Committee Certification of Approved Version

The Dissertation Committee for Richard Fritz Nauert Certifies that this is the approved version of the following dissertation:

TELEHEALTH CONSUMER-PROVIDER INTERACTION: A CHRONIC DISEASE INTERVENTION IN AN UNDERSERVED POPULATION

Committee:

E. Glynn Harmon, Supervisor

Janet Bezner

Helen Cronenberger

James Legler

Jody Rogers

Ronald E. Wyllys

TELEHEALTH CONSUMER-PROVIDER INTERACTION: A CHRONIC DISEASE INTERVENTION IN AN UNDERSERVED POPULATION

by

Richard Fritz Nauert, B.S., M.S.H.F., M.S.H.A.

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Dedication

To my mother, Rita Nauert, and my children, Richard, Mary and Rachel.

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TELEHEALTH CONSUMER-PROVIDER INTERACTION: A CHRONIC DISEASE INTERVENTION IN AN UNDERSERVED POPULATION

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Supervisor: E. Glynn Harmon

The purpose of this study was to evaluate the efficacy of home-based telehealth intervention for the management of diabetes mellitus. The research targets an underserved, predominantly Hispanic population in Laredo, Texas and surrounding counties. Telehealth allows diabetic care management to be delivered to individuals who are not receiving home-based follow-up. The daily transfer of clinical information and provision of health behavioral training to diabetics, *within the home*, serves as a catalyst for health improvement and long-term behavioral change. As a patient-centered sphere of influence develops, positive health behaviors increase, quality of life improves, and utilization of medical resources declines.

Test participants (*n* = 133) received a home device while controls (*n* = 71) did not. Data from participant records were retrospectively analyzed to assess the initial, 18-month usage impact of the telecommunication-augmented device on individual diabetic health status. Participants' HbA1c levels and frequency of outpatient, inpatient, and emergency clinic utilization were compared to pre-group activity. The objective was to determine (a) if this new communication device intervention resulted in improved health, as measured by HbA1c diabetic test values, and (b) if it served to cut costs through decreased resource utilization.

Findings displayed by the test group included a mean 21% reduction in HbA1c values and a 49% reduction of total charges. The percentage of test subjects seeking care declined by 38% for inpatient services, and by 13% for outpatient care. Total encounters, or episodes of care, were reduced by 31% for the test cohort with inpatient encounters dropping by 46% and outpatient encounters declining by 25%.

Conclusion: A contribution of this study is the evaluation of a new healthcare delivery method as applied to an underserved, predominantly Hispanic population (>99%) living with chronic disease. Although this new form of provider-patient relationship might never replace the traditional office visit, telehealth can be found to improve health and decrease outpatient and inpatient utilization. The benefits of this form of intervention are sufficiently promising to support extended implementation. Virtual healthcare as a supplement to traditional, face-to-face medical encounters continues to be a relatively new but potentially groundbreaking area of research.

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CHAPTER ONE: INTRODUCTION

STATUS OF AMERICAN HEALTHCARE

As the 21^{st} century commences, the American health delivery system finds itself in a mire of contention. Healthcare in the United States, an asset the nation proudly values as a world leader, faces a mounting crisis. Expensive medical, technological, pharmaceutical, and genetic advances collide against an acknowledged scarcity of resources (Aaron, 2002). An aging population, coupled with a view of healthcare as an entitlement, threatens failure of the current system (Altman & Levitt, 2002). Healthcare expenditures were $1.2 trillion in 1999 with spending growth projected to average 7.2% for 1998–2010 and reach a 15.9% share of gross domestic product (GDP) by 2010 (Heffler, Levit, Smith, Smith, Cowan, Lazenby, & Freeland, 2001). No country in the history of the world has ever allocated so much of its economic activity to healthcare. The trend is foreboding as a large population of Baby Boomers advance in age and healthcare utilization increases dramatically.

Recent efforts to reform the healthcare industry have attempted to improve supply-side efficiency of care delivery rather than to address the root cause for demand (Fries, Koop, Sokolov, Beadle, & Wright, 1998). This focus is now under review as half of all causes of mortality in the United States are linked to lifestyle choices including smoking, diet, alcohol use, sedentary lifestyle, and accidents (McGinnis & Forage, 1993). Individual responsibility for one's own health and well-being is a critical prerequisite for the redirection of healthcare. A consumer-centered paradigm stressing health promotion, even among those with a chronic disease, needs to replace the traditional provider-centered, illness-focused system. Reduction of risk behaviors and delivery of efficient medical intervention are key components for improving the nation's health and lowering healthcare costs in the new century (Institute of Medicine, 2000).

The task is daunting, as indicated by preliminary efforts to promote prevention and wellness (Glanz, Lewis, & Rimer, 1997). In acknowledging the dynamic and eclectic role of health education and promotion, Glanz et al.(1997) commended the improvements over the past two decades toward public, private, and professional awareness of the value of health promotion and disease prevention, yet reflected that "much work remains to be done in these areas" (Glanz et al., p. 5). Indeed, levels of obesity are reaching epidemic proportions, some forms of infectious disease are increasing (for example, tuberculosis), new infectious diseases such as antibody resistant infections and HIV and AIDS are emerging, and chronic diseases, especially diabetes mellitus, threaten to overwhelm the system. However, success has been demonstrated in some areas. The use of tobacco products is declining, blood pressure control is improving, and mean population blood cholesterol levels are decreasing (Glanz et al, 1997.).

Despite the known benefits of exercise and physical activity, only 15% of adults participate in regular vigorous physical activity (U.S. Department of Health and Human Services, 1996). Primary care physicians (PCPs) face many obstacles in their quest to educate and advise patients on performance of physical activity. Barriers include limited time, the perceived ineffectiveness of counseling, the lack of an appropriate measure of physical activity, and the failure of the current system to appropriately reimburse the physicians for their efforts (Wee, 2001).

Effecting health behavioral change has proved to be a difficult task. Over the past two decades, the challenges and complexities associated with achieving behavioral change have resulted in an expansion of the theoretical constructs guiding intervention efforts (Glanz et al., 1997). Contemporary approaches extend beyond episodic or singular domains, spreading the focus to incorporate a multidimensional perception of health. Indeed, an indicator of actual health today is perceived as wellness, which is posited to include physical, social, spiritual, psychological, intellectual and emotional domains (Adams, Bezner, & Steinhardt, 1997).

A setting where health promotion has been successful, although hindered by limited outcome measures, is worksite intervention. Such programs, launched by many large corporations, acknowledge the large proportion of time an individual spends at work. These corporation managers recognize the value of preventive efforts including the role of stress reduction and social support (resiliency training). Common goals of these interventions are increased worker productivity and decreased healthcare expenditures. The value of wellness and health promotion has been documented. For example, in a recent long-term study of a corporate health and wellness program, significant reductions in medical care expenditures were demonstrated over a 4-year period (Ozminkowski, Ling, Goetzel, Bruno, Rutter, Isaac, & Wang, 2002).

A new direction for healthcare delivery redirects managed care efforts from limiting population-wide overutilization of services to a focus that promotes *effective utilization*. This emerging perspective acknowledges the disproportional expense in caring for the very sick. Berk and Monheit (2001) suggested any effort to control costs must focus on the very ill, that is, those receiving large amounts of care. Bringewatt (1998) discovered that chronic conditions, which affect 100 million Americans, incur 70% of all medical costs and result in $500 billion a year in expenses. Remarkably, despite managed care initiatives, proportionate resource utilization has remained stable over the past 30 years. In 1996 the top one percent of the population comprised 26% of aggregate expenditures, an increase of only one percent from 1970 (Berk & Monheit). Furthermore, in 1996 the top five percent of the population attributed to 55% of all healthcare expenditures, as compared to 1970, when the same fraction contributed 50% of the cost (Berk & Monheit).

Parsimonious use of the healthcare dollar begins with early mitigation of a disease process or, even better, prevention of a disease. A recent landmark study funded by the National Institute of Diabetes and Digestive and Kidney Disease (NIDDK, 2001) demonstrated the effectiveness of incorporating moderate exercise and changes in diet to reduce the chance of developing diabetes for those most at risk (individuals with a prediabetic condition of glucose intolerance). This major clinical investigation (3,234 study participants at 27 centers) showed that intensive lifestyle training, including a low-fat diet and exercising for 150 minutes a week, could reduce the risk of developing Type 2 diabetes by 58%. Lifestyle training was judged to be almost twice as effective, as a comparative drug intervention in reducing the risk of diabetes (NIDDK). Strategies incorporating lifestyle changes, including diet and exercise, are critical for improving the health of all individuals and provide a glimmer of hope as society grapples with delivery and funding of healthcare in the new century.

Many believe economic proscriptions will significantly alter the delivery and provision of health services within the next two decades. Over half a century ago, economist Joseph Schumpter (1934) coined the phrase "creative destruction" to describe how market forces and respondent innovation drive capitalism and industrial evolution. Unmistakably, the healthcare "battleship" has started to turn, with technologic innovation steering or contributing to mutation of the traditional healthcare paradigm.

This interdisciplinary investigation combines the above approaches and seeks to determine the benefits of technological developments that recreate traditional information brokerage related to health improvement and effective resource utilization. Telecommunication channels expand the "contact zone" between providers and patients by enhancing two-way information flow. Access to the information allows timely clinical intervention, thereby improving the effectiveness of healthcare services. Moreover, the new communication ubiquity may revolutionize the delivery and subsequent effectiveness of heath promotion. For instance, cost-efficient daily instruction and reinforcement of appropriate health behaviors can be delivered to the home environment. The frequency and setting of the information delivery may prove to be the catalyst for effecting long-term behavioral change.

This first chapter contains background information and describes the problem to be investigated. Chapter Two includes a review of current literature related to physician information needs, clinical problem solving, and the integration of telehealth to satisfy and to improve these processes. Models are presented to demonstrate how information is used and how telehealth can satisfy clinical needs. Chapter Three entails a literature review of health promotion efforts including theoretical foundations as applied to new forms of telehealth intervention. A paradigm shift toward a patient-centered healthcare focus facilitated by telehealth is explored along with a discussion of future possibilities. Chapter Four explains the methods that were used to compile and analyze the data. Chapter Five describes the results of the research effort. Finally, Chapter Six discusses the findings as they relate to clinical and cost-savings outcomes and presents recommendations for current and future practice and research.

Rationale

A paternalistic physician-patient relationship has been sanctified for over 2,000 years. In the 20th century, medical knowledge has grown exponentially producing a greater knowledge-information gap between physicians and patients. The reliance on the physician provider to "know all" and to "cure all," authenticated by a reimbursement system for this behavior, has resulted in a decline of self-directed health responsibility and, perhaps not coincidentally, an ignorance of the cost associated with the delivery of health services.

The new century will focus on changing this provider centric relationship to a patient-centered focus, from paternalism to a mutuality, encouraging a bond whereby patients are empowered to take responsibility for their own well-being (Herzlinger, 1997; McKinney, 1989). Indeed, some observers posit that socioeconomic pressure will reverse the traditional physician-patient relationship to a consumer orientation. Thus the "power" of the patient, the consumer, will outweigh that of the physician (Herzlinger, 1997; Lutz, 2000). Ideally, mutuality between provider and patient will result in a sharing of responsibility, wherein patient autonomy is enhanced and provider expertise is acknowledged.

The setting for this investigation is Laredo, Texas and surrounding counties. The Laredo area demonstrates the highest morbidity and mortality rates associated with diabetes in the state. Environmental and lifestyle factors undeniably play a significant role in the emerging epidemic. Furthermore, cultural factors may explain the present difficulties in performing and achieving lifestyle adjustments and medication compliance. A recent policy-tracking report from the Center for Studying Health System Change (HSC) for the period 1997–2001 found Latinos, the majority population in this investigative area, continue to have less access to medical care than White Americans (Hargraves, 2002). The report has showed that fewer Latinos had regular healthcare providers, access to specialist declined, and that more of their healthcare visits, as compared to Whites, occurred in emergency rooms (Hargraves).

Telehealth is broadly defined as the use of information technology to improve the delivery and promotion of healthcare. In this study, telecommunications and the Internet provide a revolutionary information channel to fulfill specific health and medical needs for both consumers and providers. Specifically, this Laredo study incorporates two distinctive yet interrelated areas of telehealth: (a) telehealth as a means to improve physician and provider information needs, problem solving, and communication; and (b) telehealth as an intervention vehicle to deliver broad-based health behavioral modification strategies. Emerging telehealth applications may erase traditional constraints of timeliness and cost efficiency on clinical information transfer and health education promotion.

Relationships between the provider and patient can now develop within the framework of everyday life. If individuals encounter difficulty complying with diet, exercise, and medication prescriptions, opportune intervention might mitigate, or even avoid, a medical crisis. Daily reinforcement and education for health-enhancing behaviors improve knowledge and confidence, furthering self-management skills for individuals with chronic diseases. This investigation presents data that shows that as a patient-centered sphere of influence develops, positive health behaviors increase, quality of life improves, and utilization of medical resources declines.

Purpose

The fulfillment of patient and provider information needs by a telecommunicative channel could improve health and decrease medical utilization. Timely intervention should result in a shift of care away from crisis-based, episodic occurrences. The new vision of healthcare reassigns responsibility for health maintenance from a dependency on providers to a self-directed focus. In this new vision, health autonomy is encouraged, accompanied by oversight and support from a consultative medical community. The transfer of conscientiousness from a provider-centered "take care of me" philosophy to a self-directed acceptance of responsibility is expected to improve individual health and ultimately decrease resource utilization.

Telehealth allows diabetes care management to be delivered to individuals who were not otherwise receiving it (Shea et al., 2002). The expanded volume of patients who can be managed and who can receive timely intervention in the form of clinical or behavioral direction is the salient characteristic or prospect of emerging information technology. This low-cost information channel via normal telephone lines allows coordinated, widespread intervention to targeted individuals. The distribution of health information, delivered to the end-user setting (the home and daily routine of individuals), can cultivate behavioral changes such as improved compliance with medications, diet, and exercise guidelines. Such connectivity can provide a sense of support, resulting in a more fulfilling and satisfying relationship between an individual and the healthcare system. Moreover, self-empowerment improves the perception of mental and physical health status, thereby enhancing quality of life.

This new delivery method and philosophy was evaluated in an underserved, predominantly Hispanic population (>99%) living with chronic disease. The goals of this study are to apply telehealth communications to improve clinical outcomes and decrease hospital-based resource utilization for Mexican Americans diagnosed with diabetes. Objectives include improved health and reduced resource consumption from inpatient and emergency room settings. Improvement of individual health and the reduction of high-cost services were monitored.

The telecommunication-augmented intervention in this study allows daily transfer of clinical information and health behavioral training to diabetics within their home. The multidisciplinary approach included several areas of research, including information science (concerning clinical information needs of consumers and providers), cognitive behavioral theories (for health behavioral modification), health administration, and telecommunications. Study goals reflect health administration and health policy issues regarding service deficits for this population and a disproportionately high healthcare expenditure. By examining the healthcare service deficits for this sample population, specific health policy issues centering on intervention and healthcare expenditures can be addressed.

Background and Significance

Many healthcare providers face a moral and ethical quandary when providing care to underinsured and underserved patients suffering from chronic disease. The rising cost of care to manage this population threatens to strip community, state and federal resources. A new paradigm emerges: health promotion as an intervention to effect behavioral change, to increase self-directed care, and thereby to decrease medical utilization. Improved health outcomes, at a lower cost, is a mantra forced upon the healthcare industry and one objective addressed, at least in part, by telecommunications and information technologies. The intervention in this study seeks to improve the health of individuals diagnosed with and receiving care for diabetes. As the patient participants are 99% Hispanic, and indigent, the investigation provides insight as to the benefit of this form of intervention on this underserved, defined population segment. Diabetes mellitus (DM) is a chronic disease condition that is currently stressing the American healthcare system. The American Diabetes Association reports 16 million Americans have diabetes. Diabetes is a leading cause of blindness, kidney failure, and amputations, and it dramatically raises the risk of heart attacks. Diabetes annually kills about 180,000 Americans. The disease is increasing rapidly, rising 33% among American adults from 1990 to 1996. A 2001 study by the Centers for Disease Control (CDC) reported that the diabetes rate climbed another 6% among adults in 1999. The use, cost, and intensity of resources are substantially higher for individuals with diabetes than for people without the disease. Annually, an estimated $44 billion in direct medical and treatment costs, and $54 billion for indirect costs attributed to disability and mortality are spent on diabetic care (Laditka, Mastanduno, & Laditka, 2001). The CDC (2001) study warned that the unfolding epidemic of diabetes will "overwhelm the nation's healthcare costs if the trends continue."

A promising method to manage these expenditures is the concept of disease management, a holistic extension of traditional, hospital-based utilization management, which seeks to contain costs by decreasing inpatient lengths of stay or costs (Sherer, 2000). Strategically, this method mimics the Pareto principle, focusing on the 20% of patients who create 80% of the healthcare costs (Disease management, 2000). The approach coordinates care through integration of components across the entire delivery system, including the application of appropriate tools (e.g., guidelines, protocols, information systems) specifically designed for the disease (Institute of Medicine, 2001). Traditional disease management programs assign registered nurses to individual patients diagnosed with a long-term illness. The nurses then coordinate the care for individuals, providing oversight to eliminate procedural or access difficulties throughout the spectrum of care (hospital, outpatient, rehabilitation, social services, etc).

Although the concept of disease management via the route described above has merit, the dearth of registered nurses and the inadequacy of existing communication technology (telephony) to deliver the appropriate intensity of care have combined to limit implementation (Joch, 2000). New technology (telecommunication channels in conjunction with the Internet) provides a vehicle for information transfer of unprecedented intensity and frequency. Rule-based software consolidates and stratifies information according to algorithmic formulas that provide for management of an increased number of clients. The capability to aggregate patients with common disease patterns is a significant attribute of the new information connectivity. This aggregation can result in enhanced productivity and minimized staffing burdens.

For clients with DM, reductions in medical utilization occur by means of two primary mechanisms. First, the care manager monitors the patient's physiological and metabolic parameters and symptoms (e.g., blood glucose; insulin; reports of kidney, eye, or foot problems) and notifies the patient and the patient's physician of any abnormality. Consequently, any necessary intervention occurs before the condition exacerbates. Second, the delivery of daily education reinforces knowledge and understanding of the disease by educating and providing feedback on health-enhancing lifestyle behaviors.

Use of information technology over normally available communication lines presents a cost-effective method to improve patient outcomes for patients with a chronic disease. The new delivery model advances the effectiveness of health education and intervention by changing the focus and responsibility of health maintenance from provider-centered care to self-care.

Health and lifestyle behavioral modification is a foundation for reducing medical resource consumption by diabetics (Collins & Anderson, 1995; Franz, et al. 1995; Kaplan, Hartwell, Wilson, & Wallace, 1987). Repetitive training is essential to the development and incorporation of self-management skills into an everyday routine. Comprehensive education instills patient self-efficacy, the knowledge of the benefits of salutary health behaviors and the conviction that one can perform the desired behaviors. A Web-based connection provides ongoing reinforcement of appropriate behaviors, including insulin administration, compliance with medication regimens, performance of prescribed exercise programs, and adherence to dietary guidelines.

Improved compliance with the medical care plan provides short-term benefits of enhanced functional status. Conformity with the prescribed plan also mitigates or prevents complications associated with the cumulative effects of the disease, including blindness, kidney disease, heart disease, stroke, nerve disease, amputations, and impotence (American Diabetes Society, 1995; Diabetes Control and Complications Trial Research Group, 1993). Providing chronically ill patients with personal self-care skills improves the health of the patient and reduces long-term health utilization. In short, behavioral change, knowledge building, and symptom monitoring all play a key role in optimizing medical management of DM.

The delivery of online health information to underserved individuals suffering from DM is the foundation for this investigation. Typically, the medical plan of care for people with chronic illness is complex, since co-morbidities necessitate intervention from multiple medical specialties. Commonly, although instructions on home care are provided to the individual at the time of treatment or discharge from an institution, the care plan may lack provision for coordination among the various medical specialties. Patient or individual compliance with the program is often poor, and typically involves delayed recognition of complications associated with a chronic illness (Brown, 1999; Cerkoney & Hart, 1980; Rosenstock, 1985). The fulfillment of patient and provider information needs is a foundation for disease management. Effective information transfer furthers coordination of the care plan. Timely intervention enhances self-care and self-management skills for coping with the disease, and reinforces lifestyle adjustments within the home environment.

In this study, the manager assumes more responsibility than mere coordination of care. The manager oversees the medical care plan, monitoring adherence to the prescribed medical regimen for medications, diet, and exercise. The investigation seeks to determine if documentation and review of daily blood sugar levels and insulin dosage facilitates timely intervention, thereby reducing medical resource consumption. Furthermore, if appropriate lifestyle modifications are adopted, can the cost and burden of care be reduced? Integral to the disease management paradigm is a transfer of healthcare responsibility from the provider to the individual.

In many geographic regions, the escalation of chronic illness is approaching epidemic proportions. One geographic region reflecting this dangerous trend is the study area, the three counties including and surrounding the city of Laredo, Texas: Jim Hogg, Webb, and Zapata. Laredo is one of the fastest growing cities in the United States (>100,000 population). Ninety-three percent of the residents are Hispanic, with one in three families living at or below the poverty level. Access to healthcare is poor, with a physician-patient ratio ranking well below the national average.

Medical management of underserved individuals who suffer from a chronic illness has traditionally been hospital-based and episodic. Mercy Regional Medical Center, the host site for the study, identified diabetic patients as one of the highest cost and highest medical resource consumers of the system. Poor compliance with prescribed medical regimens commonly exacerbates the need for provider intervention. Frequently, the medical encounter occurs in a high-cost location such as an emergency room, urgent care, or inpatient hospital setting. Typically, providers and patients lack information, which delays intervention, impedes clinical effectiveness, and suppresses patient awareness and appreciation of the disease state. This study investigates an unexplored approach to healthcare assessment and delivery using a new telecommunication technology to fulfill unmet information needs.

Historically, many behavioral interventions have failed to alter high-risk lifestyles (Institute of Medicine, 2000). Promising research on behavioral change has suggested a move beyond the provider-centric medical model to a broad-based, consumer orientation. Bandura's social cognitive theory first described a multidisciplinary, individually centered approach as it addressed the dynamic and interactive influence of biology, behavior, and the environment (Bandura, 1986;

Baranowski, Perry, & Parcel 1997). A contemporary model incorporating and expanding these multifaceted components for effecting behavioral change is the ecological approach (Satariano, 2001).

When examining the ecological approach, questions may arise about the utility of this diverse intervention. Specifically, is the multidisciplinary and individually centered approach effective? Also, in the medical arena, how can a broad-based model be delivered? One answer is use of information technology. Indeed, with the advancement of technology, it may now be possible to use telecommunications to support health behavioral modification.

Although the advancement of information technology in most economic sectors has been rapid, the information intensive healthcare industry has been relatively slow to utilize electronic channels for clinical care (Goldsmith, 2000). Indeed, information technologies have not always significantly enhanced healthcare efficiency, productivity, or effectiveness (Moore, 1996). Myriad factors have contributed to slow diffusion and ineffective application, including the complexity of the healthcare environment, legal and privacy constraints, expensive legacy (pre-existing) information systems, and, perhaps the most important factor, the absence of market pressure to bring about industrial change (Kleinke, 1998). However, the tide has changed during the past decade, owing to the widespread use of technology, with the industry now desperately looking for solutions to enhance efficiency and effectiveness.

Emerging communication technologies provide new platforms to promote change in the financially ailing healthcare industry. Particularly, the ubiquity of the Internet offers a means and method by which to economically deliver healthcare information. This study evaluates the effectiveness of new consumer-provider telecommunication interaction to manage and improve the health status of individuals diagnosed with specific chronic diseases. In this study, consumer and provider use patterns will be investigated in the most costly segment of the health industry, the management of individuals with chronic illness. Specifically, the researcher investigated the efficacy of online information utilization for medical management of patients, including instruction in self-management skills and the assessment of subsequent performance. The population studied consists of underserved individuals in South Texas diagnosed with diabetes mellitus (DM). Medical markers and mitigation of resource utilization, benchmarks for this telecommunication application, assess improved health.

Telehealth can offer a new means to revive or revamp the healthcare industry. Internet-facilitated intervention provides a one-to-many communication channel between a provider and targeted populations. Daily communication delivered through the new medium can potentially transform health education and health behavior. A self-management strategy, applied to a population with chronic illness, has the potential to redirect the focus of care from episodic, provider-centered intervention to individual or consumer-centered acceptance of health responsibility. Unlike many medical interventions, the goal is not to eliminate or eradicate the illness, which is a chronic condition, but rather to learn effective self-management techniques to improve health and ensure appropriate utilization of community-based medical resources.

This investigation draws its data from records kept by the Mercy Health System in Laredo, Texas during the system's 1999–2001 attempt to decrease resource utilization among diabetic patients in the Laredo area and to improve their health. The effectiveness of Web-based disease management intervention for Mercy Health System patients diagnosed with DM forms the basis for this study. The investigation by Mercy Health System, in collaboration with The University of Texas Health Science Center San Antonio (UTHSCSA), aimed to improve the health status of indigent border residents. This dissertation research contributes to the ongoing Mercy and UTHSCSA study for the period from January 1, 2000 to June 30, 2001 primarily through a retrospective analysis of collected resource utilization and patient data. The dissertation is thus the major evaluation tool of the Mercy Health System and UTHSCSA study for the specified time period.

