating the traditions and knowledge of the tribe; likewise, as we prepare and become more effective storytellers we will also better communicate the traditions and knowledge of the service management sector.

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