The goals of this study are to improve patient clinical outcomes and to decrease hospital-based resource utilization especially associated with high-cost settings (emergency room and inpatient facility) for the diabetic test population. Improved clinical patient outcomes can be assessed through changes in a standard diabetic health status marker (HbA1c marker). Resource utilization may be mitigated by reducing the absolute number of individuals who receive care from a particular setting or by reducing the number of encounters or episodes of care delivered from the setting. The intensity or cost of care is reduced when individuals receive timely medical attention before a condition exacerbates. Early intervention decreases overall resource consumption by minimizing the duration of the encounter (e.g., length of stay if an inpatient) and the resource burden of the encounter (the cost of care delivery) for the admitting diagnosis.

Research Questions

The rich and varied data sets generated in this study were best analyzed by a variety of techniques. Much of the information was examined by looking at and summarizing averages and percentages. In addition to the descriptions, *t* tests, *z* tests of proportions, descriptive tables, means, percents, ordinary least squares regression (OLS), and multivariate repeated measures analysis of variance (ANOVA) were also used to describe the data.

The following research questions were addressed:

1. Does analysis of the HbA1c medical marker reveal the existence of significant differences among the participants receiving the intervention and those not receiving the intervention (test and control groups) ($p <= .05$)?

2. Is aggregate health service consumption, in the form of individual utilization, encounters per year, and charge per individual, significantly different between test and control groups ($p <= .05$)?

3. Do emergency room, inpatient, and outpatient facilities present a significant difference (p <= .05) between test and control groups for:

a. the number of individuals who sought care,

b. the number of encounters per individual, and

c. the charge per individual?

4. Is inpatient utilization, as measured by length of stay (LOS), significantly different between test and control groups (p <= .05)?

Definition of Terms

The National Institute of Diabetes & Digestive & Kidney Diseases (NIDDK) describes *diabetes mellitus (DM)* as a disease in which the main source of fuel for the body, blood glucose, is not transferred or used appropriately. Glucose, a form of sugar in the blood, is created when the food we eat is digested. *Insulin*, a hormone created by the pancreas, serves as a transfer agent transporting blood glucose into the body’s cells thereby providing the necessary fuel required to support life. Although the cause of diabetes is not completely understood, both genetics and environmental factors such as obesity and lack of exercise appear to play key roles in the development of the disease. Diabetes is a leading cause of blindness, kidney failure and amputations, and it dramatically raises the risk of heart attacks. Diabetes is a chronic disease that has no cure.

The institute discusses two main types of diabetes, *insulin dependent diabetes mellitus (IDDM)* or *Type 1 diabetes*, an autoimmune disease characterized by the body's failure to produce insulin, and *noninsulin dependent diabetes (NIDDM*) or *Type 2 diabetes*, where for unknown reasons, the body cannot use the insulin effectively. For individuals diagnosed with NIDDM, the insulin resistance is eventually accompanied by a decrease of insulin production, resulting in a buildup of blood glucose similar to Type 1 diabetes.

IDDM (Type 1) may develop at any age, although children and young adults are the most frequent group to have this form of the disease. NIDDM (Type 2) is the most common form of the disease, and usually occurs after age 40. NIDDK reports that about 80% of people with Type 2 are overweight. This type of diabetes is often a part of a metabolic syndrome that includes obesity, elevated blood pressure, and high levels of blood lipids. Sadly, as the number of overweight children increase, Type 2 diabetes is becoming more common in young people.

Significant for the state of Texas is the fact that the leading population growth sectors, Hispanics and African Americans, are especially prone to the disease. Currently, 7.1% (277,368) of all Hispanics and 7.8% (120,288) of all African Americans in Texas have the disease, although the pervasive nature of the disease typically results in an understatement of the actual number of individuals with diabetes. Often, Type 2 diabetes can be controlled through losing weight and improving nutrition and exercise, but many people need oral medications or insulin to maintain glycemic control. Many individuals display early warning signs of diabetes (e.g., elevated glucose intolerance) and could prevent or postpone the development of the disease through a healthcare plan consisting of appropriate nutrition or diet and exercise (NIDDK, 2001).

Physiological and metabolic measures include blood sugar measurements, insulin dosage, the HbA1c blood marker for blood sugar control, body weight, foot complications, and eye problems.

Outcome management is a system that measures patient outcomes over time using functional status and well-being evaluations as well as traditional physiological indicators (Elwood, 1988). An outcome system typically has five important features. First, health-related, quality-of-life outcomes are emphasized. Second, data collection is part of ongoing operations, not an isolated research study. Third, follow-up measurements of health status are performed after an intervention period. Fourth, the results are reported regularly to those responsible for the patient's care plan. Fifth, reporting is done with the goal of improving practice (Tilly, Belton, & McLachlan, 1995).

Telehealth is the use of information technology to improve the delivery and promotion of healthcare. Telehealth promises to provide a partial solution to improving safety, effectiveness, patient centrality, timeliness, efficiency, and social equity of healthcare provision (Institute of Medicine, 2001).

HbA1c or *glycosolated hemoglobin* is a blood marker that reveals glycemic control over time. Tight control can delay, prevent, or even reverse most microvascular complications. Most diabetic complications are because of long-standing, poorly controlled hyperglycemia. The goal of most therapy is to lower HbA1c while avoiding hypoglycemia (Merck Manual Online).

Encounter describes the entry into the healthcare system and subsequent care for services relating to a specific admitting diagnosis. A unique account number is assigned including a matched diagnostic code per the International Classification of Diseases, 9th revision, Clinical Modification (ICD-9-CM) describing the medical condition attributed to the intervention. The encounter account number tags the episode of care (EOC). The EOC may be a single visit or may include multiple days of hospitalization for the admitting diagnosis. An individual may have several encounters over the course of a year.

Medical Record Number (MR#) is the unique identifier assigned an individual upon receipt of healthcare services from the hospital system. The number is maintained over the life of the individual and is used in this study to depict individual utilization.

Total charges is the charge incurred by the healthcare system for the deliver of medical services. In this study the charges are viewed in aggregate, then segregated into silos reflecting the origin of the medical intervention (i.e., inpatient, outpatient, emergency room).

Charge per encounter is the charge per encounter, either as aggregate or facility specific.

Encounters per individual is the number of encounters per individual, either as aggregate or facility specific.

Charge per individual is the charge per individual, either as aggregate or facility specific.

Length of stay (LOS) is the aggregate number of days an individual is hospitalized (i.e., receives care from an inpatient setting).

CHAPTER TWO: LITERATURE REVIEW

TELEHEALTH AND PROVIDER-CENTERED MANAGEMENT

The purpose of this study was to investigate if a telehealth intervention could decrease hospital-based utilization and improve clinical outcomes for individuals with diabetes mellitus. This study illuminates the efficacy of a new form of healthcare delivery for an underserved, underfunded, predominantly Hispanic population.

In this chapter, healthcare providers' information needs are described and the way in which emerging telehealth applications can provide new solutions for improving clinical care for individuals with a chronic disease is presented.

Telemedicine Overview

Some researchers suggest that rudimentary telecommunications (telephone-based) have contributed positively to healthcare delivery for over a century (Hallam, 1989). However, the use of more advanced information technology to provide medical information and service began in the 1950s.

During this decade, interactive television provided a channel for psychiatric consultations between a state mental hospital and the Nebraska Psychiatric Institute, and also for the delivery of medical care to the Papago Indian Reservation in Arizona (Huston & Huston, 2000).

Historically, telemedicine has demonstrated apparent clinical effectiveness and cost benefits for only select settings and for specialized populations. Four particular applications have been associated with cost-effectiveness: tele-radiology, telepsychiatry, tele-home care, and tele-prison care (Allen, 1998). However, Allen commented on the failure of a majority of telemedicine studies to utilize a formal cost-effectiveness research methodology, with economic costs compared to a clinical outcome such as "years of life gained." He argued that economic reviews have been framed from the viewpoint of the organization or entity performing the analysis (e.g., third-party payer, patients, providers, or society) and, consequently, provides equivocal opinion (Allen, 1998).

Nevertheless, as higher speed communication links become more common and less costly, and as specialized hardware and software move to the desktop platform, utilization of the Internet for clinical telemedicine becomes an affordable, global vehicle. Indeed, many believe the world is in the midst of a communication revolution rivaling or even surpassing telephonic transfer of information developed over a century ago. For some business sectors, given exploding information needs and escalating resource scarcity, new communication modalities are arriving just in time. Cimino (1997) suggested that the impact of the Internet is analogous to a description of atomic energy made by

Harry Truman a half century ago: "a new force too revolutionary to consider in the framework of old ideas" (p. 281). Cimino elaborated that although the Internet may support conventional tasks, it also offers, for those with sufficient insight, methods to carry out entirely new tasks. Indeed, the link and subsequent connectivity to a vast majority of the population is now available over existing telecommunication lines using either touch-tone phones or home-based computers. This revolutionary development promises a new means by which providers obtain real-time, or close to real-time, clinical data stimulating timely and appropriate intervention.

The enormous success and spread of the Internet promises to fulfill unmet clinical needs. A broader term, and a descriptor appropriate for the entire gamut of telecommunication services, is *telehealth*. Telehealth incorporates clinical diagnosis and treatment, electronic medical records, clinical and administrative information systems, Web-based consumer information sites, video teleconferencing, interactive television, provider decision support, and artificial intelligence (Networking Health, 2000).

One area of promising telehealth application combines clinical care and health education for management of individuals with a chronic disease (Huston & Huston, 2000; Sandberg, 2000; Tieman, 2000). Although the impact of telehealth to augment information flow is perceived to be significant, telehealth does not redefine clinical problem solving nor is it a new medical diagnostic or therapeutic procedure, rather a method of delivery. Telecommunicative information sharing and knowledge transfer is becoming more utilized as an aspect of the care process of individuals with chronic diseases. Shea et al. (2002) eloquently articulated a vision where current and emerging technologies "will alter not only the way care is delivered, but also what care is delivered, and that these two changes will occur in tight linkage" (p.91).

A key component of the federal Department of Health and Human Services Strategic Plan is use of communication technology to provide broad-based improvements in the health and economic well being of individuals, families, and communities (U.S. Department of Health and Human Services, 1996). Additionally, in an age of information, National and Global Information Infrastructure Initiatives endeavor to advance medicine and public health on a global basis. Information technology is viewed as a means to improve access to care for underserved individuals. These individuals face social and economic barriers in their quest for healthcare and, consequently, often suffer from compromised health status and limited quality of life.

The use of technology to augment patient-physician interactions has increased in the last decade (Revere & Dunbar, 2001). As healthcare reform encourages economy and efficiency, the provision of care is shifting toward delivery of care in ambulatory settings and by interaction with the patient directly at home. Telehealth services and information systems augment and support this shift by providing a natural fit toward establishing the necessary communication links (Greenes & Lorenzi, 1998).

Indeed, telehealth could provide a method to mitigate the "knowledge-performance gap" commonly observed in clinical practice (Elson, Faughnan, &

Connelly, 1997). For example, telehealth might offer a solution to a potential decline in quality of care brought upon by managed care limitations on the number of visits and amount of time a physician is able to spend with a patient (Elson et al.). In an inventory management model, described as a "just-in-time" strategy, consolidated patient data such as lab tests, x-rays, and consultant reports, are anticipated and provided to the physician at the time of the examination (Elson et al.). Supplying the physician with this timely information could improve the quality of care while reducing the number of office visits and expense.

Provider-Centered Health Manager

An understanding of physicians' needs, tasks, and behavior is an essential step toward development of innovative solutions to enhance clinical decision-making. The purpose of this study was to investigate if new communication channels improve clinical outcomes and reduce resource utilization in high-cost healthcare settings. The study examines how a new means of information transfer, characterized by unprecedented frequency and timeliness, impacts clinical care and patient self-management.

In this section a review of the literature begins with an overview of how telecommunication has augmented clinical care in the past, and how clinical decision making may be enhanced in the future. The types of information used by clinicians, the information needs of the physician or healthcare provider, how physicians prefer to acquire information, and then how they use the information for day-to-day activities are important considerations for assessing the relevance and practicality of new communication channels.

Two models of physician behavior are reviewed below. The first model profiles physician behavior as being influenced by the environment or work setting, the particular work role or task involved, the sources of information utilized, and the characteristics of the information. The second clinical model provides a structural description of how information is used to determine a medical diagnosis and to conduct subsequent clinical care.

INFORMATION NEEDS

The topic of information use has been studied for over 40 years. The field of information science formally began in the early 1960s and included a number of studies on information needs and uses, particularly in science and technology. Studies generally focused on the way scientists and engineers use information systems. "User-studies" were performed in an effort to identify methods by which existing systems could be improved and to gain insight about organizational behavior. Investigations targeted providers, consumers, and the interaction between providers and consumers/patients. Researchers discovered the environment of information use and the particular task or problem addressed influenced the need for and use of information (Leckie, Pettigrew, & Sylvain, 1996; Taylor, 1991).

Information needs, uses, and behaviors of healthcare professionals have received considerable investigation. Historically, the volume and disparate nature of data, and failure of system designs to conform to the end-user needs, has confounded effective and efficient use of information (Allen 1969; Patel & Kaufman, 1998; Smith 1996). Medical informatics emerged largely as a discipline for the management of unique data sets relevant to clinical information needs and uses. Greenes and Shortliffe (1990) defined medical informatics as

> the field that is concerned with the cognitive, information processing, and communication tasks of medical practice, education, and research including the information science and the technology to support these tasks. (p. 1114)

The study of physician information-seeking behaviors has greatly exceeded that of any other healthcare group (Leckie et al., 1996). Physicians' use of various information sources has been found to be related to such factors as their type of practice, specialty, location of practice, age, and the size of their primary hospital (Stinson & Muellar, 1980). Multiple investigations supported the observation that particular physician specialties have unique patient care information needs, and these needs are met by distinct sources (Ely, Burch, & Vinxon, 1992; Gruppen, Wolf, Van Voorhees, & Stross 1987; Stinson & Muellar, 1980).

Strasser (1978) discovered pediatricians and family practitioners had a greater interest in the psychological aspects of a disease process while surgeons were more interested in direct clinical knowledge. Gorman (1995) suggested community-based providers require less direct patient data because physicians and their staff are more familiar with the patient. However, an opposing viewpoint, based on studies that discovered specialists ask half as many questions to reach a diagnosis as non-specialists, is also germane (Kassirer & Gory, 1978). Levinson (1983) included information management as a natural component of clinical practice:

> The physician is an information manager who acquires, processes, stores, retrieves, and applies information related to 1) individual patient history and clinical course, 2) diagnostic and therapeutic protocols, 3) disease patterns in patient populations, 4) functioning of the health care system, and 5) the vast store of published knowledge. Little occurs in the clinical encounter that is not in someway related to obtaining, processing, or applying information. Optimal performance of clinical information tasks has for years exceeded the cognitive capability of the human mind. (p. 607)

Gorman (1995) provided a framework of met and unmet physician clinical needs, calling for information systems that help practitioners solve the clinical problems they face in practice. Several studies revealed only 30% of physician information needs are met during the patient visit, and that 25% of physician questions remain unanswered throughout the clinical course of care (Covell, Uman, & Manning, 1985). Efforts to mitigate the information deficit have included such networks as Medline and clinical knowledge-based systems.

Research techniques for discovery of physician and patient information needs have ranged from mail surveys, after-hours interviews, interviews immediately following a physician-patient visit, ethnographic studies, and stimulated recall (Gorman, 1995). Taylor (1991) posited “the problems, the questions, a physician faces have, historically speaking, remained the same over the centuries. The answers to those questions, and the means of deriving information useful in diagnosis have changed dramatically—but not the questions" (p.245).

Gorman's (1995) review of user study methodology identified a lack of common terminology and frame of focus as critical shortcomings. Examples included studies concentrating on a particular type of information, such as patient data (Tang, Fafchamps, & Shortliffe, 1994), or investigations reviewing acquisition of medical knowledge (Dee & Blazek, 1993; Ely et al., 1992; Gorman & Helfand, 1995). Some studies employed a broader approach including different types of information (Covell et al., 1985), while many other investigations failed to disclose or define the type of information being considered (Gorman, 1995). Consequently, Gorman incorporated ideas generated from his observations of primary care physicians, along with other researchers' empirical data, to create a framework (Table 1) describing the types of information used by clinicians when caring for patients (Gorman, p. 730).

Table 1. Types of Information Used by Clinicians

Type of information	Description	Examples	Usual sources
Patient data	Refers to a single person	Medical history, physical exam, laboratory data	Patient, family and friends; medical record
Population statistics	Aggregate patient data	Recent patterns of illness, public health data	Recent memory, public health departments
Medical knowledge	Generalizable to many persons	Original research, textbook descriptions, common knowledge	Journal literature, textbooks, consultants, colleagues
Logistic information	How to get the job done	Required form, preferred consultant, covered procedure	Local, P & P manual, managed care organization
Social influences	How others get the job done	Local practice patterns	Discussion with colleagues

Source: Gorman, 1995.

Gorman (1995) lamented the lack of uniformity in defining when an information need exists, and consequently, categorized the various types of information needs measured by researchers. Gorman cataloged various forms of information needs as shown in Table 2.

Table 2. States of Information Need

Type of need	Description	Comment
Unrecognized needs	Clinician not aware of information need or knowledge deficit	Inferred from assessment of knowledge; external action required to correct (e.g., reminder systems, self-assessment programs)
Recognized needs	Aware that information needed; may or may not be pursued	Articulated by clinician or inferred by observer
Pursued needs	Information seeking occurs; may or may not be successful	Observed or recalled information-seeking behavior
Satisfied needs	Information seeking succeeds	Recalled information-seeking successes

Source: Gorman, 1995, p. 732

Unrecognized needs must be inferred from measurement of physician knowledge or observation of clinical practices (Gorman, 1995). Clearly, this endeavor is difficult to qualify as the practice of medicine often presents divergent yet equally effective methods. However, Gorman cogently suggested unrecognized needs are important because information systems that depend on the clinician to seek information cannot succeed until the clinician recognizes that a need exists (p. 731).

Recognized needs have received considerable study and investigation (Covell et al., 1985; Leckie et. al., 1996; Taylor, 1991). Gorman (1995) warned of experimental error when data are obtained from either interviews or observations. He commented that “needs may be overstated as a consequence of interview prompts, or of observation, since neither provides a means of determining whether the information in question is actually necessary to benefit either the patient or practitioner” (p. 732).

Pursued needs are needs that stimulate information-seeking behavior. Investigation of this information acquisition has focused on either immediate or delayed information gratification (Covell et. al., 1985; Ely et al., 1992; Leckie et al., 1996; Taylor, 1991). Gorman (1995) observed that

> Little is known about how the questions that physicians pursue differ from those that they choose not to pursue, how physicians choose which questions to pursue and which to leave unanswered, or how the availability or use of information resources affects their information seeking behavior. (p. 732)

Satisfied needs are instances where the pursuit of information is successful. Gorman (1995) remarked that frequently, studies do not acknowledge the tertiary benefits secured when satisfying the primary need. This asset could include information gained by encountering or browsing while fulfilling the primary need.

Taylor (1991) called for investigation of the influences of specific information on physician behavior or patient well-being and warned that most studies start from the information service, rather than from the user. He gave the example of a medical library's query to physicians who use the service about the benefits of the service—hence, subject to information provider bias and sampling bias. For physicians and the healthcare community, successful retrieval and use of information is frequently measured by improved clinical outcomes and corresponding reduction in medical utilization.

MODELS

Discovery of innovative solutions to enhance clinical decision-making begins with an understanding of physicians' needs, tasks, and behavior. Modeling of physician information needs is a method used to ascertain the diverse types of information utilized, the environmental influence on information-seeking behavior, and the dynamic aspect of problem resolution.

Caveats associated with this approach include acknowledgment of each model's descriptive, rather than predictive, representation of behavior. Furthermore, the models' focus on group behavior may obscure recognition of cognitive or individual behavior. Finally, the models are specific and represent informal use by a select group of educated professionals toward goal-directed, problem-solving needs. However, by examining these models from an aggregate perspective, including the end use of information, common patterns and themes may be identified. These insights may provide a platform for research on the satisfaction of physician information needs by new telecommunication channels.

Taylor (1991) studied information transfer from an end-user perspective using three representative professional groups—engineers, legislators, and physicians. His model presented the importance of context when determining choice of useful information. His approach focused on how sets of people (defined within a social context as a particular group) use and value information differently. Each group presented discrete information-seeking behavior as a consequence of the problem, the setting, and the method of resolution. A graphic representation of the narrative model (Taylor, 1991) created by this author is represented by figure 1.

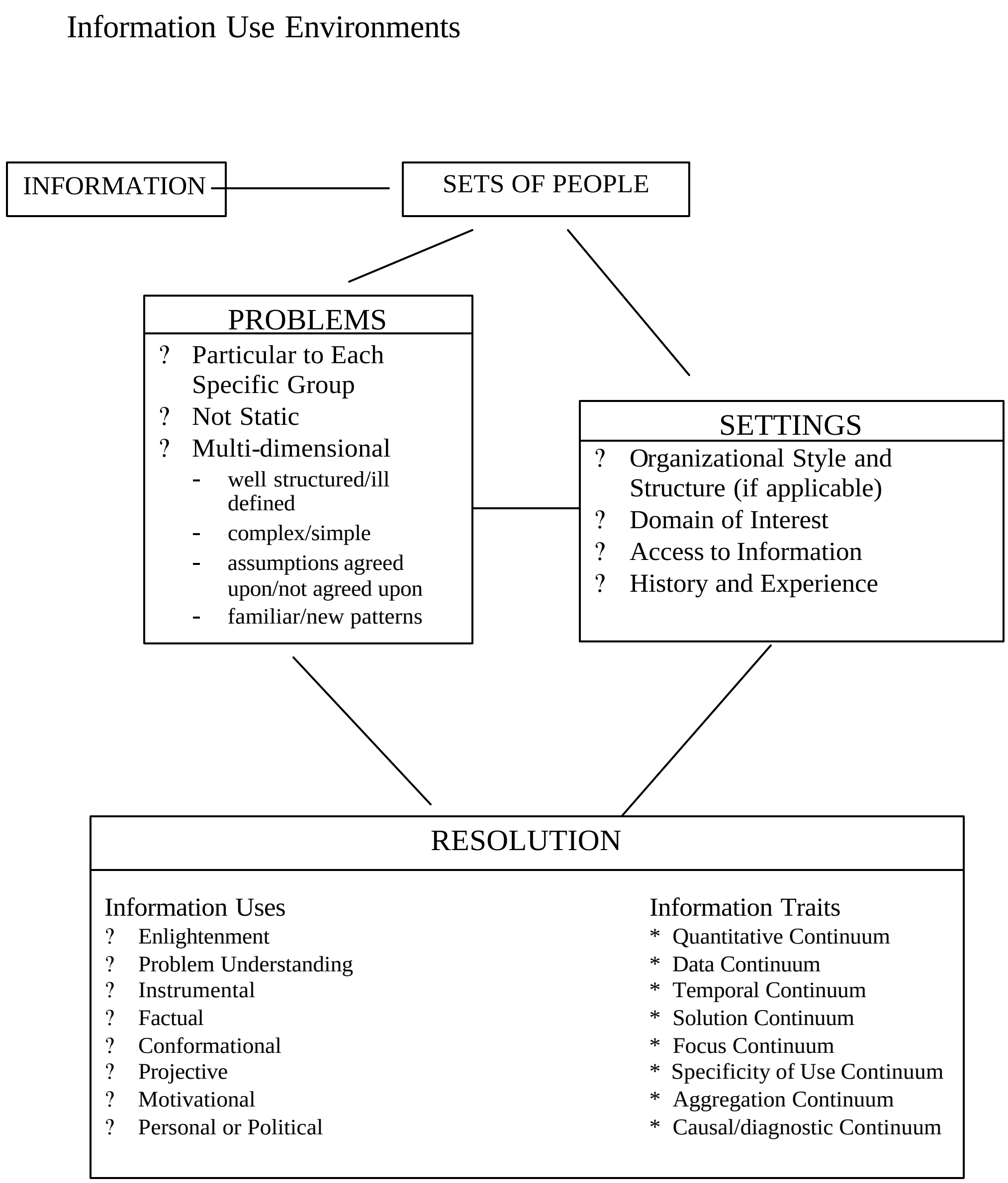


Figure 1. Taylor's Model of Information Use Environments

Taylor's (1991) key concepts comprise five major components: Information Transfer, Sets of People, Problems, Settings, and Resolution. Central to the model, problems are characterized as group specific, dynamic, and multidimensional. Settings include respective group work environments. Resolution of problems is accomplished through use of information in a variety of manners. Solution of one aspect of the problem may lead to another corresponding question, and information demand, and so forth. Taylor's stated objective was to "create a bridge between the world of the system designer and the end-user" (p. 218).

Specifically, the model demonstrated the importance of informal sources of communication, the predilection toward information that can be easily accessed, the realization that information needs may include needs that are not consciously realized, and the recognition that problems are not static. Leckie et al. (1996) suggested that the work of the professional is task oriented and continually requires the setting and achievement of goals to produce service (to clients) in the most cost-efficient manner. Indeed, the ability to retrieve information informally (and easily) corresponded to physician preference of colleagues as a major information source. Information scientists have described this activity as the use of *invisible colleges*, a behavior that seems consistent among scientists (Crane, 1971; Crawford, 1978; Price, 1963).

Dee and Blazek (1993) posited that physicians prefer information sources that are immediately assessable, familiar, and reliable, therefore presenting efficiency. Additional studies confirmed this information predilection, suggesting time, quality, and accessibility are determinants of perceived information utility (Connelly, Rich, Curley, & Kelly, 1996). Connelly et al. discovered that although physicians use the *Physician Desk Reference* (PDR) on a daily basis, and consult with colleagues at least weekly, they rarely use electronic information retrieval systems (e.g., Medline) because of the lack of easy clinical availability and the often doubtful value of information retrieved. For a clinical practitioner, information utility cannot be understated. Taylor (1991) believed his model could explain how the practice setting can influence different clinical behaviors, such as information uses exhibited by a physician practicing in an academic setting, as compared to a rural primary care physician.

Observed clinical behavior from South Texas field studies is best described from an information context. A model adapted from Cutler (1985) portrays a telehealth-facilitated, patient management, problem-solving process used by physicians in clinical practice (see figure 2).

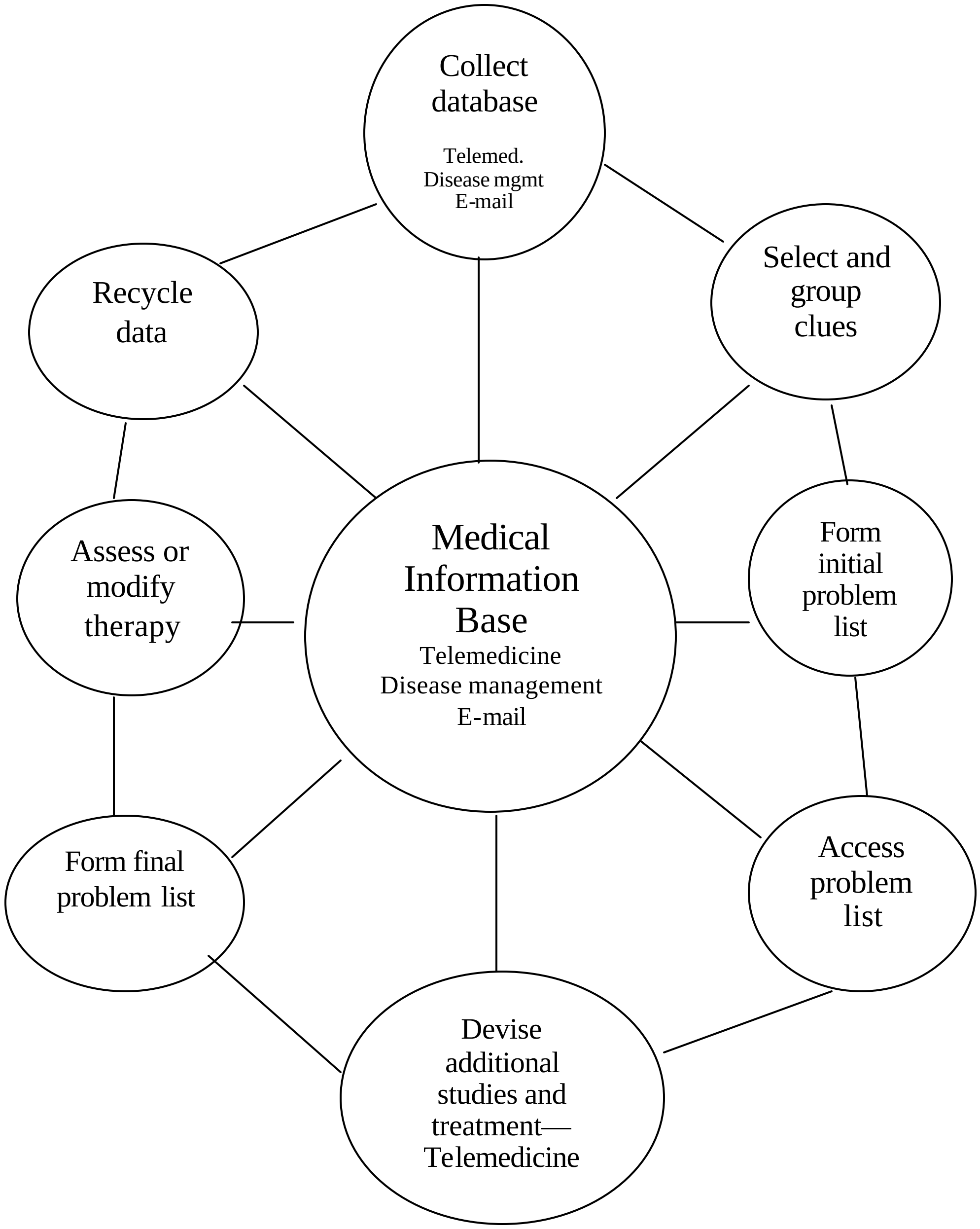


Figure 2. Cutler's Clinical Decision-Making Model

The model describes the total clinical management of a patient including diagnosis, treatment, and education. As presented by Cutler (1985), the outer ring of the model may be compared to a wheel, with the central component the axle, around which everything revolves. The model suggests a continuous recycling of data and perpetual revolution of the cycle.

After reviewing the problem list and daily clinical findings, the primary care physician (PCP) may decide to see the individual in his or her office or choose to consult with a specialist (devise additional studies). The baseline individualized data are forwarded to the specialist, beginning the process of data collection and starting the cycle from his or her perspective. Recommendations from the consultant then become a portion of the primary care medical record.

The telehealth-augmented model portrays how telecommunications links information sources, fulfills information needs, and enhances clinical decision-making. Leckie et al. (1996) suggested "multiple variables define an individual's overall level of awareness (of information), including ease of access, prior success when using the source, timeliness of the retrieval process, and assessment of relative cost-effectiveness" (p. 184). The overall process is directed toward development of an outcome.

In the clinical setting, the capacity to receive timely and accurate medical data (e.g., daily reports of clinical signs and symptoms) significantly expands the data set, thereby facilitating appropriate intervention. Moreover, in the case of DM management, the trending of data, a longitudinal review of blood sugars and insulin dosage, is invaluable for determining the efficacy of the medical therapy regimen. Improvements in patient-clinician communication also allow early medical intervention if a new problem is suspected, or if compliance with the current program is suspect.

CLINICAL INFORMATION USE

The use of information technologies to improve the clinical care process is fundamental for 21st-century healthcare, yet literature confirming improved clinical care subsequent to implementation of information technologies is scattered. Elson et al. (1997) elaborated on the difficulties associated with measuring the expected improvements in decision-making, following the implementation of information systems. He identified system constraints as the major factor in the variability of decision outcomes. Some limitations were uncontrollable, such as human memory and cognition, while other impediments were a function of delivery systems failing to collate and to present documented and available information to the clinician in a timely manner. Examples of this disconnect may be seen in studies of adverse drug effects occurring in hospitals, where dissemination of drug knowledge was not matched with particular patient history, resulting in clinical error (Elson, et al.).

Many believe the impediment to determining quantifiable benefits (for clinical care) may be associated with difficulties defining and measuring clinical care processes and clinical outcome measures (Epstein & Sherwood, 1996; Gorman, 1995). Still, the value benefit (determination) of any type of technological innovation is critical, given the prospective healthcare resource scarcity.

SIGNIFICANCE OF USER MODELS OF TELECOMMUNICATIONS TO THE CURRENT STUDY

New telecommunication and information systems may be used to deliver accurate clinical data at time of need to the provider, analogous to a *just-in-time* inventory management system for an industrial setting (Elson et al., 1997). For example, telehealth, as delivered through a home messaging device, proffers the benefit of a daily record of physiological markers such as blood glucose levels and home insulin dosage. The detailed medical history can be anticipated and pulled for review prior to a scheduled patient-clinician encounter, enhancing diagnosis and care plan management. The data continuum allows improved clinical management by depicting how an individual is self-managing the disease on a daily basis. Moreover, since the information is automatically captured and collated for daily review by the nurse care manger, the information is easily obtainable and germane. Trend data is developed and may be graphically depicted for on-demand physician review.

The revolutionary capability to review daily blood sugars, blood pressure, and insulin administration enlightens healthcare providers as to the efficacy of the current care plan. The new information data set enhances provider understanding of how an individual is self-managing the disease. Discovery of home-based clinical data removes barriers for previously underserved populations. Home-based monitoring, performed over telephone lines, enhances the connection between the provider and the community. Comprehensive healthcare may thus be delivered to those who previously did not receive care or who received only episodic, crisis-oriented intervention. This knowledge gain allows proactive intervention rather than discovery of problems during the scheduled revisit (which could be potentially months distant) or when an individual has a medical crisis necessitating a visit to the emergency room or requiring hospitalization.

Summary

Using the Internet and telecommunication technology to obtain daily clinical information in an affordable manner is a practice that needs further investigation. This new information source provides a means to satisfy unrecognized and recognized clinical needs, enriching the traditional physician-patient encounter, improving the clinical decision process, and advancing health outcomes. This new technology allows daily clinical information to reach health professionals. The easily obtained information allows improved medical management of the chronic disease. The next chapter reviews studies on emerging theories and models for health modification using telehealth as a means to disseminate behavioral training. These models provide methods for transferring health responsibility from the provider to the individual.

CHAPTER THREE: LITERATURE REVIEW

PATIENT-CENTERED HEALTHCARE AND THE PATIENT-PROVIDER PARTNERSHIP

To recapitulate, the purpose of this study was to investigate if a telehealth intervention could decrease hospital-based utilization and improve clinical outcomes for individuals with diabetes mellitus. This study illuminates the efficacy of this new form of healthcare delivery for an underserved, underfunded, predominantly Hispanic population.

In this chapter, a theoretical foundation for the opportunities afforded by the information age in delivering health and lifestyle training is presented. Integral to improving population health in the coming years is a transfer of responsibility from a provider-centered medical system to a consumer or patient-centered health system. The new paradigm is not just for the young or healthy, as morbidity from chronic disease may be substantially reduced by compliance with prescribed medications, diet, exercise, and stress reduction activities. However, the impetus and dedication required for effecting behavioral change must come from within, and is thus not an easy task. Telehealth provides a new vehicle to facilitate behavioral change by providing tailored information to enhance an individual's knowledge about the disease and to provide suggestions, cues, and reinforcement toward performance of health enhancing activities.

Patient-Centered Health Manager

Use of information technology is integral for a redirection of 21st-century medical care (Institute of Medicine, 2001). As care delivery shifts from high-cost institutional settings to ambulatory and home environments, telehealth provides the link not only to deliver effective *clinical care*, but also to facilitate a move to patient-centered *health management* (Greenes & Lorenzi, 1998). Iterative information delivered to the end user (patient) within the confines of his or her home has the potential to influence individual factors (health knowledge and attitudes, motivation for behavioral change), and interpersonal processes (social environment including family and community). Telehealth is a means to reform patient health management by channeling health promotional and educational information to influence nutritional and exercise habits, improving disease self-management skills and mitigating complications associated with a chronic illness (Balas et al., 1997). Patient-centered health management might thus reduce utilization and cost of medical care.

This section begins with a synopsis of consumer, or patient, acceptance of health information delivered over telecommunication channels. Then two applicable theories are discussed: social cognitive and ecological theories, along with models associated with these theories. Finally, an application of telehealth in a patient- or consumer-provider interaction model will be described.

FULFILLING INFORMATION NEEDS THROUGH NEW CHANNELS

In the Information Age, consumers rapidly accept new communication channels. In fact, in some areas consumer adoption of communication technology has surpassed professional utilization (Goldsmith, 2000; Goldstein, 2000; Lorenzi & Riley, 2000; Moore, 1996). In 2000, Goldstein predicted 30 million consumers would search for online medical information in 2001, up from 17 million in 1998. Moreover, the notion that consumers consider computer-generated dialogue encounters to be impersonal, and consequently ineffective, appears to be untrue. Goldstein shared research from Stanford University's Center for the Study of Language and Information that revealed people relate to computers and new communication technologies in ways that are similar to the way they interact with other human beings. Goldstein described an experiment reported by Reeves and Nass (1995) in which subjects were asked to evaluate "a computer's performance" on a particular task. Half the participants responded on the same computer that performed the task, the other half answered on a different computer. Unequivocally, those who moved to a second computer were more critical of the first computer. Goldstein (2000) went on to say that the participants in Reeves and Nass's study seemed freer to criticize the computer they worked with when they could do so behind the computer's back—anthropomorphism. Other findings in Reeves and Nass's study suggest people are often *more willing* to share sensitive information about themselves with computers than with human interviewers. Goldstein noted this observation is consistent with behavior presented by alcoholics and individuals with mental disorders, as they utilize interactive voice response technology. Indeed, newer telecommunication channels, especially the Internet, could provide a means to train and to reinforce positive health behaviors within the home environment. This, in turn, might improve adoption of new positive health behaviors and motivate positive changes in lifestyle.

Historically Underserved Populations in Need of More Consistent Intervention

New studies link health risk behaviors to social and economic conditions (Kaplan, Everson, & Lynch, 2000). The knowledge base for health promotion and disease prevention isscanty in many minority populations (Nickens, 1990). Brown and Hanis (1999) confirmed the need for culturally relevant interventions for Mexican Americans residing along the Texas-Mexico border. Healthcare professionals have long appreciated the potential of home-based interaction to accomplish health behavioral change and to improve health maintenance for individuals with a chronic illness. Telehealth provides the convenience of delivering information to individuals and families in their home. Indeed, this communication channel delivers an unprecedented volume of timely and focused medical information to impoverished minorities (given they have a touch-tone telephone). Moreover, low delivery costs provide bountiful clinical and educational opportunities to render higher quality healthcare.

HEALTH PROMOTION THEORY MODELS

Historically, directed intervention to develop, to perform, and to adhere to positive health behavior followed an interpersonal value-expectancy model (Revere & Dunbar, 2001). This approach hinged on education regarding the detrimental consequence of poor health behavior. Furthermore, a major construct of the models was the belief that performance of the prescribed action would remedy the potential harm and consequently influence individuals to perform the "safer or healthier" behavior (Glanz, Lewis, & Rimer, 1997; Revere & Dunbar, 2001). Current research has focused on expanding these health beliefs and theory of planned behavior models in an attempt to develop a model explaining willful health actions as well as dealing with behaviors over which an individual has limited control (Gauff, 1992). Various models have been advanced to explain or to enhance patient compliance with medication, exercise, and diet regimens in addition to stress management strategies (Barlow, 1998; Clark & Dodge, 1999; Rosenstock, 1985). While implementation of some models (Health Belief Model, Theory of Reasoned Action, Theory of Planned Behavior, Transtheoretical Stages of Change) were successful in modifying health conduct, many have lacked the scope, intensity, and rigor required to stimulate behavior change, especially in high-risk situations (Institute of Medicine, 2000; Rosenstock, 1985).

Social Cognitive Theory Model

Promising new models of health promotion have built on older cognitive theories by confronting social, behavioral, and health issues to promote patient-centered health management. Bandura's 1986 Social Cognitive Theory (SCT) first introduced the multifaceted components of behavioral change. Cognitive-behavioral theories recognized that knowledge, although necessary to produce behavioral change, is often not sufficient to produce the behavioral change alone; behavioral intervention is also required (Revere & Dunbar, 2001). SCT extends or builds on intrapersonal motivational techniques that provide individuals an understanding of why a particular behavior is desired and a belief that they can successfully perform the action. Intrapersonal methods acknowledge that an individual must present readiness to change and understand that a behavior, or the potential benefit of the results of the behavior, must outweigh the costs of performing the action (Glanz et al., 1997; Revere & Dunbar, 2001). SCT supplements this intrapersonal direction by also including the need for interpersonal support, reinforcement, and reward. Behavioral change must be coached and presented within an environmental context (Revere & Dunbar). This comprehensive, all-inclusive, multilevel intervention forms the basis of SCT (Bandura, 1986; Lewis, 1997; Rosenstock, 1985).

An example of theory application is a recent health education program that, rather than simply targeting a behavior, focused and delivered attention to the environment and to the individual. The study, the Child and Adolescent Trial for Cardiovascular Health (CATCH) (Edmundson, et al., 1996), sought to increase physical activity and improve diet for third- to fifth-grade students. Multifocal intervention included classroom instruction on healthy exercise and dietary activities as well as environmental changes in the manner in which food was prepared and presented in the school cafeteria. Modification of the school physical education program also accompanied the educational training. Opportunities to practice the new behavior were then provided and reinforced both at school and at home (Edmundson et al., 1996). The findings of improved nutritional intake and increased physical activity support the value of comprehensive intervention. This study is an example of developing patient-centered health management behaviors.

Reinforcement of an individual's behavior is a central theme of SCT. Researchers have discovered that intrinsic reinforcement of educational programs improve learning and retention (Lepper & Green, 1978). Furthermore, reinforcement of the immediate or short-term positive expectations of the behavior, rather than an emphasis on the long-term negative effect, is more likely to accomplish long-term behavioral change (Baranowski et al., 1997).

Reinforcing home medical plans is a challenge. Many times patients are emotionally excited by their health issues and their ability to hear and to understand information delivered by healthcare professionals is inhibited. Generally, patients receive instruction on the home medical care plan in a hospital or medical office while they are only partially recovered from a medical event. The medical setting often contributes to high anxiety, poor learning, and limited retention (Ley & Spelman, 1965). The SCT constructs and methods can help address these challenges by providing behavioral cues, reinforcement, and expectations, enhancing compliance with the medical care plan.

Ecological Theory Model

Research has shown that efforts to improve the nation's health should include multilevel social and behavioral intervention strategies to promote patient-centered health management (Institute of Medicine, 2000). A holistic or ecological approach that develops patient-centered health management concentrates on the social and behavioral determinants of a disease as well as on a need for multiple levels of intervention. Researchers have also found that intervention is more effective when delivered to a targeted or specific audience, because it recognizes the special needs of particular groups (Revere & Dunbar, 2001). Finally, an ecological approach views health outcomes over the long run and focuses on reducing risks caused by preventable conditions (Institute of Medicine, 2000).

Sallis and Owens (1997) posited an ecological approach that evolved from roots in public health and psychology, including work by Lewin, Skinner, and Barker. Although healthcare professionals have been relatively slow to embrace health educational or health behavioral modification theory, the medical community has long valued home-based intervention. Enhancement of quality of life is the ultimate goal for all medical intervention. Undeniably, the capacities to perform daily activities and to improve function within the home environment serve as critical benchmarks for healthcare effectiveness.

Ecological models extend Bandura's (1986) themes, suggesting that interaction among interpersonal, social, cultural, and physical environments is necessary to influence health behavior (Sallis & Owens, 1997). These theories focus on intrapersonal factors, including "an individual's knowledge, beliefs, motivation, attitudes, developmental history, experience, skills, self-concept, and behavior" (Revere & Dunbar, 2001). A central thesis suggests differences in levels of health and well-being are affected by an ongoing interaction among biology, behavior, and the environment. These associations are fluid and continuously evolving throughout the life course of individuals, families, and communities (Glanz et al., 1997).

SIGNIFICANCE TO CURRENT STUDY

Compliance with the prescribed home care plan is the objective for medical management of individuals with a chronic disease. In a study by Cerkiney and Hart (1980), 30 IDDM individuals were interviewed and assessed to determine compliance 6–12 months after receiving diabetic education classes at a community hospital. The researchers discovered that the highest level of correlation between compliance with prescribed medical regimen and motivation to perform the plan occurred with the construct "cues to action." In other words, when individuals were prompted or reminded to perform the activity, they were much more likely to do so. Griffith (1996) noted the need for the health field to mimic retail companies that target specific population segments and use more message repetition. He suggested that successful behavioral change strategies require efforts beyond simply informing people about opportunities.

THEORETICAL SYNTHESIS OF PATIENT-CENTERED APPROACHES

Telehealth provides an excellent medium to mirror the multiple levels of focus in an ecological approach and deliver multifaceted intervention. In fact, health information delivered to the home may influence an individual's microsystem, or interpersonal context, as the social cognitive model suggests (Bronfenbrenner, 1979). Thus home information stimulates direct and indirect reinforcement, perhaps obtaining vicarious behavioral change. Furthermore, telehealth may be expanded to deliver health messages at work and at school. This multifaceted approach is needed to affect deeply ingrained social and cultural health behaviors.

Telehealth services and information systems can redefine home-based healthcare and health promotion (Greenes & Lorenzi, 1998). Earlier studies demonstrated the clinical benefit of focused weekly information access for patients with diabetes (Friedman, Stollerman, Mahoney, & Rozenblyum, 1997; Piette & Mah, 1997; Tilly et al., 1995). Balas et al. (1997) foresaw the application of distance communication technology as a means to strengthen the continuity of care between patient and clinician, thereby improving access and supporting the coordination of healthcare. Gold (1997) endorsed computer technology as a means to promote patient satisfaction and compliance and to improve health status.

The following section presents two models. The first is Goldstein's Telehealth Consumer-Clinician Model. The second is a Telehealth-Consumer Behavioral Model. These models combine the SCT and ecological theory models into a composite, patient-centered, telehealth interaction.

Patient-Provider Health Manager

The model, created from a synopsis of work by Goldstein (2000), places the patient as the centerpiece of the frame, a departure from past models with the healthcare system centered as the focal point or sphere of influence. Information technology or telehealth fosters a shift to an ecological, patient-centered care focus, with multilevel intervention (including behavioral interventions) and support. Internet-based technology facilitates communication between healthcare providers or the healthcare system and the end user, the patient or consumer. Clinician information needs may also be satisfied, resulting in improved health outcomes. Furthermore, fulfillment of patient information needs empowers individuals to take responsibility for their own health and well-being.

The Goldstein model combines both of the theory models previously discussed. The Internet can be a significant enabler of consumer health initiatives by providing an increasingly available communication channel for health information. In *Networking Health* (2000), the National Academies posit a new emphasis on consumer autonomy; the "Internet could change the culture of healthcare from one in which patients are viewed as recipients of care to one in which they are partners in care" (p.59).

THE TELEPHONE AS AN INFORMATION CHANNEL

Telephone-linked care (TLC) to enhance clinical care and to supplement office visits has been in use for nearly a decade (Friedman et al., 1997; McBride & Rimer, 1999; Shultz, Bauman, Hayward, & Holzman, 1992). Piette (1997) reported several meta-analysis studies in which the patients' health and health behaviors improved subsequent to automatic voice messaging. In one study, as an adjunct to diabetes outpatient care, Piette and Mah (1997) used specialized computer technology (Automated Voice Messaging, or AVM), to call patients on a weekly basis. The system, programmed to relay queries in a human rather than a computer-synthesized voice, inquired about self-care problems with glucose monitoring and foot care, adherence to diet and medication schedules, and diabetic symptoms that have been prognostic of poor glucose control and adverse health outcomes. Additionally, the system provided an option for patients to listen to health promotion messages concerning various aspects of diabetic self-care (Piette & Mah, 1997). The study results were promising, as 98% of the patients reported the calls were helpful and 77% stated the calls made them more satisfied with their healthcare. Clinically, 26% of all patients reported chest pain or discomfort that either could or did signal follow-up, 19% reported foot problems, and 19% reported one or more weeks of poor glucose control.

Significantly, the technological capabilities at the time of the study only allowed a weekly intervention rather than an Internet-facilitated daily contact. Nevertheless, after an economic evaluation, Piette and Mah determined that the AVM system could not only be cost effective but even cost saving if implemented on a large scale.

Another trial (Ahring, Ahring, Joyce, & Farid, 1992) included a random assignment of patients with similar diabetic profiles and compared compliance with health plans to blood glucose determinations. One group transferred data telephonically every week, while the other group brought their data to the provider on regularly scheduled 6-week intervals. The modem group (telephonic transfer) displayed improved HbA1c readings. The researchers concluded that the telephone monitoring system seemed to stimulate the patient to keep closer control of blood glucose levels, thus resulting in more patient-centered health management behaviors. Additional researchers discovered a 58% compliance rate among patients accessing an interactive telephone system for self-reported daily glucose levels or hypoglycemic symptoms (Meneghini, Albisser, Goldberg, & Mintz, 1998). Patient responses indicating a potential medical crisis evoked a phone call from the nurse care manager. Participants presented a three-fold reduction in diabetic-related crisis with concomitant statistically significant decreases in HbA1c. Correspondingly, the healthcare system observed a two-fold reduction in outpatient clinic visits for complicated diabetic cases (Meneghini et al.).

These studies have demonstrated the value of a telehealth information channel as an improved healthcare model, redirecting diabetes management from the clinic setting to the patient (Ahring et al., 1992; Jaffrey et al., 1997; McBride & Rimer, 1999; Meneghini et al., 1998; Piette, 1997; Tilly et al., 1995). The preliminary success of automated voice messaging, such as the AVM intervention, was always accompanied by a time lag—that is, technical and logistical considerations prevented an immediate response (Piette, 1997). Clearly, response time is diminished, if not entirely eliminated, with Internet connectivity.

GOLDSTEIN'S TELEHEALTH CONSUMER-CLINICIAN MODEL

In *Crossing The Quality Chasm* (Institute of Medicine, 2001), an essential construct for redesigning and improving the healthcare delivery system is the use of emerging information technology to advance the level of connectivity. Preliminary studies suggest applications via the Internet in areas of consumer health, clinical care, administrative and financial transactions, public health, professional education, and biomedical and health services research (National Research Council, 2000).

Information technology or telehealth fosters a shift to an ecological, patient-centered care focus, with multilevel intervention and support including behavior interventions. A model adapted from Goldstein (2000) depicts consumer-provider telehealth-facilitated interactions representing a new healthcare delivery paradigm. The model incorporates (a) an unprecedented capacity for timely and available clinical care (via telemedicine); (b) health information Web sites, either generic or custom designed, reflecting a provider's treatment philosophy and protocols; (c) home-based patient monitoring and home care including rules-based intervention and either real-time or asynchronous clinical communication; (d) an integrated electronic medical record; (e) social support including real-time call centers, chat groups, and interactive voice response; (f) targeted and tailored health intervention providing access and information delivery to specific population groups and to individuals; and (g) provider e-mail enhancing the efficiency and effectiveness of the patient-provider relationship.

Goldstein (2000) visualized the new delivery model as incorporating a variety of mediums whereby personalized service enhances the effectiveness of patient-provider encounters and improves the quality of care. For example, Web-enabled call centers could include a telehealth-augmented triage system with options to transfer urgent calls to a nurse or physician for communication over traditional phone lines; availability of text-based chat with a physician or nurse; an ability to participate in an online self-care triage module; use of Web telephony to support verbal communication with nurses or physicians (e.g., to provide written instructions on advice given over the phone); provision of a link for traditional e-mail to the physician or nurse to communicate patient questions; and online triage with a Web video connection to a healthcare call center (Goldstein, 2000). A well-designed, interactive Web portal with interactive digital channel capability will allow organizations to partner with patients/consumers, resulting in targeted and tailored health advice and connectivity (see figure 3).

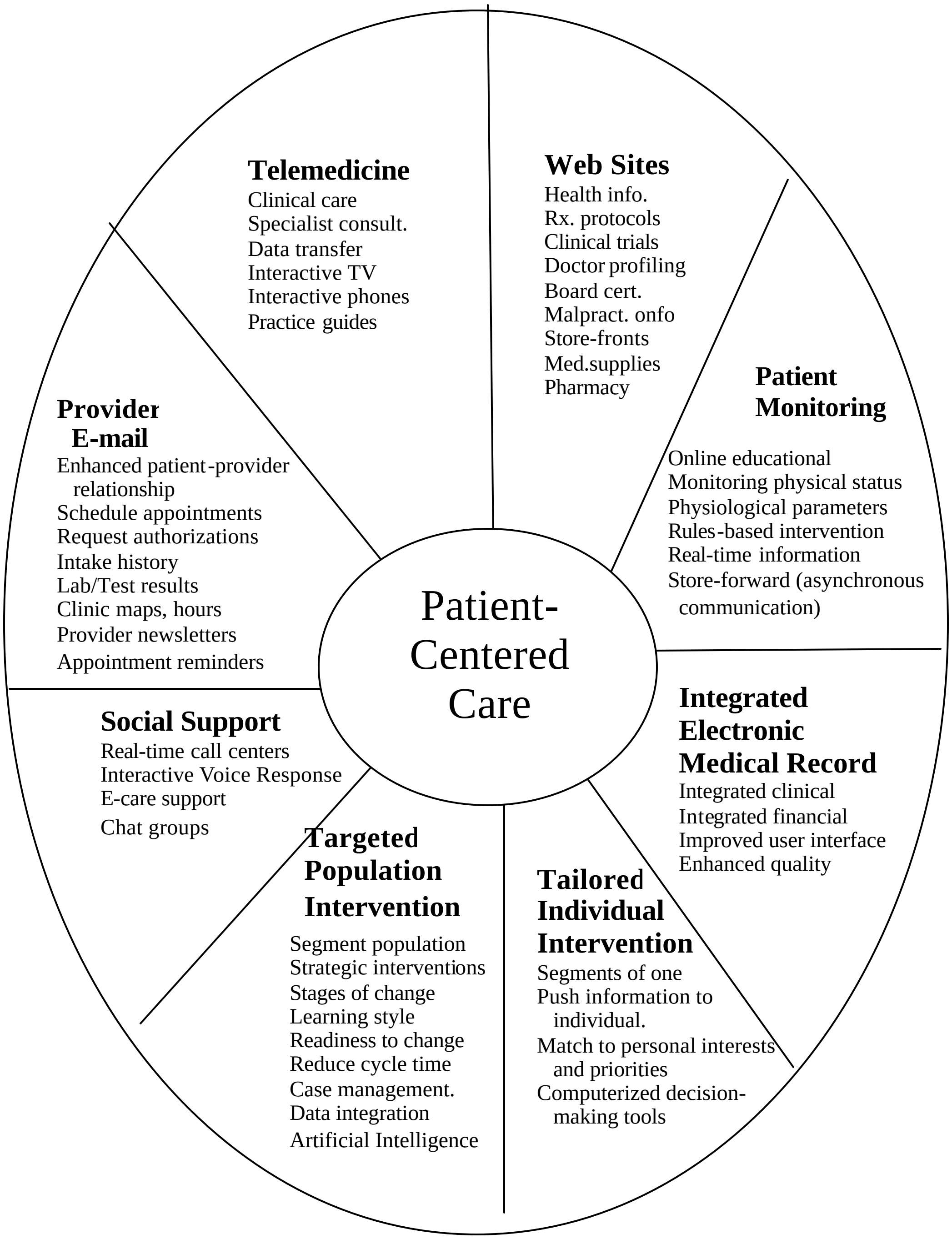


Figure 3. Telehealth Consumer-Clinician Model as adapted from Goldstein

Telehealth promises to satisfy consumer demands for more personalized attention by delivering informational or clinical support in what now appears to be the most efficient and effective setting—the home. Providers have acknowledged the benefit of home-based care for well over 30 years, even though the typical home health session was of short duration, few visits, and conducted over a limited time period. Moreover, the time permitted for traditional home-based intervention is in decline because of reduced funding, pursuant to the Balanced Budget Act of 1997 and subsequent health reform efforts. Nevertheless, telehealth may provide an answer to consumer needs for access and to provider needs for enhanced clinical outcomes.

A recent review of 80 controlled trials concluded that telemedicine technologies were particularly beneficial in the areas of preventive care, and for management of osteoarthritis, cardiac rehabilitation and diabetes (Balas et al., 1997). Many believe technology has finally reached the point where health-behavioral models can be integrated with computer-generated interventions to provide consistent, continuous, and interactive therapeutic care in the home or as an adjunct to ambulatory care (Revere & Dunbar, 2001). However, research is necessary to compare different protocols and to identify the behaviors and pre-existing conditions for which interventions are effective.

TELEHEALTH-CONSUMER BEHAVIORAL MODEL

The next model operationalizes a telehealth application using a home-based messaging device as applied to a historically underserved or insufficient area of care—the management of chronic disease. Piette (1997) cited several studies documenting the ineffectiveness of the healthcare system to adequately address issues associated with chronic disease management. Persistent issues included (a) the absence of systematic monitoring of patients' health status to identify problems before they become severe; (b) the lack of assessment and reinforcement of health behaviors (e.g., diet and exercise); and (c) the failure to review adherence to treatment regimens, usually including prescribed medications, on a timely basis. Paradoxically, despite the preponderance of healthcare expenditure for this cohort, provider management is often inadequate, since standard care management plans call for only quarterly follow-up outpatient assessment, despite the complexities of the disease and associated comorbidities (Piette, 1997).

In the application utilized in Piette's 1997 study, diabetic patients received quasicustomized, or tailored, health instruction and education. A discussion of the model and previous research efforts follows.

The proposed model (see figure 4) is an "electronically-facilitated" extension of Social Cognitive Theory (SCT) combined with recent ecological health behavior models. Telehealth provides a new means to deliver health intervention that is believed to influence individual health behavior. Baranowski, Perry, and Parcel (1997) suggested that individual health behavior emanates from a “triadic, dynamic, and reciprocal model in which behavior, personal factors (including cognitions), and environmental influences all interact” (p.153). The necessity for multifaceted intervention is satisfied by telehealth’s capability to deliver home-based intervention (environment) and support (intrapersonal) while delivering specific or personalized information (desired behaviors). Daily feedback and education instill knowledge of the value and expected results from a new behavior, fostering confidence toward performance of the behavior (i.e., self-efficacy).

Although prior studies have suggested the value of weekly telehealth intervention, the proposed telehealth-facilitated model seeks to improve effectiveness by sharing information *on a daily basis* between the patient and the provider. Clinical information is delivered and, perhaps as important, a social support network is established, allowing timely feedback and assistance on issues including noncompliance or crisis situations.

Telehealth appears to provide a superior delivery vehicle for the transmission of behavioral intervention. Messages may be individualized or tailored, providing personalized messages in response to individual needs. Many of the key components for successful behavioral intervention are effectively addressed via telehealth. These factors include self-control (the discipline needed to maintain compliance with medical, diet, and exercise prescriptions), expectations (clear understanding of the benefits of the care plan), expectancies (knowledge of the benefits of performing the behaviors), reinforcement (daily recognition of successful performance of a behavior, or support to overcome a setback), and coping skills (techniques and information to empower individuals toward self-management of their chronic disease). Ongoing didactic promotion of health-enhancing behaviors, in association with targeted or disease-specific messages, is delivered to the home setting and provides a basis for improving an individual's perception of his or her overall environment and circumstances. Instructional intervention is therefore delivered in an optimal setting for incorporation of self-care and self-management skills into an individual's daily routine.

Numerous researchers have demonstrated the value of social networks or social support in reducing the consequences of disease and improving compliance with medical regimens (Glanz et al., 1997). Social support, as defined by House (1981), is the functional context of relationships. The physical presence of the device and active monitoring may represent a tangible or perceived sign of caring and concern by the provider community, and thus may serve to motivate medication compliance and lifestyle modification. Furthermore, instantaneous response feedback to the question battery improves knowledge about the disease (DM) and promotes positive health behaviors. Additionally, patient perception of emotional support may result from the daily encounters.

The ongoing connection between the individual and the healthcare provider obviously alters the standard patient-provider relationship. Traditionally, when an individual visits the provider, he or she receives instruction on a medication and lifestyle regimen at either the time of discharge or at the end of the clinic visit. The individual then returns home and is effectively ignored until a catastrophic event necessitates an emergency room visit, a call is placed to the provider regarding a condition of ill health, or, in a best-case scenario, a scheduled follow-up visit is performed 3–6 months later. Furthermore, patient satisfaction is strongly associated with the amount of information transferred from the provider to the individual (Hall, Roter, & Katz, 1987). Prior studies have discovered that successful recall of information is predicted by a physician's communication behavior, including information delivery, asking fewer questions, positive talk, and partnership building (Hall et al., 1987; Roter & Hall, 1997). The link between effective communication, patient satisfaction, compliance with medical regimens, and health outcomes has been established in both hospital and outpatient settings (Devine, 1992; Kaplan, Greenfield, & Ware, 1989). Daily communication restructures the physician-patient relationship, enhances patient satisfaction, improves medical regimen compliance, and advances health outcomes.

Numerous studies have demonstrated the value of care management in reducing hospital costs by reducing the number of hospitalizations and ER visits (Landi et al., 1999; Rich et al., 1995). Telehealth via online home intervention provides ongoing information and education and empowers individuals, potentially shifting health responsibility from the provider to the individual. For this study, early research findings suggest significant perceptions by patients of the value of electronic connectivity to the health system. One patient made the following comment:

> I am very, very grateful to all who made it possible for me to be in this program. I feel as if the doctor or a nurse is available for me to tell when I feel bad or if I'm anxious. In few words, I no longer feel alone. I can count on you. I thank you very, very much and may God bless you and help you help other 75-year-young ladies like me. Much love.

A key aspect of the intervention is behavioral capability. The following is a description of the telehealth-consumer behavioral model (see figure 4). Expectations and expectancies pursuant to a particular behavioral activity are extremely important constructs for this population. The battery of questions addressing disease knowledge and health behavior strives to educate and inform patients (within their home environment), which, in turn, enhances performance of healthy behaviors. Questions provide education on frequency and timing of blood sugar checks, blood pressure, and potential hazards of weight gain. Additionally, the question battery instructs patients about appropriate and/or inappropriate blood sugar levels, causes of low/high blood sugars, the benefits of exercise, and the advantages of a diet high in fiber, for example. The knowledge set and confidence learned over the home messaging device are key constructs that promote long-term behavioral modification, including medication compliance and adoption of healthy lifestyles.

Self-control and reinforcement are additional targeted constructs in this intervention. Self-control is vital for medication compliance and lifestyle modification. Essential tasks include multiple daily assessments of blood sugars and administration of insulin (if insulin dependent). The daily question battery provides reinforcement of task performance and mirrors actual behavioral performance. The routine of answering the question battery establishes a pattern and discipline that may translate to medication compliance and lifestyle modification. The long-term objective of the intervention is behavioral change, with utilization of the device as a means to provide external rewards facilitating the intrinsic rewards of the behavioral change itself.

Telehealth-Consumer Behavioral Model

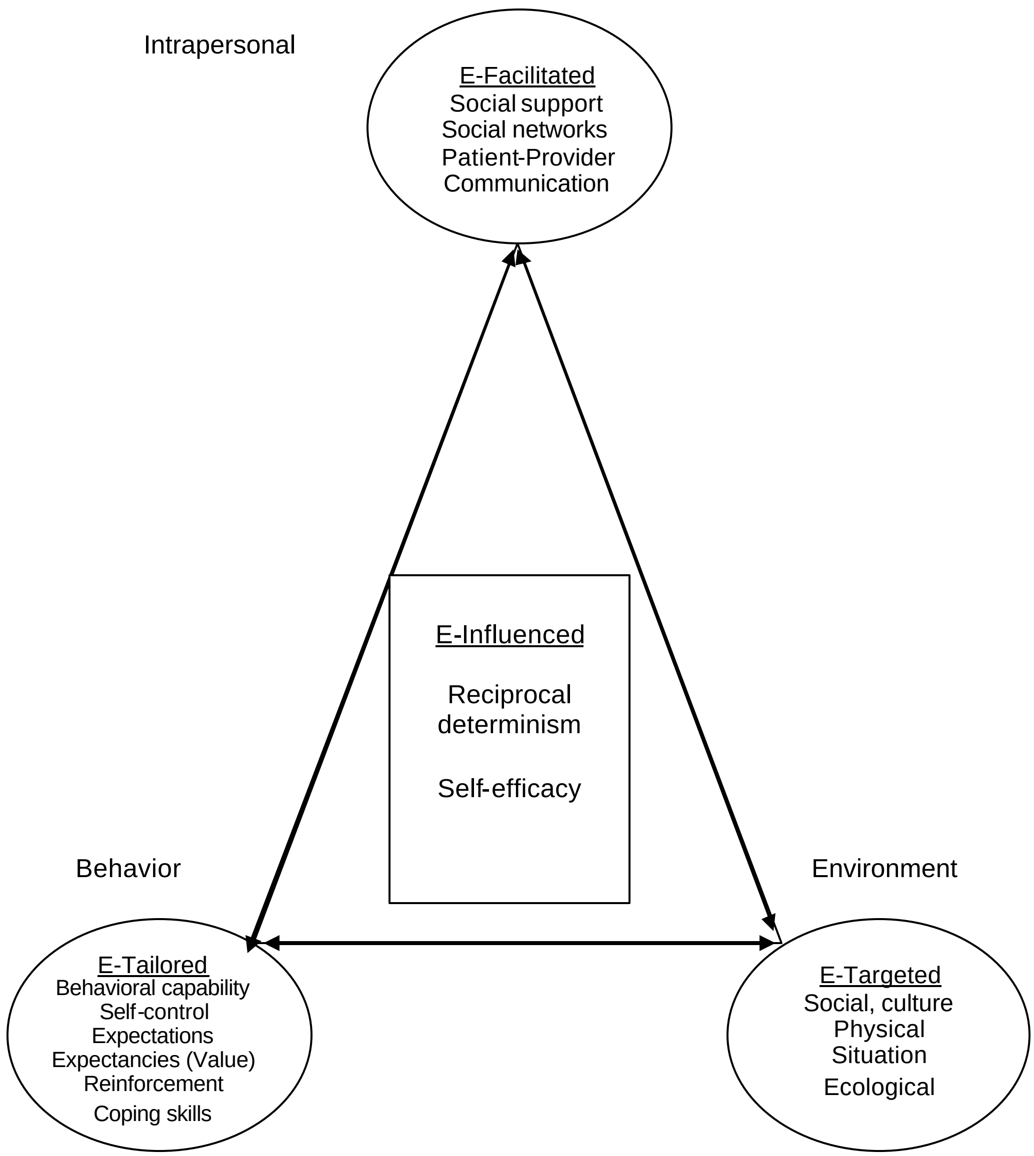


Figure 4. Telehealth Consumer Behavioral Model

Revere and Dunbar (2001) classified 37 earlier studies of computer-generated health behavioral interventions, according to the delivery device (print, automated telephone, computer, and mobile communication) and intervention type (targeted or tailored). Print communication systems consisted of a letter, fax, postcard, or newsletter, while mobile communication systems included a pager, mobile telephone, or other wireless communication device. Computerized delivery systems encompassed use of a computer, modem, touch-sensitive screen, home messaging device, or other interfacing equipment for the delivery of the information. Automated telephone delivery usually consisted of computer-generated messages received via a regular telephone line and telephone. Revere and Dunbar report that the primary distinction between *targeted* and *tailored* intervention is that *tailoring* adapts content or the way content is presented according to the needs of the individual. In contrast, *targeted* intervention is information geared to a particular audience (e.g., generic diabetes health education or a wellness curriculum). The intervention in the present study may be called quasi-tailored, since generic, scripted information is delivered to patients with follow-up information triggered by their individual responses, or new questions posed to patients as a result of their responses.

Ten of the reviewed studies by Revere and Dunbar (2001) used a computerized delivery system and three of the trials addressed DM. Two of these studies utilized a tailored format addressing disease knowledge and improved self-care while the other study delivered targeted messages in an effort to reduce blood glucose levels (Schultz, 1992). Revere and Dunbar noted the absence of a theoretical basis for the 14 studies using computer generated or mobile intervention devices. They lamented this absence of a theoretical framework and suggested that an appropriate model could assist the development of behavioral messages to enhance patient motivation and compliance.

As voiced by Revere and Dunbar, studies applying conceptual models to computer-generated intervention are needed. The efficacy of device intervention and method of delivery (targeted or tailored), matched to certain health behaviors and disease states, also deserve investigation. Revere and Dunbar also suggested a study of the extent to which technological intervention could replace interpersonal health behavior recommendations. Friedman et al. (1997) foresaw the future as a multimedia information collage with intervention devices incorporating features of the current telephone, wireless, television, video, and computer. Finally, investigations of economic consequences of intervention have lagged. Research is necessary to access the economic value and efficacy of computerized intervention.

SIGNIFICANCE TO CURRENT STUDY

New communication technology—telehealth—has the potential to improve the efficiency and effectiveness of healthcare delivery. Asynchronous, daily information transfer improves home-based clinical management of a chronic condition by presenting a realistic view of how an individual is coping and living with a disease on a daily basis. The new connectivity is especially urgent for previously underserved populations since timely clinical intervention may prevent an escalation of the illness and the need for expensive medical care such as hospitalization. Moreover, the information transfer is efficient, not limited by the time demands of a face-to-face or even a real-time, online connection. The new knowledge base improves clinical care, resulting in better health outcomes and an enhanced quality of life for the individual. Furthermore, as viewed from a societal perspective, perhaps the most significant benefit of telehealth is the promise of enhanced self-directed health responsibility. Telehealth allows ecologically based health behavioral interventions to be delivered on a daily basis. The personalized messages include cues to performing desired behaviors, reinforcement of behavioral performance, opportunities for social support, and suggested coping skills if or when a real-world issue arises. A value of telehealth is daily education, which helps individuals to be aware of their health status and to be knowledgeable and confident that they can perform the tasks necessary to self-mange their condition. This self-efficacy and empowerment toward responsibility for an individual's own health status is critical as society grapples with demographic shifts and resource scarcities.

Summary

The communication capability of the Web forms the backbone of the new healthcare paradigm. Consumerism and patient-centered care may be driven by Web technology, allowing access to basic information, treatment protocols, physician profiling, and even exchange for medical products and pharmaceuticals. The 24-7-365 information connectivity could create a new information-sharing and knowledge-building bond between patients and providers. Moreover, amplified clinical and behavioral interactions for particular patient population segments form the basis for disease management. The transfer of knowledge—information and education of patients, caregivers, or providers—is an essential component of a disease management program (Brown & Hanis, 1999; Piette, 1997; Tilly et al., 1995). An expanded view of a physician's treatment philosophy, including protocols, could be available for the individual to review at any time, transferring information power and improving self-management. Conceptually, the demand for face-to-face visits with a physician will likely decrease, as will the number of phone calls to the doctor's office, because the individual will be able to find basic information and eventually e-service through the doctor's interactive text, graphics, audio, and video Web services (Goldstein, 2000). The new paradigm is driven by the premise that it is not necessary for every patient encounter to take place face-to-face in the physician's office. The purpose of this study is to assess if a DM telehealth intervention can decrease the need and intensity of traditional health care services while concomitantly contributing to an improvement in health.

The next chapter describes the methods used in the study, including the selection process, data measures, limitations of the study design, and the analytical tools used to instigate study data.

CHAPTER FOUR: METHODS

ASSESSING INTERVENTION OUTCOMES

Assessment of healthcare outcomes is an arduous and difficult task. Study designs for outcome-management projects frequently concentrate on the practicalities associated with a day-to-day clinical setting. Tilly et al. (1995) comment that simplicity and practicality (such as absent or small control groups) are gained at the price of additional threats to validity and interpretation difficulties. In this chapter, the format of the study, including study selection processes and measurement tools are described in detail.

Participants

Study participants were required to be either indigent or underfunded, at least 18 years of age, mentally competent, and demonstrate, or have a caregiver who possessed, the capability to read at a sixth-grade level in either Spanish or English. Participants or their caregivers were also required to display sufficient physical dexterity to fulfill the daily tasks of assessing physiological and metabolic measures, administering medications (e.g., insulin), and inputting data into the home device. Participants also agreed to conditions of participation, and acknowledged the risk of removal from the study if the test battery was not answered for 3 consecutive days without notification. Voluntary self-removal from the study was allowed. All study participants received clinical care from the health care system in either 1999 or 2000 prior to entry into the study. DM study participants received the home devices, glucometers, strips, and lancets.

Study recruitment extended through the first three quarters of calendar year 2000 with the second and third quarters representing the greatest period of enrollment. Recruitment locations included mobile clinics extending to the colonias, women's health ambulatory clinics, hospitals (at time of discharge), primary care physician offices, and community-based diabetic clinics. Assignment to test and control groups was determined in the field by clinical practitioners. Typically, a practitioner would identify an individual they deemed appropriate for the study then contact the nurse care manager. The care manager would then determine if the individual desired to participate in the study and if study participation criteria were satisfied.

Clinical care and resource utilization for test and control groups were compared in two time periods—before the beginning of the study and subsequent to the initiation of the study. For test subjects, the study entry date was defined as the date the test group began to receive the daily home messages, while for controls, the entry date was the date an individual was assigned to the control group. The first time period (pre-study)--*pre-test* and *pre-control* consisted of utilization activity in calendar 1999 and 2000 (until entry into the study). The second time period began when an individual started using the home device (during Calendar 2000) and ended on June 30, 2001 (with the exception of four individuals who, after more than ten months of participation, chose to withdraw from the study). For test subjects the period after initiation of the intervention is called *post-test* and included utilization occurring while receiving the intervention. For controls, the *post-control* period entails the time frame after controls were assigned to the study until the end of the study period.

The variable *patient days* quantified the span of time over which utilization variables were measured. This variable allowed the assignment of a relative weight to the discovered utilization. In other words, clinical and financial measures were reduced to a daily value.

Pre- and post-utilization activity was matched to account for seasonal variation in usage patterns. For example, if a test subject entered the study on April 15, 2000, retroactive review for pre-test activity would begin with the first encounter before April 15, 1999 and then extend until April 14, 2000. Post-test utilization would include any activity from April 15, 2000 until June 30, 2001 or study termination.

This approach resulted in pre-control patient days of 18,085 days for control subjects, or an average of 255 *pre-control* days per individual, while the pre-test tome period consisted of 45,956 days, or an average of 346 *pre-test* days per individual. The retrospective review of the test group for post utilization activity included 46,985 days for the test group, or an average of 353 *post-test* days per individual. Post-control group utilization occurred over 26,912 days, an average of 379 days *post-control* days per individual. Individuals who participated in the study for less than 3 months, for any reason, were considered drops.

Descriptive statistics for the study populations are presented in Appendix A. Of the 211 study participants, 159 were women (75%) and 52 men (25%). The population was 99% Hispanic and 85% (179 individuals) chose to receive intervention via instructions written in Spanish. Seventy-one individuals served as controls, 133 participated as test subjects, and 7 individuals dropped from the study. Forty-eight women were in the control group, 105 in the test cohort, and 6 dropped. Twenty-three men were controls, 28 test participants, and 1 dropped. Female participants in the control group averaged 57 years of age, while participants in the test group and drops displayed a mean age of 54 and 58 years old, respectively. Male participants in the control and test groups averaged 55 years of age; the 1 participant who was dropped from the study was 57 years of age. Sixty percent of the test group was classified as self-pay or indigent, 33% Medicare/Medicaid, and 7% had private insurance. The financial status for the control cohort consisted of 46% self-pay or indigent and 52% Medicare/Medicaid (see Appendix A).

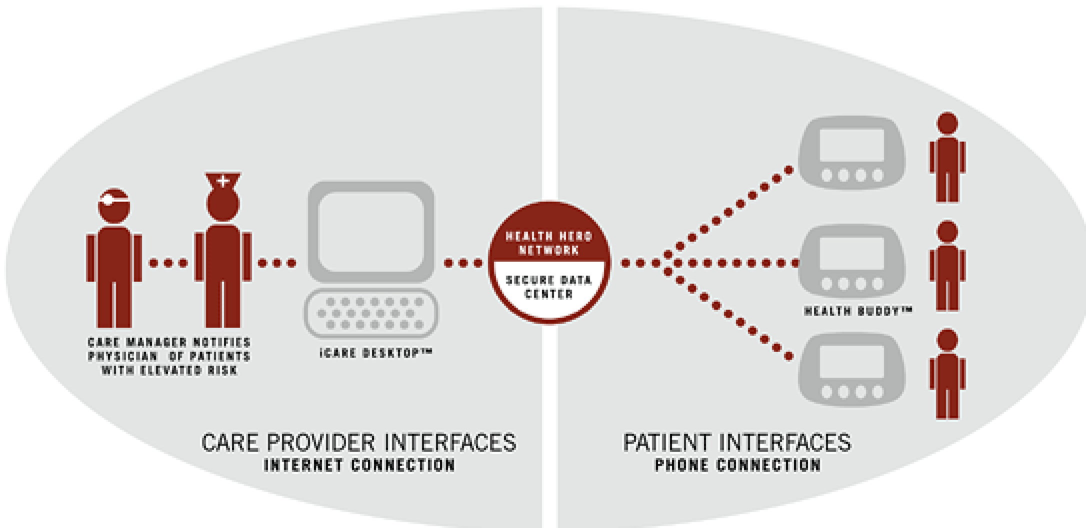
The control participants (n = 71) did not receive a messaging device. The test group (n = 133) received and used the home messaging device. A 3-month period was determined to be the minimal intervention length for qualification as a test group participant. Fifty one percent (36 individuals) of the control group received the SF-12 assessment of perceived mental and physical health status upon entry into the study, and on at least two subsequent occasions. The remainder of the control cohort consisted of individuals who initially agreed to participate in the study but then declined intervention.

Of the 7 participants who were dropped from the study, 2 requested to be removed from the study, 1 was removed for failure to participate, 1 moved, 1 had the telephone disconnected, and 2 died during the study.

Procedures

Individuals selected to participate in the test group received a small home device, the Health Buddy®, to be plugged into an existing telephone line. The Health Buddy®, is a product of the Health Hero Network® http://www.healthhero.com/index.html , a privately held healthcare information services company based in Mountain View, California. Health Hero Network was founded in the late 1980's to develop information systems and tools for chronic care. Currently Health Hero Network® offers health management programs for conditions such as heart failure, cardiovascular disease, asthma, pulmonary disease, post-acute care and diabetes. The Health Hero Network® content library includes over 7,000 dialogues for fourteen standard disease management programs. Healthcare institutions working with Health Hero Network include the Veterans Administration Health System, Council on Aging – Silicon Valley, Kaiser Permanente Southern California and Rocky Mountain Network.

The Health Buddy® device delivered a daily set of 6 to 10 queries to assess medical status and inform patients about health-enhancing behaviors. The informational context was delivered on a 30-day rotational basis with unique questions provided each day. Response options and dialogue gave participants instructions on living and coping with their specific medical condition. Additionally, documentation of physiological and metabolic signs including weight, blood pressure, blood sugars, and insulin dosage provided ongoing feedback to the provider. The question battery was to be completed at any time during the day or evening, and was automatically uploaded during the early morning hours to a Health Insurance Portability and Accountability Act of 1996 (HIPPA) compliant secure data center, which interfaced with a web-based care management solution, iCare Desktop™. Therefore, patient privacy and confidentiality were ensured. A nurse care manager then logged into Health Hero® iCare Desktop™ on the Web to review risk-stratified patient data each day. Additionally, iCare Desktop™, provided a set of patient enrollment, scheduling, and monitoring tools that served to enhance the care manager's efficiency and effectiveness. Figure 5 illustrates the Health Hero Network® and the Health Buddy® http://www.healthhero.com/index.html.



Health Buddy Device

Figure 5. Health Hero Network® and Health Buddy® Illustrations

The question battery or dialogue reflected the health organization's philosophy regarding home-based medical management of the study population, For example, early symptom detection of detrimental blood sugar trends, ongoing review of insulin dosage, and monitoring of pharmaceutical care plan compliance were deemed important for successful management of DM. Furthermore, as an integral component of the intervention, the question dialogues promoted the medical care team philosophy regarding general health education as well as a particular focus on the specific disease state (diabetes). Since individuals with a chronic illness face unique daily challenges, methods to cope with these situations or events were included in the educational script. The question battery provided an excellent forum to promote and then to reinforce, the development and implementation of health-enhancing behaviors (diet, exercise, stress reduction), all integral aspects of home-based self-care.

The educational format of the information transfer typically consisted of a question related to a key facet of care and included answer options and related follow-up dialogue to each answer. The follow-up would consist of another question for further assessment, a motivational statement, a directional statement, information, education, and/or an incentive for the patient. For each dialogue, the healthcare organization assigned a risk category to each possible response (i.e., *low-risk*, *medium-risk*, and *high-risk* answers). For example, a high-risk dialogue might accompany the response to daily blood sugar monitoring and appropriate insulin dosage and administration, while a medium-risk classification might be assigned to assessment of knowledge and performance of prescribed diet and exercise regimens. In contrast, a low-risk dialogue could include monitoring of self-checks for swelling or weight gain. Daily and cumulative responses to the question battery were automatically risk-stratified for timely review and intervention. If high-risk symptoms or behaviors were flagged, the nurse care manager would typically call the individual and provide counsel, often including a recommendation for the patient to call a physician. In the case of a potential medical crisis, the nurse manager would contact the physician.

Example dialogues (actual dialogues are proprietary)

Behavior Question

Did you check your blood sugar today?

- Yes ? Very Good!
- No ? Checking your blood sugar is very important. You should do this now.
- Not Yet ? Checking your blood sugar is very important. You should do this now.

Symptom Question

How much insulin did you take today?

Use the arrows to indicate the number, then push OK.

Knowledge Question

How many times should you exercise each week?

1. Once or twice ? No, not quite. It is important to exercise five times per week with each exercise session lasting at least 30 minutes.
2. Three times ? No, not quite. It is important to exercise five times per week with each exercise session lasting at least 30 minutes.
3. Five times ? You are absolutely right! Good job.

DATA MEASURES

Two data sources were used in this investigation. First, the nurse care manager documented, and provided to the researcher, values for the clinical marker, HbA1c, during the pre- and post-time periods. The investigator pulled core data for this investigation from an inclusive set of hospital system claims data extending from January 1999 through June 30, 2001. The raw data included a number of items: health system assigned medical record number (MR#s); an account number identifying the encounter; the financial class for service remuneration; a listing of the facility from which the care was provided; admission and discharge dates; length of stay; total charges for the encounter; age; a brief description of the admitting problem; and a coding by ICD-9CM classification. The hospital system assigned a study identification number, placed individuals into either control or test groups, and documented whether each test participant requested for the intervention to be provided in Spanish or English.

This researcher cleansed the raw data to remove all encounters not associated with primary, secondary, or tertiary DM related ICD-9CM codes. These exclusion criteria removed utilization episodes for admitting diagnosis of dermatological, obstetrics/gynecological, musculoskeletal, orthopedic, traumatic, oncology, psychiatric, and surgical origins. Additionally, admissions associated with worker's compensation claims were not included in the analysis. Fifty codes were used to depict DM and associated manifestations, with some additional codes used to capture medical intervention for specific complications associated with DM such as kidney failure, or retinopathy (see Appendix B).

Variables associated with the medical encounter or episode of care were analyzed. The encounter variable included the initiation and inclusive medical course of care for a particular admitting diagnosis. The encounter variable was measured by number of medical care encounters. For example, an individual may have had six encounters with the health system during the pre-time period, and then four encounters with the healthcare system during the post-time period. Aggregate number of medical encounters, sum of total charges, average charge for all encounters, and average number of encounters per individual and average charge per individual were determined. A composite view of the 1999 total population is shown in Table 3.

Table 3. 1999 Population Utilization for DM Related Conditions

Study information	1999 Total population
Number of medical encounters	9,699
Number of individuals	4,662
Sum of total charges	$43,361,756
Average charge per encounter	$4,471
Average number of encounters per individual	2.08
Average charge per Individual	$9,301

In this investigation, data were disaggregated into the physical facility setting or location of medical care delivery. Three general types of settings were defined: inpatient, outpatient, and emergency room. Inpatient classification included hospital service labels of ambulatory medical, ambulatory surgical, and inpatient care. Outpatient activity included encounters provided from three freestanding clinics scattered throughout the city reflecting medical care, nursing, and physical therapy. Emergency care included encounters performed in the hospital emergency room or a freestanding urgent care center. (Post-discharge care, that is, services delivered in a skilled nursing or long-term care facility, was reviewed, but a small sample size precluded analysis.)

In addition to a direct assessment of health status (HbA1c), user patterns for clinical care were investigated. Specifically, the researcher sought to determine if telehealth altered facility utilization, reduced individual medical care encounters, mitigated the level or severity of care (as measured by charges), and shortened length of stay (for the inpatient setting). Since an objective of the investigation was to evaluate if the intervention could reduce high-cost emergency room and inpatient medical intervention, a review of population patterns can be insightful (see Table 4).

Table 4. 1999 Population Proportional Utilization by Facility Setting

Study information *1999 Total population*	**Inpatient**	**Emergency room**	**Outpatient**
Participants receiving care	1,747	477	3,761
Number of individuals	4,662	4,662	4,662
Proportion of participants who received care	37.47%	10.23%	80.67%

Analysis of glycemic control was performed by a retrospective review of glycosylated hemoglobin (HbA1c) percentage values by group and time. Lab values were available for review if the individual received medical care from the hospital system primary care physician group. Accordingly, such lab values were documented as an aspect of an electronic medical record. The internal nurse care manager performed the review. One hundred fifty two individuals from the test and control groups (72%) had documentation of at least one glycosylated hemoglobin value during the period of investigation. Values ranged from 5.3% to 21.7% with a goal for this population group of 7.0%.

Delimitations

The subjects involved in this study were a distinct population subset of underserved, underfunded, dominantly Hispanic individuals receiving medical care for the chronic condition DM. The geographic area of study is unique in terms of proximity to Mexico and incidence of disease frequency and severity. Consequently, these factors should be considered when generalizing findings to other populations. Health status and resource utilization were analyzed from data provided by the healthcare system. Additionally, the study or sample size was determined by the healthcare system and reflects personnel, administrative, and resource limitations. However, group and sample size was controlled in the statistical analysis performed in cooperation with The University of Texas Academic Computing and Instructional Technology Services.

Historically, scholarly evaluation of telemedicine or telehealth studies has been inadequate (Field, 1996; Masys, 1997). This study addresses some previous concerns thus providing both an independent evaluation and a comprehensive utilization study. However, by nature of the study design, if improvements in health and decreased utilization were achieved, the precise method fostering the health improvement may be obscured. That is, were the benefits derived from daily clinical information transfer and consequent enhanced medical care, or from improved individual health knowledge and behaviors, or both? Moreover, as the control group intervention consisted for the most part of an absence of intervention--did the method of delivery matter? Would traditional disease management and aggressive patient management have presented the same outcome?

These and similar concerns were voiced by Hersh, Patterson, and Kraemer (2002) in regard to an ongoing demonstration study funded by the Centers for Medicare and Medicaid Services (CMS; previously the Health Care Financing Administration) in the state of New York. The New York study is designed as a randomized controlled trial and is being conducted by a statewide consortium with an overall goal of assessing feasibility, acceptability, effectiveness, and cost-effectiveness of telemedicine in the management of Medicare beneficiaries with diabetes (Shea et al., 2002). Shea et al. responded to criticism of study methodology by acknowledging the inability to practically separate the electronic medium for delivering diabetes care from the care itself—an incapability to artificially simulate electronically delivered care.

A significant design limitation of this Laredo study involved the selection or assignment of individuals to the test and control groups and the dissimilar sample size of the control cohort. Recruitment methodology was determined by the healthcare system with field assignment to the test group taking priority over assignment to the control group. Consequently, the assignment methodology favored test participant recruitment. Although the size of the control and test groups was nonequivalent, this researcher believes the sample provided a realistic description of the study population. Selection bias should be considered when extrapolating the results of this investigation to other populations.

Some statistical procedures, such as repeated measures analysis of variance (ANOVA), were hindered by individual variation in facility usage, which resulted in an unbalanced repeated measure data set. For example, some individuals may not have received or sought care from a particular facility during the pre and post time periods. Additionally, for controls, pre-control patient days were 49% less than post-control patient days and jeopardized comparison between test and controls in some statistical procedures. In particular, the discrepancy in control patient days influenced cost per patient day comparison analysis. A sham device was not used for this cohort because of the difficulty to mimic electronic care. Fifty-one percent of the control group participants were administered a standardized self-health assessment at scheduled intervals, while the remaining control group participants received standard care.

As discussed in more detail in the Methods section of this document, qualification criteria included targeting a population with the greatest need for intervention: underserved, underfunded diabetics. Although educational level was not directly accessed, a sixth-grade-level reading competency was necessary for the participant or the caretaker. Additionally a critical component for successful home-based management of DM is the ability to obtain blood samples, interpret the findings, then measure, draw, and administer the appropriate insulin dosage. This study does not address kinesiological or cognitive aptitude necessary to perform these tasks. However, new technology, although not available for this study, does decrease the burden for the patient by automatically analyzing the blood sample and calculating the required insulin dosage while recording the episode in a digital format.

A major component of the study analysis depended upon the accuracy and integrity of Mercy Health System's claims data. However, the "charge" associated with care does not accurately reflect the actual "cost" to provide the service. Charges are specific to a particular institution and therefore potentially limit broad-based or absolute application. Furthermore, charges are considered a proxy for intensity of care received.

An important limitation of the study is the unknown cost incurred by the health care system for the Health Hero Network® and related devices. Additionally, the personnel costs for monitoring and managing the caseload were unknown, although the known staffing burden was a Registered Nurse (1 full-time equivalent). According to the health system, the majority of the start-up costs were covered by a telecommunication infrastructure (TIF) grant. Obviously, the omission of health system related costs does not allow a precise analysis of cost-effectiveness and cost-savings.

Frequency and duration of care are consistent parameters, generalizable across settings, and represent core problems of high-cost intervention. This study reviewed only diabetes or diabetes-associated encounters. This limits broad-based analysis of the intervention's overall impact on individual health and patterns of access to the healthcare system (for example, emergency room use versus outpatient care for non-diabetic-related conditions). Furthermore, only a small sample of individuals had documentation of both a pre- and post-time period HbA1c. This sample inclusion limitation could be a shortcoming of the investigation. However, statistical methodology to adjust for the small sample will be utilized.

The study design is similar to that used by Tilly et al. (1995), where patients receive the intervention, then are followed for an appropriate interval. An advantage of this study over Tilly's is the inclusion of a control group, although caveats associated with applied clinical outcome research remain. Tilly et al. described three main potential problems: history, statistical regression, and maturation. In brief, a potential problem of outcomes study is the passage of time. A change in HbA1c or encounter frequency and duration could have occurred because of some influence other that the study intervention. Another influence could be the selection of patients who were in compromised health, or in crisis, with improvements expected with or without intervention. Finally, a maturation effect could occur if change in HbA1c could be attributed to a biological or psychological process that systematically varies with time (Tilly et al., 1995). Statistical methods were used to address these potential conflicts for this segment of the study population.

Conceptually, a potential limitation of this study's attempt to improve behavioral and lifestyle modifications is the reality that for many, positive expectations associated with compliance are low. There tends to be a lack of hard incentive to change health behavior, since a return to "normal" health is not a realistic expectation for many individuals. This concern broaches the application of an important construct, self-efficacy, the belief that you can perform the new behavior and that the new behavior will be effective in improving your health status. Indeed, Lewis (1997) questioned the ability to enhance self-efficacy when emotional and cognitive perceptions are related to illness and cannot be diminished. She referred to work by Parcel (1994) in reference to the question: "In the case of chronic life-threatening illness, is self-efficacy mutable?" In this application, although the disease is chronic, the condition is not immediately life threatening, thus the value of self-efficacy remains high.

Data Analysis

The inimitability of healthcare data presents analytical challenges. For example, on a yearly basis some individuals may be exposed to the healthcare system for only a single encounter or interaction, while others may experience upward of 20 episodes or interactions. An individual may receive care in multiple facilities over the course of a year, but may not receive any services from a particular setting in the following year. Additionally, given the variability of medical care necessary for a particular admitting diagnosis, an encounter may range from a single care event or procedure to weeks, or even months, of intervention. This diversity of individual healthcare experience data promotes interpretation of results at an aggregate level. Furthermore, variability in the data set is also a function of physician practice patterns concerning documentation for glycemic control markers; this information is not available for all individuals.

The rich and varied data sets generated in this study were analyzed by a variety of statistical techniques. Specifically, *t* tests, *z* tests of proportions, descriptive tables, means, percents, ordinary least squares regression (OLS), and multivariate repeated measures analysis of variance (ANOVA) were used. OLS regression provided a review of several explanatory variables by reducing unexplained variance and improving predictive capabilities (Wonnacott & Wonnacott, 1981). Regression analysis was selected as a statistical tool that introduces as much control as possible into an observational study (e.g., it compensates for nonrandomized data) (Wonnacott & Wonnacott, 1981). Doubly repeated measures (multivariate) ANOVA method to describe the model was used to analyze the charge per patient day, from multiple categorical independent variables. A balanced data set was created by replacing missing values with zero values (when an individual did not receive health services from a setting). A description of the statistical approaches chosen for each research question follows.

RESEARCH STATISTICS USED TO ANSWER STUDY QUESTIONS

Question 1. Does analysis of the HbA1c medical marker reveal the existence of significant differences among the test and control groups ($p <= .05$)?

Descriptive *t* tests were used to analyze means between groups (post-test to post-control) and within groups, over time (pre-test to post-test and pre-control to post-control). *T* tests compare means between two groups, assuming each population has a normal distribution and the same variance. Practically, these assumptions are sometimes violated with a small affect on the conclusions (Hays, 1988). The *t*-test calculation analyzes whether there is a statistically significant difference between the means of two groups. A chart was also used to provide mean and percent comparison of the changes experienced by the test and control groups during the study period.

Question 2. Is aggregate (total) utilization, in the form of individual encounters per year and charge per individual, significantly different between test and control groups ($p <= .05$)?

Charts and tables can illustrate investigative results by comparing and contrasting total pre-group to post-group activity. The graphic analysis of total charges and number of encounters aptly depict comparison utilization. Relative ratios, charge per patient year, and encounters per patient year are helpful in determining and clarifying the intervention impact. Multiple regression (versus bivariate regression) provides an improved explanation of the dependent variable because most occurrences have more than one cause (Lewis-Beck, 1980). This is an important consideration for this investigation as independent variables such as age, gender, language, financial status, and, perhaps most important, prior health status (i.e., pre-time period encounter and charge history), influence prospective health service utilization. For this research question, regression techniques help describe the post-total charge per individual (dependent variable).

The assumptions of equal variance, linearity, and normality were all investigated for each model considered. The assumptions of equal variance and linearity appear to be more valid when the dependent variable has a distribution that is less skewed and more normal. Examinations of residual plots, curve estimations, and statistical tests for equal variance can help suggest appropriate transformations and control variables needed to improve the models to meet these assumptions.

The final regression model was determined by investigating many models with different combinations of independent variables. The independent variables are both categorical and continuous. The importance of a variable depends on the variable's ability to control for variance as well as its relevance to the investigation. For this analysis, the most important variable to examine was the intervention group assignment, test versus control. The following regression model was used:

$$Y_{(logpostcharge)} = a + ß_1 x_1(Log)(PRETOTChrg) + ß_2 x_2(FEMALE) + ß_3 x_3(AGE) + ß_4 x_4(TEST) + ß_5 x_5(LANG) + ß_6 x_6(POSTSP) + ß_7 x_7(DIFPD) + ß_8 x_8(PSTCNT) + ß_9 x_9 PRECNT) + E$$

$Y_{(logpostcharge)}$ = Log transformation of total individual charges during the post-time period activity.

$LogPRETOTChrg_{log}$ = Log transformation of total individual charges for pre-time period activity.

FEMALE = Females subjects as compared to male subjects.

AGE = Age of test and control subjects.

TEST = Test group as compared to control group.

LANG = Language by which messages were delivered

POSTSP = During the post-time period, the financial classification of self-pay as compared to Medicare/Medicaid and third party sources.

DIFPD = Difference in pre-patient days to post-patient days, justifies charges to days over which they were derived, and controls for inaccurate data

PSTCNT = Number of encounters during post-time period

PRECNT = Number of encounters during pre-time period

The final regression model controlled for pre-time period total individual charges, gender (as females comprised 75% of the study participants), age (cost rises with increase in age), language, financial status, difference in pre- and post-patient days (charges and encounters are related to number of days reviewed), and the pre and post number of encounters.

Question 3. Do emergency room, inpatient, and outpatient facility demonstrate a significant difference ($p <= .05$) between test and control groups for:

1. the number of individuals who sought care,
2. the number of encounters per individual, and
3. charge per individual.

Z tests of proportions were used to determine if there was a statistically significant reduction of the proportionate number of individuals (patients) who required services from the various settings. This test used a standardized score, with the standard deviation as the unit of measurement. The *z* test of proportions was used to analyze the probability of individuals who received care from a particular setting compared to the probability of not receiving care from a particular setting. Since the null research question included an a priori assumption that the intervention will decrease the need for care, a one-tailed test was used in the analysis.

Encounter frequency, charge per facility, mean charge per individual, and mean charge per encounter were analyzed with descriptive statistics and displayed in the form of charts, graphs, and tables.

To conduct repeated measures ANOVA for comparison of charge per individual per day per facility, the assumption that individuals could access all three facilities was adopted. All possible combinations of pre and post time period charges were described for the three facilities. The data set was balanced by analysis of each individual's pre and post period utilization patterns. If an individual did not receive or require services from a particular setting during a time period, a place-keeper value of zero was inserted, thereby balancing pre- and post-activity. For example, if an individual did not require emergency room services during the post-time period, a place-keeper value of zero was inserted into the data set to document the experience.

While regression predicts the dependent variable based on the effect of independent variables, ANOVA compares the two groups to see if there is a measurable difference between them. An advantage of ANOVA is the ability to test interactions between the variables, an important factor when considering real-world issues. Obviously, this is an important consideration for appropriate direction of healthcare intervention and prevention activities.

ANOVA compares two or more means to see if there are reliable differences among them. The general method for ANOVA analyzes the estimates of within-group and between-group variance (Tabachnick & Fidell, 1996). With the repeated measures data there is a time effect by the different groups. This can violate the assumption of homogeneity of variance. To resolve this issue, the model can be modified from the regular singly multivariate technique to a doubly multivariate technique. The model allows repeats over time and among facilities.

Differences among within- and between-group variances are evaluated as ratios, where the variance associated with sample means is in the numerator and the error variance in the denominator. This ratio between the two variances forms the *F* distribution and serves as a test for the null hypothesis. *F* is calculated by the division of mean square (MS). MS is the division of the sum of squares by degrees of freedom and is the variance.

$F = MS_{between}/MS_{within}$

Comparing the calculated *F* to a critical *F* tests the null hypothesis. The larger the *F* value, the higher the significance of difference between the two groups. A measure of the main effect for multivariate analysis is Wilks' lambda, a measure of strength of association. ? , the determinant of the error matrix, is the variance not accounted for by the combined dependent variables. So (1 - ?) is the variance that is accounted for by the combined dependent variables (Tabachnick & Fidell, 1996). The ANOVA format allows analysis of multiple main effects (time, group and gender) including interactions such as (time*group), (group*facility), and (time*facility).

In order to answer the research question, a dependent variable was created and called charge per individual per day. This variable was calculated from total individual charge divided by the number of days over which the charges were measured (patient days). In this type of analysis, the dependent variable is measured at several points in time (during the pre-time period or post-time period and within the three facilities). A participant receives care in pre- or post periods and at one or more of the different facilities (inpatient, outpatient, or emergency room), thus doubly repeated measures. After investigating many models with different combinations of variables, a doubly multivariate ANOVA model was selected.

Variables used were:

Charge per individual per day = Calculated from total individual facility charge divided by the total number of days (patient days) during the pre- and post-time periods over which utilization (charges, encounters) were measured.

Time = Pre-time period or post-time period.

Group = Test or control group.

Gender = Male or female.

Facility = Inpatient, outpatient, emergency room settings.

The between-subject independent variables were the group variable and the gender variable. The major dependent variable was the charge per individual per day in the pre- and post-time periods. When a dependent variable is measured repeatedly for all sample members across a set of conditions, this set of conditions is called *within-subject factors*.

Analysis of variance determines the impact of each variable on the outcome of individual charge per facility per patient day (the major dependent variable). ANOVA allows examination of the extent to which reliable mean differences of the dependent variables are associated with group membership. Since the advantage of ANOVA is the ability to test interactions between the variables, analyzing the interaction is important to this study. The following interactions were analyzed:

Time (prepost)*Gender

Time (prepost)*Group(test or control)

Facility*Gender

Facility*Time

Facility*Group

Time*Facility*Gender

Time*Facility*Group

Results for the doubly multivariate repeated measure ANOVA report the within-subjects main effects, the between-subjects main effects, the between-subjects interaction effects, and the within-subjects by between-subjects interaction effects. As will be noted later, the researcher questioned the accuracy of the pre-control group patient days variable. The variable in question was used in the calculation of the created dependent variable (charge per individual per patient day). It should be noted that this data inaccuracy may have skewed the results from this analysis.

As mentioned earlier, a major advantage to the ANOVA technique is the ability to examine the extent to which reliable mean differences of the dependent variables are associated with group membership. After determining that there was a reliable difference between group means using the ANOVA technique, but at the same time realizing that the use of the possibly inaccurate patient day variable in the creation of the dependent variable could have skewed results, it was decided to also run regression models. By running OLS regression models it was hoped that the data problem could be circumvented. Regression models are appropriate for this data set because regression methods can add control for variables that may influence the prediction of the post-time period charges.

The dependent variable differed for each separate facility model. The dependent variable was the log of the charges for a facility per individual. The major independent variable for these models was the test subjects compared to the control subjects (TEST) and whether the TEST variable significantly contributed to the prediction of the dependent variable. A control variable was used to account for the number of encounters for these charges at the specific facility. Other control variables were added to account for care received at other facilities. The three regression models for the facility analysis included slightly different variables to control for the minor differences in the data for subset of participants receiving care at each facility. It should be noted that the emergency room group of subjects was substantially smaller than the outpatient and inpatient groups of subjects. The following are the final regression models for each facility:

Inpatient Model:

$Y_{(log)(postinpcharge)} = a + ß_1 x_1(\text{Log})(\text{PREINPChrg}) + ß_2 x_2(\text{FEMALE}) + ß_3 x_3(\text{AGE}) + ß_4 x_4(\text{TEST}) + ß_5 x_5(\text{LANG}) + ß_6 x_6(\text{POSTSP}) + ß_7 x_7(\text{POSTMCMK}) + ß_8 x_8(\text{POSTUD}) + ß_9 x_9(\text{ZEROPOST}) + ß_{10} x_{10}(\text{PSTCNT}) + ß_{11} x_{11}(\text{INPVISIT}) + ß_{12} x_{12}(\text{ERVISIT}) + E$

Outpatient Model:

$Y_{(log)(postopcharge)} = a + ß_1 x_1 (Log)(PREOPChrg) + ß_2 x_2 (FEMALE) + ß_3 x_3 (AGE) + ß_4 x_4 (TEST) + ß_5 x_5 (LANG) + ß_6 x_6 (POSTSP) + ß_7 x_7 (POSTMCMK) + ß_8 x_8 (POSTUD) + ß_9 x_9 (PSTOTCNT) + ß_{10} x_{10} (PSTCNT) + ß_{11} x_{11} (PRECNT) + ß_{12} x_{12} (INPVISIT) + ß_{13} x_{13} (ERVISIT) + E$

Emergency Room Model:

$Y_{(log)(postercharge)} = a + ß_1 x_1 (Log)(PREERChrg) + ß_2 x_2 (FEMALE) + ß_3 x_3 (AGE) + ß_4 x_4 (TEST) + ß_5 x_5 (LANG) + ß_6 x_6 (POSTSP) + ß_7 x_7 (POSTMCMK) + ß_8 x_8 (POSTUD) + ß_9 x_9 (PSTERCNT) + ß_{10} x_{10} (PSTCNT) + ß_{11} x_{11} (PRECNT) + ß_{12} x_{12} (INPVISIT) + ß_{13} x_{13} (OPVISIT) + E$

$Y_{(log)(post\_\_charge)}$ == Log transformation of the charges for a facility per individual for post-time period activity.

LogPRE__Chrg = Log transformation of charges for a facility per individual for pre-time period activity.

FEMALE = Females subjects as compared to male subjects.

AGE = Age of study participants.

TEST = Test group as compared to control group.

LANG = Language by which messages delivered.

POSTSP = During the post-time period, financial status classification: Self-pay.

POSTMCMK = During the post-time period, financial status classification: Medicare/Medicaid.

POSTOTHR = During the post-time period, financial status classification: Other.

POSTUD = post-patient days.

PST__CNT = post encounters at a specific facility.

PSTCNT = Total number of encounters during post-time period.

PRECNT = Total number of encounters during pre-time period.

INPVISIT = Dummy variable if any inpatient visit.

OPVISIT = Dummy variable if any outpatient visit.

ERVISIT = Dummy variable if any emergency room visit.

ZEROPOST = Dummy variable if zero for post charges.

The examinations of residual plots, curve estimations, and statistical tests for equal variance lead to the use of several control variables that assisted in model improvements to meet regression assumptions (equal variance, linearity, and normality). The assumptions of equal variance and linearity appear to be more valid when the dependent variable has a distribution that is less skewed and more normal. The importance of variables depends on whether a variable is utilized mainly for its ability to control for variance or whether it has particular relevance or importance to the investigation.

Question 4. Is inpatient utilization, as measured by length of stay (LOS), significantly different between test and control groups ($p <= .05$)?

This question was best answered by a repeated measure ANOVA. The average length of stay was determined by summing all LOS per individual and dividing by the number of encounters. The repeated measures ANOVA used pre- and post-mean LOS as the dependent variables and group (control or test) and gender as the independent variables. Descriptive charts present the comparison for test and control groups, including the mean length of an encounter and the average length of stay (hospital days) per individual.

Summary

The purpose of this chapter was to describe the investigative procedures followed in this study. The research design was explained and the statistical processes for study evaluation were presented. The data sets required multiple levels of analysis, as unbalanced findings characterize clinical care and utilization experience.

CHAPTER FIVE: TELEHEALTH

THE PROSPECT OF IMPROVED HEALTHCARE AND LOWER COSTS

This chapter presents results for the study questions. The data were investigated through a variety of statistical procedures including descriptive statistics, analysis of variance *t*-tests, and regression. In this chapter, the research questions are addressed in a different order to allow for a systematic review of effects. To begin the chapter, an aggregate overview presents intervention results as portrayed over the entire health system. This summary is then followed by a more detailed analysis of individual facility activity. The chapter concludes with a review of individual clinical indicators as measured by the physiological marker HbA1c.

Impact on Healthcare System

RESEARCH QUESTION: Is aggregate utilization, in the form of individual encounters per year and charge per year, significantly different between test and control groups?

Descriptive statistics illustrating study results were useful to answer part of this question. Utilization parameters included encounter frequency, number of individuals receiving care, total charges, average charge per encounter, average encounters per individual, and average charge per encounter. Individuals receiving the home messaging device demonstrated a reduction in charge associated with DM care while individuals serving as controls experienced an increase in charges (see Table 5).

Table 5. Aggregate utilization findings between test and control groups over time, including 1999 population baseline

Study information	1999 Total population	Pre-Time Period Test	Pre-Time Period Control	Post-Time Period Test	Post-Time Period Control
Number of medical encounters	9,699	759	261	522	270
Number of individuals	4,662	133	71	133	71
Sum of total charges	$43,361,756	$1,471,684	$589,213	$757,015	$799,039
Average charge per total encounters	$4,471	$1,939	$2,258	$1,450	$2,959
Average number of encounters per individual	2.08	5.71	3.68	3.92	3.80
Average charge per individual	$9,301	$11,065	$8,299	$5,692	$11,254

The average charge per individual declined by 49% for the test cohort ($11,065 to $5,692) and increased by 36% among controls ($8,299 to $11,254) (see Chart 1).

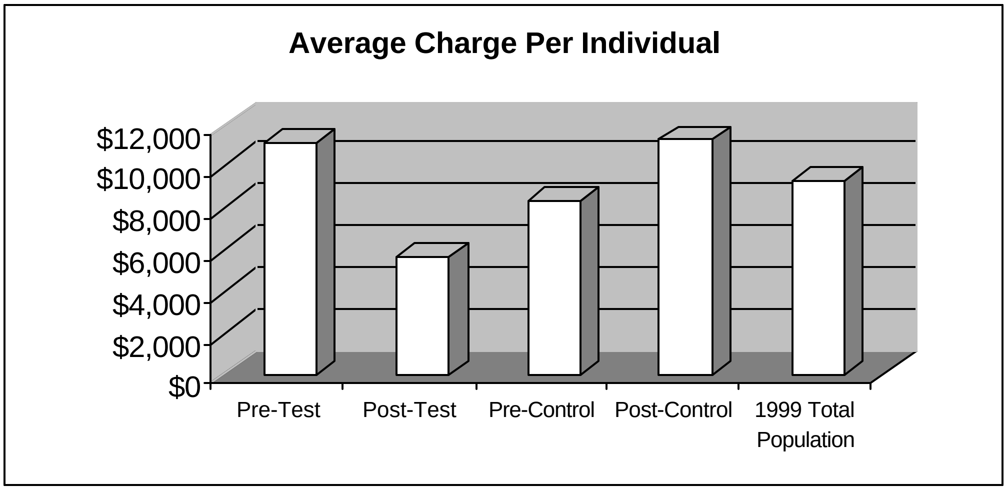


Chart 1. Average charge per individual by test and control groups over time

Charge reduction, from this perspective, was influenced by a reduction in the number of encounters and a decline in average charge per encounter. Average encounters per individual dropped from 5.71 to 3.92 in the test group (-31%) and rose from 3.68 to 3.80 among the control group (3%) (see Chart 2).

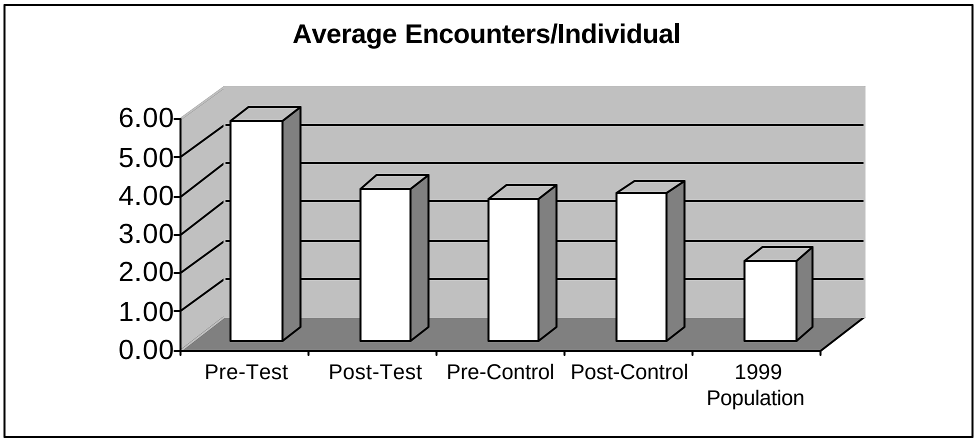


Chart 2. Average number of encounters per individual by test and control groups over time

The average individual charge per encounter declined by 25% for the test group ($1,939 to $1,450), while the charge per encounter rose by 31% for the control group ($2,258 to $2,959) (see Chart 3).

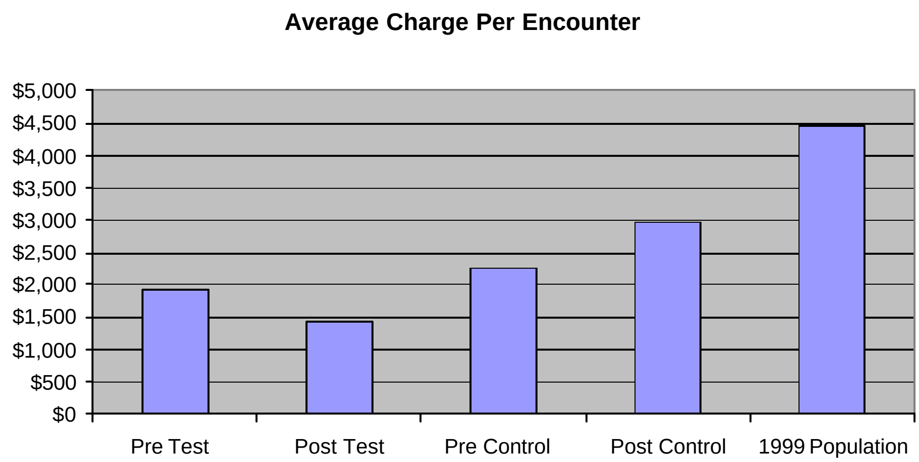


Chart 3. Average charge per encounter by test and control groups over time

The patient day perspective is valuable in presenting relative utilization. For example, although the test cohort pre-test and post-test patient days are similar with 45,956 days accounting for pre-test utilization versus 46,985 post-test days, control utilization displayed a 49% increase in post-control days (from 18,085 to 26,912 days). Consequently, for controls, the calculation of pre-control charge per individual per patient year portrays a meaningful variation from the value found by the charge per individual calculation. Indeed, while charge/individual presented a charge of $8,299, the calculation accounting for patient days reveals a value of $11,892/patient year (as reflective of the unbalanced measurement period, that is, fewer days over which the utilization occurred).

The new adjusted value seems a better reflection of charge activity. Furthermore, as the patient day metric accounts for the time span over which encounters were experienced, the relative ratio of encounters per patient year is a superior descriptor than encounters per individual. This observation is important as an examination of encounter frequency (per patient year) reveals similar frequencies for test and control group, yet an analysis of charge per encounter per patient year portrays a 25% reduction in charge per encounter for the test group while a 31% increase in charge per encounter for control group (see Table 6).

Table 6. Utilization by adjusted patient days between groups over time

	Test group		**Control group**	
DM utilization	**Pre-Time Period**	**Post-Time Period**	**Pre-Time Period**	**Post-Time Period**
Encounters	759	522	261	270
Individuals	133	133	71	71
Total charges	$1,471,684	$757,015	$589,213	$799,039
Charge/Encounter	$1,939	$1,450	$2,258	$2,959
Encounters/Individual	5.71	3.92	3.68	3.80
Charge/Individual	$11,065	$5,692	$8,299	$11,254
Patient days	45,956	46,985	18,085	26,912
Days/Individual	346	353	255	379
Charge/Individual/Day/Individual	$32	$16	$33	$30
Charge/Pt.Year	$11,529	$5,800	$11,892	$10,837
(Encounter/Individual)/(Day/Individual)	0.017	0.011	0.014	0.010
Encounter/Pt.Year	5.95	4.00	5.27	3.66
(Charge/Pt.Year)/(Encounter/Pt.Year)	$1,939	$1,450	$2,258	$2,959

A regression analysis was performed to describe total post-charges per individual (dependent variable) over all facilities. Independent variables were total pre-charges per individual, gender, age, group, financial class, difference between pre- and post-patient days, and pre- and post-number of encounters. The following regression model was applied to aggregate data.

$$Y_{(logpostcharge)} = a + ß_1 x_1(Log)(PRETOTChrg) + ß_2 x_2(FEMALE) + ß_3 x_3(AGE) + ß_4 x_4(TEST) + ß_5 x_5(LANG) + ß_6 x_6(POSTSP) + ß_7 x_7(DIFPD) + ß_8 x_8(PSTCNT) + ß_9 x_9(PRECNT) + E$$

The regression analysis predicted a significantly lower post-charge for test subjects receiving care as compared to the control subjects while holding several variables constant. Furthermore the model suggested post-charges for women were significantly less than those for men, and, as expected, the difference in number of patient days and age were significant predictors of post-charges. Findings also indicated that as age increased, charges increased. Table 7 contains the parameter estimates (coefficients) and the standard error for each of the variables.

Table 7. Regression for total (aggregate) post-charges per individual

Variables[†]	All facilities $N = 202$
Log of pre-charges per individual	0.419** (.099)
Age	0.065* (.015)
Female participants	-0.914* (.401)
Test group	- 0.861* (.369)
Spanish-speaking	-0.627 (.480)
Post-payment self-pay	1.761** (.379)
Change in patient days	-0.003* (.001)
Post-encounters	0.743** (.063)
Pre-encounters	-0.178** (.054)

[†]Dependent variable = Log of post-charges per individual
*$p < .05$. **$p < .01$ $R^2 = .57$

RESEARCH QUESTION: Do emergency room, inpatient and outpatient facilities present a significant difference between test and control groups for: The number of individuals who sought care? The number of encounters per individual? The charge per individual?

Comparative Use of Facilities

Goals of the intervention included a reduction or shift of utilization from high-cost facility of inpatient and emergency room care to outpatient care. Analyzing the change in the relative percentage of individuals who required care from a particular setting is an important indicator of intervention effectiveness. The z-test of proportions analyzed the probability of individuals who received care from a particular setting compared to the probability of not receiving care from a particular setting (see Table 8).

Table 8. Proportionate percentage of individuals per population seeking or requiring care by setting over time

Proportionate receipt of care ***(Individuals seen/Population)***	**Total population**	**Pre-Time Period**	**Post-Time Period**
Inpatient			
1999 Population	37.47%		
Test		48.12%	30.08%*
Control		43.66%	35.21%
Outpatient			
1999 Population	80.67%		
Test		81.95%	71.43%*
Control		74.65%	73.24%
Emergency room			
1999 Population	10.23%		
Test		30.83%	27.82%
Control		19.72%	14.08%

*$p < .05$.

A statistical analysis using a *z* test of proportion was performed (see appendix C). The results indicated a significant *z* proportion for inpatient test group and outpatient test group. In other words, for the test group, in the inpatient and outpatient settings, there was a statistically significant ($p <= .05$) decline in number of individuals receiving medical services. For example, 48% of the test group received inpatient care during the pre-time period while 30% required hospitalization during the study post-time period. Furthermore, the proportion of individuals receiving outpatient care declined from 82% to 71% of the population.

However, emergency room proportionate individual utilization did not demonstrate a significant reduction.

ANOVA

A doubly multivariate repeated measure ANOVA was performed on the data. The dependent variable was the charge per individual per day, which was measured at several points in time (pre- and post-time periods) and place (three facilities).

Variables used were:

Charge per Individual per Day = Calculated from total individual facility charge divided by the total number of days during the time period over which utilization (charges, encounters) were measured (patient days).

Time = Pre- or post-time period.

Group = Test or control group.

Gender = Male or female.

Facility = Inpatient, outpatient, or emergency room facility.

Between-subjects design: Intercept + CT(control or test) + Gender.

Within subjects design: PREPOST + FACIL + PREPOST * FACIL

Interactions include: Time (prepost)*gender, Time*group (control or test) Facility*group, Facility*gender, Time*facility, Time*facility*group, Time*facility*gender

The tests of between-subjects effects was based on the average of the within-subjects trials. For example, the average charges of all six trials of the pre- and post-time period individual charges was computed, and then this mean charge for test subjects was compared to the mean for control subjects. The results indicate that the group assignment had a significant effect on the overall mean charges $F(1,200) = 6.126$, $p = .014$. The between-subjects effects results indicate that gender had no statistically significant effect on the overall mean charges, $F(1,200) = .707$, $p = .401$.

Results were analyzed from the multivariate approach for within-subjects effects. The interactions that contained the facility group variable and the test/control group variable appeared to be the most relevant to the current study. Examining the Wilks' value for the interaction between facility and test/control interaction, it can be concluded that differences between differing charges reliably depends on facility in conjunction with the test/control group. The triple interaction of pre/post by facility by test/control group indicates that differences between differing charges reliably depends on pre/post group in conjunction with facility, in conjunction with test/control group (Wilks' test (.968), $F(2, 199) = 3.268$, $p = .040$). See Table 9.

Table 9. ANOVA for dependent variable charge per individual per day

Multivariate ANOVA Effect	Wilks' Lambda	*F*	Hypothesis df	Error df	Sig.	Obs. power
PREPOST	0.954	9.670	1.000	200.000	0.002	0.872
PREPOST*GENDER	0.998	0.447	1.000	200.000	0.505	0.102
PREPOST*GROUP	0.973	5.569	1.000	200.000	0.019	0.651
PTFACIL	0.914	9.401	2.000	199.000	0.000	0.978
PTFACIL*GENDER	0.995	0.542	2.000	199.000	0.582	0.139
PTFACIL*CT	0.961	4.006	2.000	199.000	0.020	0.711
PREPOST*PTFACIL	0.955	4.698	2.000	199.000	0.010	0.783
PREPOST*PTFACIL*GENDER	0.995	0.461	2.000	199.000	0.631	0.125
PREPOST*PTFACIL*CT	0.968	3.268	2.000	199.000	0.040	0.617

Descriptive charts representing facility utilization over the study period in terms of encounters, number of individuals receiving care, and charges will be presented next.

Emergency Room

Both control and test groups exhibited a decline in the number of individuals who received care in the emergency room setting. Likewise, for both study groups the number of encounters decreased (see Chart 4). Utilization tables are presented in Appendix D.

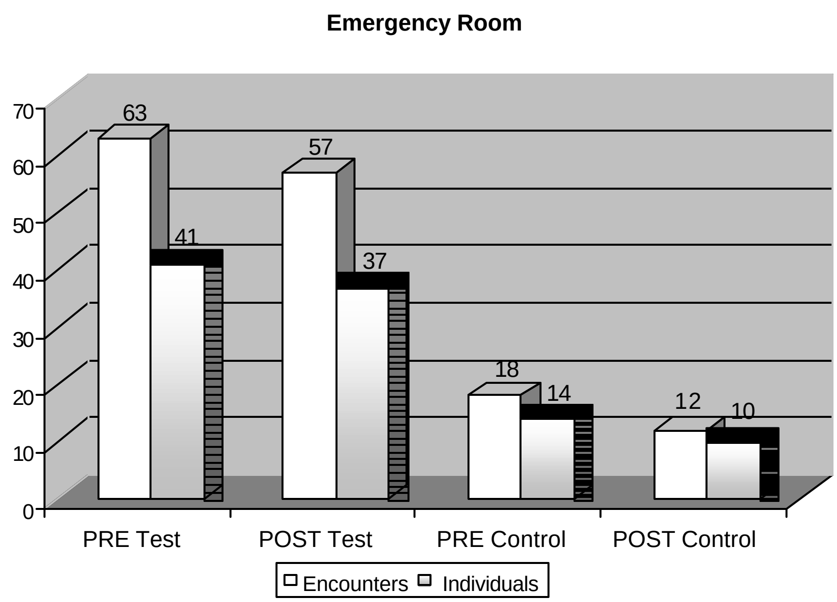


Chart 4. Emergency room volume by individuals and by encounters for test and control groups over time

Total charges associated with control and test group Emergency room care reveal a modest drop for both control and test subjects (see Chart 5). Utilization tables are presented in Appendix D.

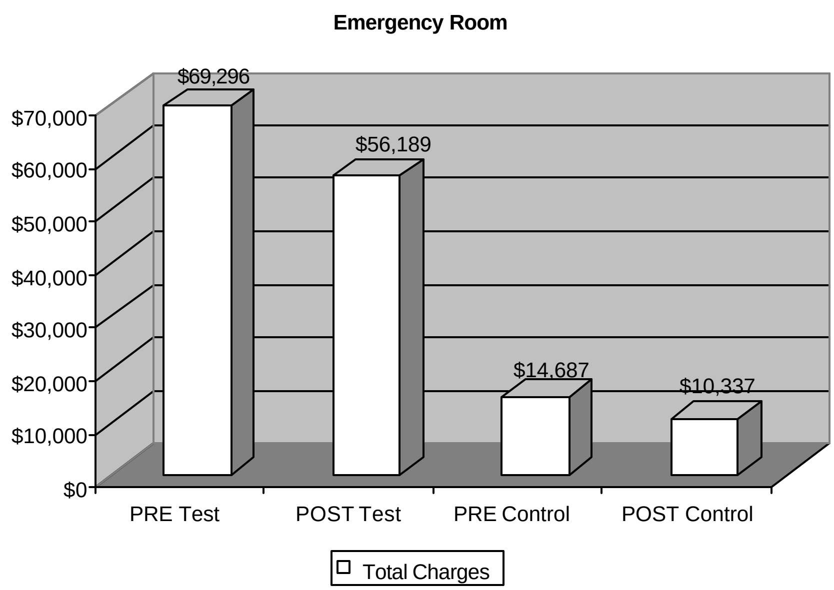


Chart 5. Total emergency room charges by test and control groups over time

Encounters per individual remained constant for the test group while declining slightly for the controls (see Chart 6). Utilization tables are presented in Appendix D.

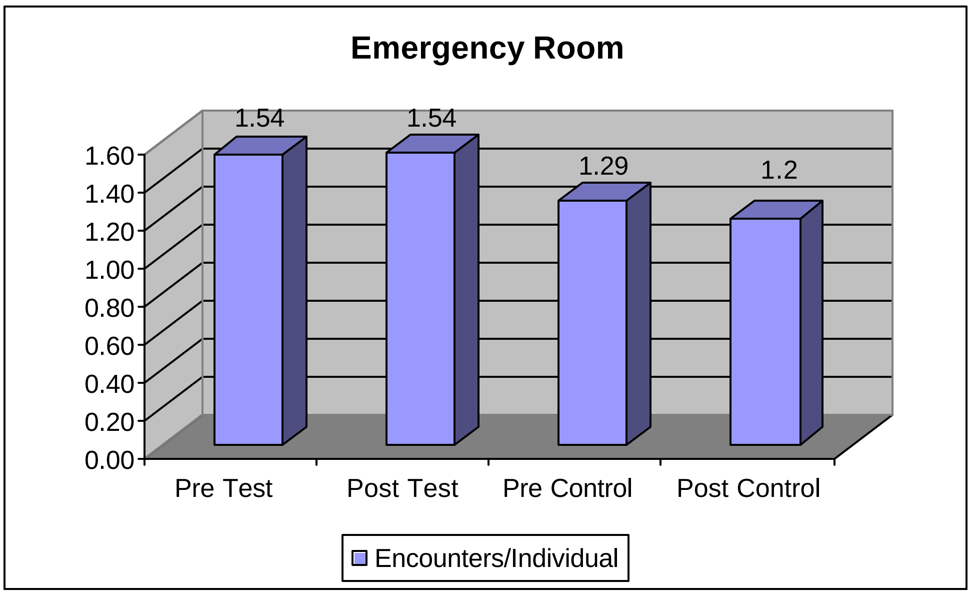


Chart 6. Emergency room encounters per individual by test and control groups over time

Emergency Room Regression Results

A regression analysis was performed to describe charge per individual at the emergency room facility (dependent variable). Independent variables were pre- and post-time period emergency room charges, age, gender, test/control group, language (Spanish/English), post-emergency room encounters, financial classification (measured by form of payment), post-patient days, pre- and post number of encounters, and whether the individual was also cared for at a inpatient or outpatient facility.

The regression analysis did not predict a significant difference in post-charge for test subjects receiving emergency room care as compared to the control subjects while holding several variables constant. As expected, the pre-ER charges were a significant predictor of post-ER charges. The model results also suggested that the number of post-ER encounters compared to other encounters increased post charges significantly. The only other statistically significant result for the emergency room model was that patients who were self-pay patients had significantly higher post–ER charges as compared to the category of other-pay patients. Table 10 contains the parameter estimates (coefficients) and the standard error for each of the variables.

Table 10. Regression for emergency room post charges per individual

Variables[†] *N* = 78	**Coefficients (Error)**
Log of pre-ER charge per individual	- 0.273** (.068)
Age	0.005 (.020)
Female participants	-0.038 (.493)
Test group	-0.452

Variables[†] *N* = 78	Coefficients (Error)
	(.544)
Spanish-speaking	- 0.485 (.584)
Post-ER encounters	2.594** (.263)
Post-payment self-pay	1.456* (.590)
Post-payment Medicare/Medicaid	0.851 (.581)
Post-patient days	0.002 (.003)
Pre-encounters	-0.015 (.061)
Post-encounters	-0.012 (.095)
Inpatient encounter	0.615 (.499)
Outpatient encounter	0.402 (.696)

[†]Dependent variable = Post-ER charge per individual

$*p < .05$. $**p < .01$ $R^2 = .80$

Inpatient

A comparison of inpatient utilization, as measured by total encounters and absolute comparison of individuals who received care from this facility are presented next (see Chart 7). Utilization tables are provided in Appendix D.

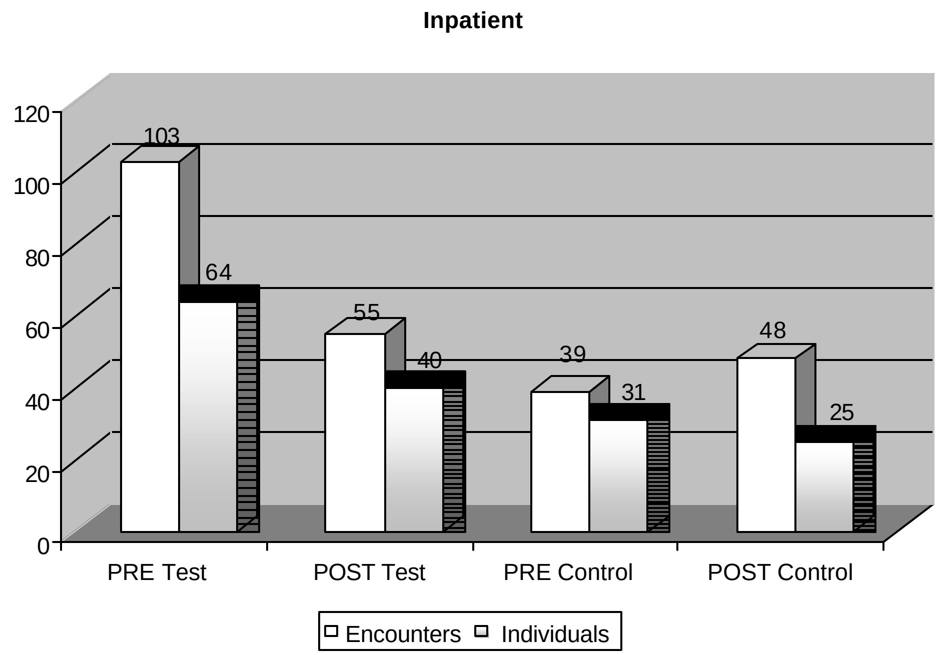


Chart 7. Inpatient volume by individuals and by encounters for test and control groups over time

The findings revealed a 45% percent reduction in encounters for the test group and a 23% increase for controls. The numbers of test subjects requiring hospital services decreased by 38% while the number of individuals receiving inpatient hospital usage for the control cohort decreased by 19%.

The variation among test and control groups for total charges, compared for pre-time verse post-time activity is revealing. A large decline of charges (50%) is displayed for the test cohort. By contrast, controls experienced a 25%

percent increase for total inpatient charges (see Chart 8). Utilization tables are presented in Appendix D.

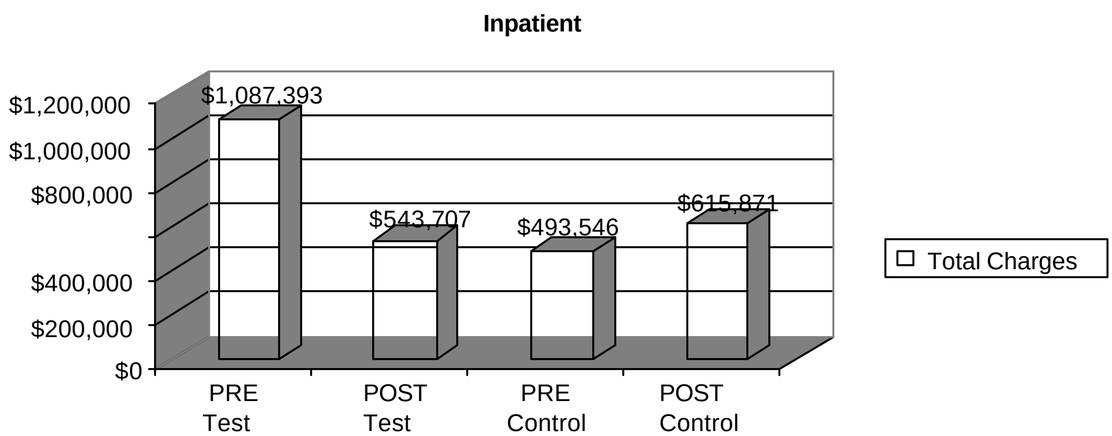


Chart 8. Total inpatient charges by test and control groups over time

Inpatient utilization, as a function of average charge per encounter and average charge per individual were important markers for this investigation. The charge per encounter declined by 6% for test subjects between pre-test and post-test while increasing 2% for controls. However, a large variation was displayed between the groups for charge per individual. Specifically, in the test group the average charge per individual declined by 20% for inpatient services while controls displayed an amazing 55% escalation (see Chart 9). Utilization tables are presented in Appendix D.

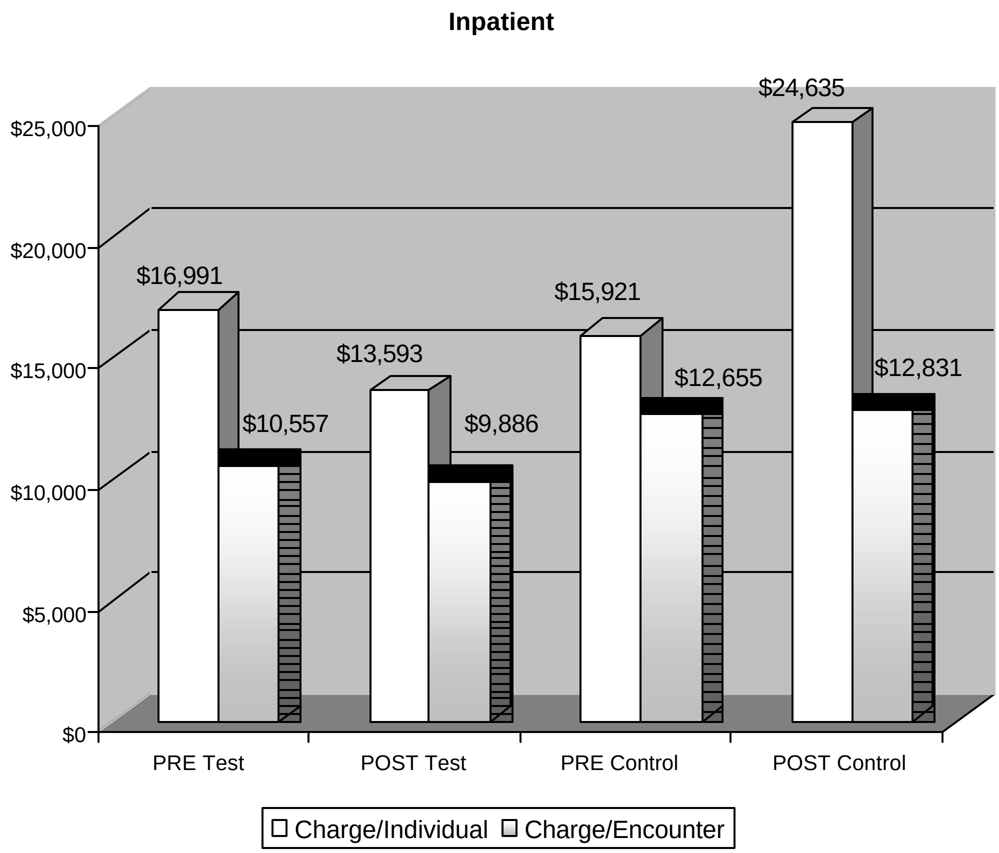


Chart 9. Inpatient charges per individual and per encounter as measured by test and control groups over time

Average number of encounters per individuals receiving care from the inpatient setting contributed to the variance in charge per individual. A 14% reduction of encounters/individual for the test group was noted, while, among the control group, a 52% increase in the average number of encounters/individual was found (see Chart 10).

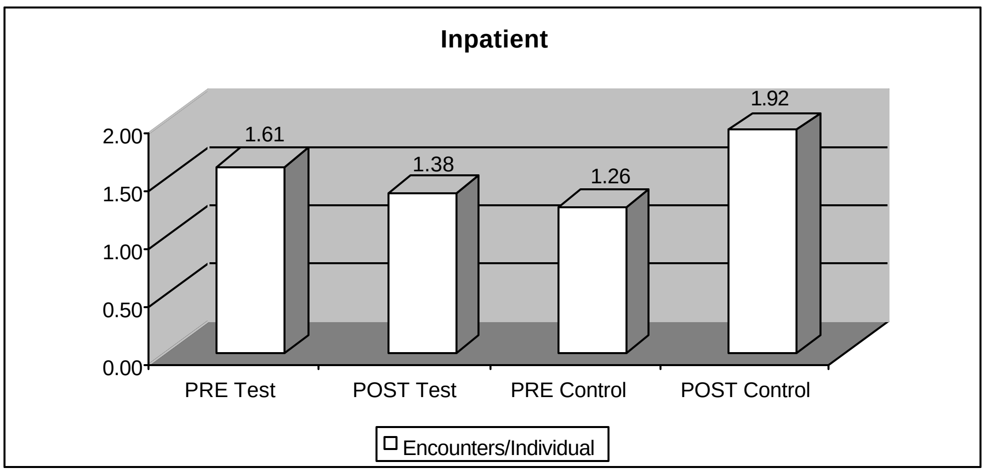


Chart 10. Inpatient encounters per individual by test and control groups over time

Inpatient Regression Results

A regression analysis was performed to describe charge per individual at the inpatient facilities (dependent variable). Independent variables were pre-time period inpatient charges, age, gender, test/control group, language

(Spanish/English), post-emergency room encounters, financial class (measured by form of payment), post patient days, post number of encounters, whether a subject had no post-charges at the inpatient facility, and whether the individual was also cared for at a outpatient or emergency room facility.

The regression analysis predicted a significantly lower post-charge for test subjects receiving care at an inpatient facility as compared to the control subjects while holding several variables constant. As expected, the pre-inpatient charges were a significant predictor of post-inpatient charges. Furthermore, the model suggested post-charges for Spanish-speaking participants were significantly less than those for English-speaking participants at inpatient facilities. Variables that were utilized mainly for their ability to control for variance, but were somewhat irrelevant to the research questions, were whether a subject had no post-inpatient charges and the number of post encounters. If a subject had no post-inpatient charges, as expected, post-charges per individual were significantly less. Again, as logically expected, if post-encounters increased, post-charges tended to increase. Table 11 contains the parameter estimates (coefficients) and the standard error for each of the variables.

Table 11. Regression for inpatient post-charges per individual

Variables† *N* = 118	**Coefficient** **(Error)**
Log of pre-facility charge per individual	-0.309** (.093)
Age	0.024 (.034)
Female participants	0.037 (.799)
Test group	- 1.821* (.836)
Spanish-speaking	-1.930* (.944)
Post-payment self-pay	0.079 (1.318)
Post-payment Medicare/Medicaid	1.521 (1.314)
Post-patient days	-0.001 (.004)
Post-encounters	0.450* (.140)
Outpatient encounter	-1.253 (1.164)
Emergency encounter	0.467 (-1.331)
Zero post-charges	-3.249 (1.779)

†Dependent variable = Post-IP charge per individual

*$p < .05$. **$p < .01$ $R^2 = .44$

Outpatient

The number of individuals receiving care from this setting, including cumulative number of encounters, is presented in Chart 11. Encounters declined by 35% among the test group and decreased by 7% for controls. Individual utilization, that is, the actual number of individuals who received care, declined by 13% in the test group and 2% for controls. Utilization tables are presented in Appendix D.

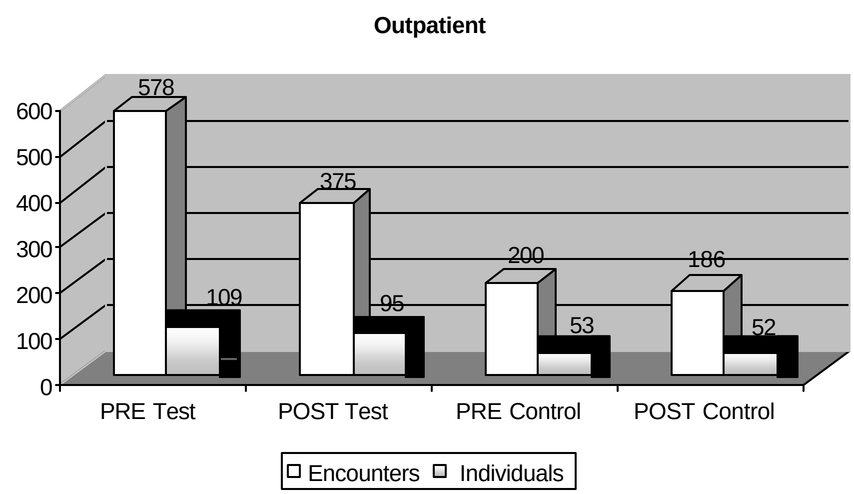


Chart 11. Outpatient volume by individuals and encounters for test and control groups over time

Total charge activity from outpatient settings demonstrated a 30% reduction for the test group and a 76% increase for controls (see Chart 12).

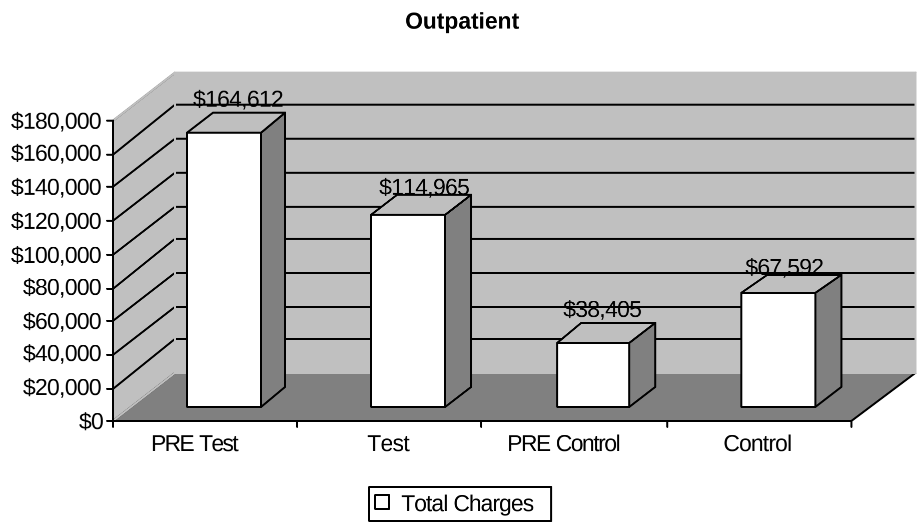


Chart 12. Total outpatient charges by test and control groups over time

Outpatient utilization, as a function of average charge per encounter and average charge per individual were important markers for this investigation. Results of pre- and post-time period activity for participants in control and test groups are visually displayed (see Chart 13). Charge per encounter for the test group increased by $22 per encounter, while for the control cohort, the charge per encounter inflated by 89% during the post period (from $192/encounter to $363/encounter). Average charge per individual declined over time (pre to post) by $300 (20%) for the test group while increasing by $575 (79%) for controls. Utilization tables are presented in Appendix D. A regression analysis for the variable cost per encounter is described later in this chapter.

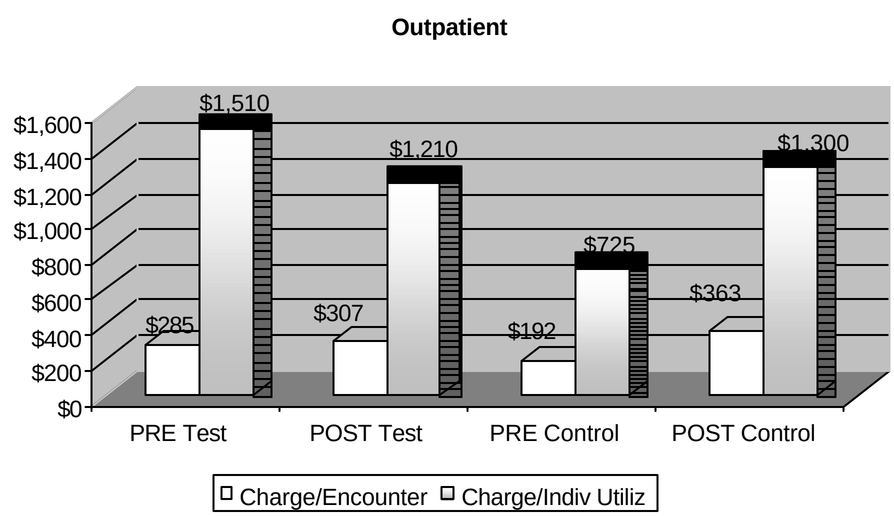


Chart 13. Outpatient charge per individual and per encounter by test and control groups over time

A 25% decline in the average number of outpatient encounters, per individual, was found for the test group. The control group also demonstrated a

5% decline in utilization (5% decline) (see Chart 14). Utilization tables are presented in Appendix D.

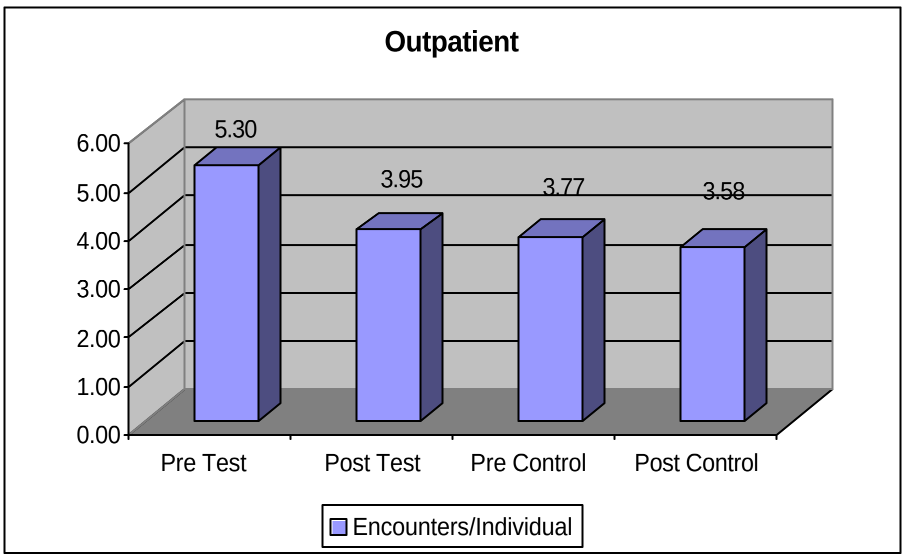


Chart 14. Outpatient encounters per individual by test and control groups over time

Outpatient Regression Results

A regression analysis was performed to describe charge per individual at the outpatient facilities (dependent variable). Independent variables were pre-time period outpatient charges, age, gender, test/control group, language (Spanish/English), post-outpatient encounters, financial status (measured by form of payment), post patient days, pre and post number of encounters, and whether the individual was also cared for at a inpatient or emergency room facility.

The regression analysis did not predict a significant difference in post-charge for test subjects receiving outpatient care as compared to the control subjects while holding several variables constant. As expected, the pre-outpatient charges were a significant predictor of post-outpatient charges. The model results also suggested that the number of post-outpatient encounters compared to other encounters increased post charges significantly. The only other statistically significant results for the outpatient model was that patients who were self-pay and Medicare/Medicaid-pay patients had significantly higher post-outpatient charges as compared to the category of other-pay patients. Table 12 contains the parameter estimates (coefficients) and the standard error for each of the variables.

Table 12. Regression for outpatient post charges per individual

Variables[†] *N* = 179	**Coefficients (Error)**
Log of pre-outpatient charge per individual	-0.187* (.075)
Age	0.01541 (.013)
Female participants	.226 (.369)
Test group	-0.240 (.183)
Spanish-speaking	-0.712 (.440)
Post-facility encounters	0.787** (.137)
Post-payment-self-pay	1.601** (.387)
Post-payment Medicare/Medicaid	2.134** (.436)
Post-patient days	-0.001717 (.002)
Pre-encounters	-0.006266 (.043)
Post-encounters	-.130 (.125)
Inpatient encounter	-0.205 (.339)
Emergency encounter	0.358 (.346)

[†]Dependent variable = Post-outpatient charge per individual
$*p < .05$. $**p < .01$ $R^2 = .57$

RESEARCH QUESTION: Is inpatient utilization, as measured by length of stay (LOS) significantly different between test and control groups (*p* <=.05)?

This question looked at the effectiveness of the intervention from the perspective of loss management. That is, if hospitalization was required, did the intervention decrease the length of hospitalization for the test group? To answer this question, a repeated measures ANOVA began the analysis. Pre and post means for LOS were dependent variables with group (control and test) and gender as independent variables. Although mean LOS decreased from pre to post time periods, the differences were not significant (see Table 12).

Descriptive analysis of LOS is presented from two similar, although slightly different perspectives, i.e., length of stay per encounter and length of stay per individual. Length of stay per encounter dropped by 2% among test subjects, from an average of 5.04 days to 4.93 days, and by 28% (7.21 days to 5.19 days) for controls. Length of stay per individual (Total LOS in days/Individuals requiring hospitalization) declined by 16% for the test group while increasing by 10% for the controls (see Chart 17).

For controls, the decline in encounter length may be a regression toward the mean as the average stay appears to be around five days per encounter. The variance in length of stay per individual between the two groups, could signify that the chance or need for a test individual to be rehospitalized was less. The assumption follows the finding that encounters per individual declined by 15% in the test group while increasing by 53% for controls. Consequently, although the duration of a hospitalization episode may be similar, the need for additional hospitalization is less among test individuals. Utilization tables are presented in Appendix D.

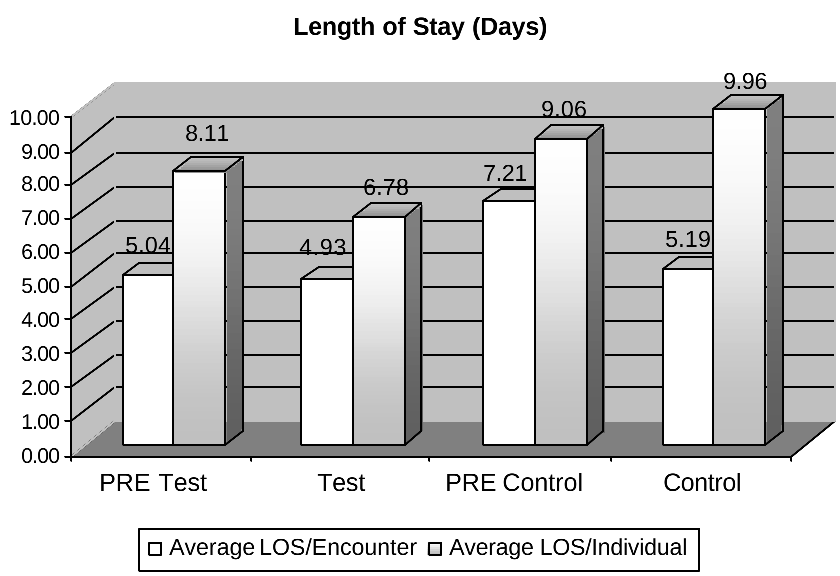


Chart 15. Length of stay for hospitalized individuals by test and control groups over time

RESEARCH QUESTION: Does analysis of HbA1c medical marker reveal the existence of significant differences among the test and control groups?

Despite the unavailability of some medical records and inconsistent documentation found therein, the analysis of physiological markers provides a few insights. Of the 211 study subjects, 151 individuals (69%) had documentation of HbA1c values although only 59 medical records (27%) displayed pre- and post-time period documentation. Forty-one test subjects and 18 control individuals were found to have documented pre and post markers. The average change in HbA1c measurement for individuals with at least two value measurements in the pre- or post-time period is displayed in Chart 16.

The low sample size, especially among controls, cautions against extrapolation between groups. A *t* test between the control and test group was not significant. Given the longitudinal downward trending of the physiological marker, separate *t* tests were performed on the test and control groups. A significance ($p = .000$) was discovered among the test group pre and post scores but control group comparisons were not significant (see Table 13).

Table 13. *T* Tests for HbA1c Values: Paired *T* Tests for Control and Test Groups

Group	N	Correlation	Significance
Control	18	0.445	0.064
Test	41	0.667	0.000

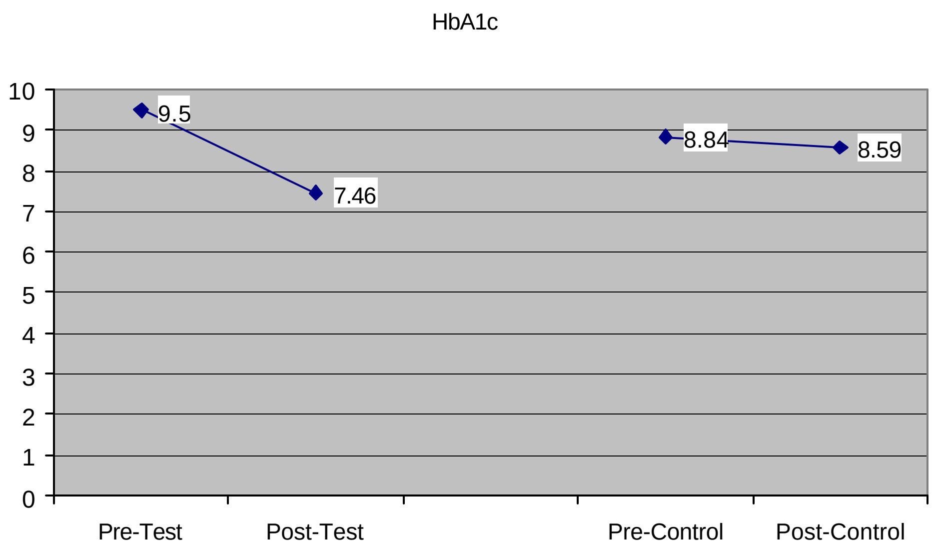


Chart 16. Average HbA1c results within test group and within control group over time

Summary

The investigation of the sample data from a healthcare system serving diabetic individuals indicated that there were significant improvements in mean HbA1c levels and decreased costs per individual for subjects receiving telehealth intervention. Also, a significant change in demand or need for intervention was displayed for inpatient and outpatient facility. The major findings follow.

1. **Significant Reduction in Mean HbA1c.**

   The mean HbA1c level dropped significantly within the test group.

2. **A 49% reduction of charges demonstrated by the test group.**

   The test group reduced charges by over $700,000. Encounters declined by 31% and charge per encounter decreased by 25%.

3. **Significant reduction of inpatient and outpatient admissions.**

   Inpatient admissions were reduced by 38% and the number of individuals seeking outpatient care declined by 13%.

4. **A 50% reduction of inpatient charges for the test group.**

   Findings included a 46% reduction in encounters and a 20% decline in charge per individual.

5. **A 25% reduction of outpatient encounters for the test group.**

   Outpatient activity declined among test subjects.

The next and final chapter provides a summary discussion and overall conclusions for this study. Implications for practice, potential contribution of the study and suggestions for future research complete the report.

CHAPTER SIX

DISCUSSION AND CONCLUSION

The purpose of this study was to investigate if a telehealth intervention could decrease hospital-based utilization and improve clinical outcomes for individuals with DM. The investigation involved a variety of study domains including telemedicine, health education, information science, health behavior, disease management, health administration, and health policy. The wide-ranging inputs included copious historical literature, which demonstrate that research combining the domains is scarce. New intervention methods capitalizing on the rapidly evolving information revolution, specifically the Internet, are becoming commonplace. A sense of urgency to improve clinical outcomes, yet contain or even decrease costs, describes current health policy. In this study, a theoretical foundation was applied to a telehealth intervention for individuals with the chronic disease DM. The investigation focused on the initial impact of the intervention with follow-up studies and long-term assessment strongly recommended.

The investigator reviewed administrative claims data for the study population over a 30-month period to determine utilization and cost variances for three facilities of service. Additionally, a review of the diabetic health marker, glycoslated hemoglobin, provided insight on the impact of the utilization on individual health status. Conclusions drawn from the study are notable since clinical findings improved, while resource consumption declined by over 50% for the test group. Indeed, the demand for inpatient and outpatient care dropped for the test group as individuals sought care less frequently.

Although beyond the scope of this study, comparisons between the population as a whole (represented by a comprehensive 1999 data set of utilization and charge history), and the study population, were instructive. That is, the incongruity for many of the utilization markers between the population and the sample may confirm recent studies of disease burden. The new findings suggest that a population perspective underestimates total individual costs. Factors cited included observations consistent with those found in this study, such as a unique number of encounters per individual, or the need for resources that far exceeded population predictions (Druss, Marcus, Olfson, & Pincus, 2002).

The 1999 population findings of only two encounters per year may signify an underserved DM population. The 1999 population data presented an elevated charge per encounter as compared to the study groups. This finding was perhaps a result of an underserved population with lower encounter frequency and the consequent need for intensive medical services (when required), or a demonstration of the difference between population and individual samples.

Telehealth intervention of virtual care provides more individual attention than traditional healthcare, at a lower cost (Goldstein, 2000). However, as stated earlier in this paper, a definitive declaration of immediate cost savings cannot be determined by this investigator pursuant to the health system's decision to maintain confidentiality of records and not divulge expenses related to equipment, hardware, software and personnel. Nevertheless, the value of a daily connection between individuals living with a chronic disease and the provider community should not be understated. Telecommunication lines, the Internet, advanced software, and powerful personal computers promote cost-effective disease management. As evidenced in this study (as a single individual managed all of the individuals who participated in the study), the capability for asynchronous communication may enhance clinical productivity three- to four-fold. For the remainder of this report, the test group will be referred to as the telehealth group, a title reflective of the intervention and a term more appropriate for discussion.

Home-based delivery of health behavioral strategies, coupled with nonintrusive provider monitoring, could provide a breakthrough in the management of chronic disease. If ecologically delivered health education messages prove to be successful, responsibility for health maintenance and health management will be transferred from the provider to the individual. Yet, providers will be able to monitor vital signs and symptoms on a daily basis, which provides for proactive intervention before a condition escalates.

Care for chronic conditions has consistently entailed about 80% of the overall health cost outlays in the United States (Disease Management, 2000). Therefore, if this form of intervention is successful in improving health at a reduced cost, the benefits to society will be enormous. The virtual format need not be limited to individuals with a chronic disease. Self-directed health management augmented by daily, personalized care plans may prove beneficial for all consumers. Health outcomes, productivity, and most importantly, quality of life will all be enhanced. The major findings described in Chapter 5 will now be discussed in more detail.

Findings

1. **Significant reduction in mean HbA1c.**

   The mean HbA1c level dropped significantly within the telehealth group.

2. **A 49% reduction of charges demonstrated by the telehealth group.**

   The telehealth group reduced charges by over $700,000. Encounters declined by 31% and charge per encounter was reduced by 25%.

3. **Significant reduction of inpatient and outpatient admissions.**

   Inpatient admissions were reduced by 38% and the number of individuals seeking outpatient care declined by 13% for the telehealth group.

4. **A 50% reduction of inpatient charges for the telehealth group.**

   Findings include a 46% reduction in encounters and a 20% decline in charge per individual resulting in an overall 50% reduction of inpatient charges.

5. **A 25% reduction of outpatient encounters for the telehealth group.**

   Outpatient activity declined among test group participants, indicating that the telehealth intervention might effectively address provider and individual information. The virtual satisfaction of information needs may serve as an impetus to reduce traditional clinical office visits.

Discussion of Findings

1. HbA1c Medical Marker

HbA1c values improved significantly within the telehealth group, given that participants experienced a 20% reduction from 9.5% to 7.46%, thereby approaching the target or goal for this population group of 7.0%. Although a significant difference was not found between the telehealth and control group, comparisons within the telehealth cohort (pre to post time period) appear to be more reliable, given the matched number of patient days and the larger sample size.

Do Results Support Past Research Findings?

The results of this investigation support other studies that found that telephone-augmented communication improved blood glucose percentages and reduced diabetic-related crises (Ahring et al., 1992; Meneghini et al., 1998; Piette & Mah, 1997). These studies, as discussed in the literature review, were initial investigations in the new era of information ubiquity. The studies typically investigated weekly interactive reporting or telephone monitoring. An important distinction between this study and others involves the frequency of intervention. In this study, information was transferred on a daily basis, rather than weekly or when self-directed, as in other studies. This detail is important in diabetic patients specifically because daily surveillance of both blood glucose levels and insulin administration provide timely, salient information to medical providers, who can then provide intervention before a crisis develops.

Implications for Clinical Practice

DM is a chronic disease and, in most cases, it tends to be irreversible. Blood sugar control, as measured by HbA1c, improves with appropriate lifestyle modifications (diet, exercise, stress reduction, and medication compliance). The improved medical status can significantly reduce the medical burden associated with frequency and intensity of medical services. The correlation between HbA1c percentages, perceived quality of life, and utilization of health services, are important areas of ongoing review.

In this study, a telehealth application transferred information between providers and individuals daily. The one-to-many communication format allowed management of an expanded population. Clinical efficiency was enhanced, and clinical effectiveness, measured by levels of glycosylated hemoglobin, improved. Given the disproportionate expenditure of resources, and the impending baby boomer demographic shift (with the potentiality of more chronic illness), management of chronic diseases is a critical health policy issue. New initiatives, such as the telehealth intervention studied, are vital for society's management of the challenging healthcare demands of the 21st century.

Theoretical Foundations

A significant decline in HbA1c, which represents improved health and enhanced quality of life for individuals with diabetes, constitutes a tangible, positive outcome from this telehealth intervention. Nevertheless, the identification of causal factors is difficult. For example, did the improved clinical findings result from the daily connection to the medical community, or were improvements a function of lifestyle changes made as a result of telehealth education? Shea et al. (2002), in their ongoing study of telehealth for the management of diabetes among Medicare constituents, agreed that the means are inseparable from the opportunity to reach an expanded population, and to do so in a 24-7-365 format. What is important is the new information connectivity, a revolutionary development toward improved clinical management and health education for individuals with diabetes.

Telehealth intervention for diabetics provides solutions to information needs of both providers and recipients. Taylor's (1991) information use model and theory described effective information transfer as one that depends on context. That is, the end users of the information (physicians or individuals) have their own particular needs. Fulfillment of needs occurs when information is presented within context, and includes specific information traits and uses. Effective information allows for a better understanding of a problem, or may provide motivation for addressing a particular problem. In this study, the information trait that allows providers to review a continuum of daily blood glucose levels and insulin dosages is an important component for improved understanding of how a given individual is managing his or her chronic disease. Furthermore, the daily question bank informs individuals about their disease and serves to enlighten and motivate then, and provides instrumental support for self-management. The daily transfer of information may satisfy or address Covell et al (1985) and Gorman's (1995) discovery of unmet provider information needs, and fit within Cutler's (1985) clinical problem-solving model, wherein information is continuously recycled for an improved end product of better clinical care.

Improved HbA1c may also result from compliance with medical care regimens, including daily assessment of blood glucose levels and administration of an appropriate insulin dosage. A strict diet, a dedicated exercise regime, and appropriate stress reduction strategies all contribute to successful HbA1c management. The nature of the intervention, home-based delivery of daily education and health behavioral messages, supports Bandura's (1986) social cognitive theory and ecological model. Interpersonal, social, cultural, and physical environments are addressed by the intervention. Telehealth has the capacity to provide daily individual instruction within the confines of the home environment, resulting in an increase in the patient's self-efficacy. Knowledge of the health behavior, including the benefits of that behavior, and the confidence that one can perform the behavior, is critical to effecting health behavioral modification.

2. AGGREGATE HEALTH SERVICE UTILIZATION

The regression analysis predicted a significantly lower post-time period charge per individual for telehealth group participants, as compared to that of the control group, while holding several variables constant. The telehealth group participants received the intervention over an average of 353 days per individual. Impressive cost savings of over $700,000 were realized for the telehealth group (n = 133) representing a 49% drop in charges!

Reduction in cost (or charges) may occur from a variety of causes including a decline of service need, a shift of care from a high-cost service to a lower cost setting, a drop in the number of encounters experienced by an individual, shorter encounter duration, and a reduction of the intensity of care associated with the encounter.

In this study the telehealth group experienced a decline in medical encounters and, importantly, a 25% reduction in charge per encounter. This decrease in encounter frequency, and, perhaps more importantly, the reduction in encounter cost, contributed to the significant reduction in charge per individual among the test cohorts. This finding may signify an improved health status for telehealth group participants so that when they do obtain medical care, the care is delivered from a lower cost setting, or the intervention is less complex and therefore less costly.

Do Utilization Results Support Past Research Findings?

Telehealth disease management is an emerging concept. Indeed, the proliferation of disease management organizations and disease management initiatives gives credence to the potential savings and enhanced care outcomes. Edlin (1999) reported a 23.0% decline in diabetic hospital admissions and a 12.3% reduction in direct health costs for a CIGNA regional HMO after a 1-year disease management initiative. However, the hard evidence to quantify the savings from telehealth and or disease management remains elusive (Walker, 2000; Whitten, Mair, Haycox, May, Williams, & Hellmich, 2002). The problem, according to Walker, is a fragmented healthcare system and a lack of integrated data. Walker has suggested the best way to attempt quantification is to follow a specific population over time and perform longitudinal studies as the technology becomes more accepted. In this study, the healthcare delivery system was unified, with the results furnishing an initial attempt to quantify the change in health service utilization over time.

Implications for Health Service Management

A decline in need for inpatient hospitalization for individuals with the chronic disease DM is a dramatic finding. The concomitant reduction of outpatient services, accompanied by improvement in HbA1c markers, gives strong promise to the benefits of telehealth intervention. Factually, charges do not reflect actual costs because bad debt, direct and indirect costs, and a margin of profit can contribute to the charge determination. In addition, it can be inferred that costs could also include indirect consequences of the need for medical care, such as lost time from work and lost productivity. Although this study reviewed clinical outcomes and cost savings for only a limited time span, the long-term potential for improving cost benefit ratios appears promising.

Along with clinical measures, long-term diabetic outcomes should include behavioral, economic, and political analysis for measures such as quality-adjusted life years (QALY) (Ratner, 1997). Ratner suggested that economic studies should include investigation of institutional opportunity cost for money spent on hospitalizing individuals for uncontrolled diabetes, versus using the money for outpatient diabetes education. His cost-utility analysis demonstrated the benefits of instituting a comprehensive diabetes management plan for individuals who have DM. The current study formally addressed cost savings and clinical outcomes, but did not systematically review cost effectiveness or cost utility. However, given the findings, the telehealth intervention does appear to have reduced significantly the need for inpatient care and thus substantially reduced the healthcare system resource burden.

This investigation reviewed a new method of connection among key stakeholders (patients and providers), and the consequences of shifting health responsibility from the medical system to the individual, while maintaining support by the medical community. In the past, goals of improving health while reducing cost to deliver care have seemed to be mutually exclusive. However, new delivery methods such as the type under investigation could prove profitable over time. Even more important are the benefits that accrue to society, as a new health orientation emerges wherein medical care is only a side product, rather than the focus, of individual health maintenance. A healthy, productive work force and the ability to shift resources to other areas of need will stimulate society's advancement in the 21^{st} century.

3. FACILITY UTILIZATION

One key objective of this investigation was to determine if the intervention could reduce the need or shift the need for high-cost intervention to lower cost intervention for DM-related medical conditions. In this study the goal was achieved through a reduction in the number of individuals who received care, a decline in the number of encounters, and a drop in charge per encounter. For analysis, medical services were disaggregated into three settings: inpatient, outpatient and emergency room. An overlying assumption was that appropriate care was available at all times for study participants. The study examined medical efficiency and effectiveness as measured by a review of service utilization. The results indicated a significant *z*-proportionate change in utilization patterns for inpatient and outpatient facilities. Furthermore, regression analysis predicted a significantly lower post-charge for test group participants receiving care at an inpatient facility as compared to control group participants, while holding several variables constant.

Inpatient

Inpatient charges declined by 50% for the test group, representing a charge diminution in excess of $500,000. Findings include a 46% reduction in encounters for the test group and a 38% decline in the number of individual admissions for inpatient services. A 20% reduction in charge per individual was evident for test group participants, while the charge per individual for control group participants increased by a remarkable 55%. However, for individuals who did require hospitalization, the intervention did not appear to influence appreciably the intensity of care or the duration of stay, as represented by length of stay (LOS). The probable reason for this finding is the recognition that all individuals had the disease DM and that while the intervention was effective in preventing hospitalization, when an individual did need to be hospitalized, the intensity of care was consistent with care for this chronic disease. The observation of a 20% decline in charge per individual may very well be related to a mathematical reduction of charges pursuant to a decline in overall costs resulting from lower hospitalization rate. Indeed, for inpatient charges, the telehealth group demonstrated a stable charge per day over time ($2,095 pre-test versus $2,006 post-test) (see Appendix D). The 55% escalation in charges by control subjects reflects, in part, the additional post-control patient days. However, charge per day for the controls increased by 41% (from $1,756/day to $2,473/day) and may represent care for a chronic condition that is gradually escalating (see Appendix D).

This data suggests the intervention was effective in reducing individual utilization of inpatient services. As inpatient costs represented 77% of the overall aggregate diabetic charges in this study, significant savings were consequently realized. Although charge does not equate to cost, the cost associated with the provision of inpatient care far exceeds that of outpatient or emergency room activity. Furthermore, reduction in the "need" for hospitalization implies an improved health status. It seems likely that early intervention, in the form of lifestyle change or primary care provider attention, prevented the need for hospitalization.

Outpatient

The potential effects of the intervention on outpatient utilization were unknown. The goal and strategy of disease management is to provide close contact with individuals, thus encouraging early intervention and appropriate use of primary care settings. Indeed, as a program objective was to reduce high-cost medical intervention, a fear was that the result could be an overburdening of the primary care practitioner.

In this study, total outpatient charges declined by 30% for the test group while increasing demonstrably for the controls. Encounters per individual were reduced by 25% for the test group while declining 5% for the control cohort. Perhaps most importantly, individual demand for outpatient service declined by 13% for the test group, compared to a 2% decline among the control cohort. This finding is notable for the telehealth intervention since appropriate care (improved clinical signs, decreased inpatient use, and decreased outpatient activity) appears to have been delivered.

Emergency Room

Emergency room utilization was difficult to measure because of the small sample of participants utilizing emergency room services. This was particularly the case among controls (*n* = 14). Charge and utilization activity did not change appreciably among the test and control groups. This was a disappointing discovery, since it was hoped the intervention would improve health or foster an enhanced connection with the health system to allow early intervention and appropriate direction to medical service before the occurrence of a diabetic crises. However, the inability to appreciably reduce emergency room utilization is a finding also discovered in other health promotion studies (Ozminkowski et al, 2002), and perhaps reflects cultural and societal issues. This is an important issue and could also be reflective of factors such as financial considerations, the absence of a primary care provider, and a lack of knowledge as to when an emergency room visit is, or is not, appropriate.

An interesting discovery was the realization that emergency room charges for diabetic-related conditions constituted less than 5% of the aggregate or total charge among the three facilities. In the test group, approximately 30% of the 133 individuals sought care from the emergency room, and on average, an individual was seen in the emergency room 1.54 times per year. Despite the low overall contribution to total charges for care, the average charge per individual ($1,500 to

$1,700 per year) is a significant organization burden as these visits are frequently underfunded, if funded at all.

Do Utilization Results Support Past Research Findings?

Diabetic economics have received considerable attention in recent years. A noteworthy finding from this study was the reduction of hospital admissions. This discovery confirms results found by managed care and specialty organizations when they applied a diabetic disease management strategy (Fletcher, 2000; Mari, 1999; Ratner, 1997). Disease management of diabetes, including compliance with home care plans and periodic screening for diabetic complications such as retinopathy, renal disease, and foot ulcers, has been found to be cost effective (Gillespie, 2002). This study confirms significant cost savings pursuant to a diabetic disease management strategy.

This research effort delivered diabetic disease management via telehealth. The study contributes to the literature by defining how utilization patterns may be influenced for a large integrated healthcare system. Historically, telehealth has proved cost effective for only select environments and niche care. The results of this study point to an expanded array of telehealth interventions benefiting the individual, the healthcare system, and society.

Implications for Healthcare Delivery

Early medical intervention for diabetics seeks to address such situations as an escalation of uncontrolled blood sugars before the condition develops into a medical crisis. The timing of the intervention is critical and can only be accomplished if an active relationship or communication channel exists between the individual and the provider. If the situation is discovered in the initial stages, verbal or virtual counseling may remedy the problem without an office visit. Furthermore, improved compliance with the prescribed home care plan of medications, diet, exercise, and stress reduction should potentially reduce office visits for diabetic conditions arising from recidivism.

Virtual healthcare as a surrogate to traditional face-to-face medical encounters is a new area of study. Although this new form of provider-patient relationship will never replace the traditional office visit, the efficiency of the interaction is undeniable. Furthermore, if telehealth can be found to improve health while decreasing outpatient and inpatient utilization and overall costs, the benefits of this form of intervention are potentially groundbreaking.

Theoretical Foundations

Goldstein's delivery model promotes virtual communication as being more effective than traditional medical care because of the availability and personalization of the information. Studies have found that individual satisfaction is strongly associated with the amount of information transferred from the provider to the individual, and that effective communication is linked with improved compliance and advanced health outcomes (Devine, 1992; Hall et al., 1987; Kaplan et al, 1989).

Connectivity and technological advances spearhead a new means of health behavioral intervention. In this study, telehealth geared to the findings of social cognitive theory and more extensive ecological models is delivered daily. Key components for successful health behavioral intervention are addressed through this new medium. Specifically, healthcare plans are communicated along with expected actions and results. Reinforcement and rewards for successful performance of desired activities are provided. Cues to prompt desired actions, advice on coping skills, and motivating reminders to perform tasks such as skin checks or blood glucose checks, all enhance an individual's capability to perform the new behavior.

Contribution of Study

Past studies have demonstrated the high value providers place on information that is germane, valid, easily accessible, dynamic, and cost efficient. Care based on the traditional medical model of face-to-face encounters results in satisfaction of only 30% of physician information needs, with 25% of physician questions remaining unanswered throughout the clinical course of care (Covell et al., 1985). Ongoing health reform and resource scarcity will inevitably reduce the frequency and duration of clinical visits, threatening the efficacy of medical care. Furthermore, the medical delivery system's ability to adequately manage individuals who have a chronic disease has been ineffective and, ironically relegated, given the disproportionate resource consumption by chronic disease patients. However, the Internet and emerging telecommunication environments present some solutions that can allow continuous, low-cost contact with patients.

The fulfillment of patient and provider information needs by a telecommunicative channel promises to improve health and decrease medical utilization. Timely intervention can result in a shift of care away from crisis-based, episodic occurrences. Furthermore, a transfer of conscientiousness from a provider-centered focus (provider “take-care-of-me” philosophy) to a self-directed acceptance of responsibility is expected to improve individual health and decrease resource utilization. The distribution of health information and the knowledge regarding a particular disease state to the end user fosters behavioral change, including compliance with medications, diet, and exercise prescriptions. A new-found sense of self-efficacy can help create a more fulfilling and satisfying relationship between individuals and the health system. This enhanced connection with the health system can improve perceptions of mental and physical health status and contribute to quality of life.

A contribution of this study is its positive evaluation of a new delivery method and philosophy, as they apply to an underserved, predominantly Hispanic population (>99%) living with chronic disease. The multidisciplinary approach of this study draws on several areas of research, including information science (concerning clinical information needs of consumers and providers), cognitive and behavioral theories of health education, health administration, and telecommunications. Health administration and current health policy issues regarding disproportionate healthcare expenditure for a small segment of the population experiencing chronic disease are addressed in this study. This investigation studied telehealth intervention as a means to improve clinical outcomes; reduce provider, patient, and third-party costs; and transfer a sense of responsibility among the chronically ill to maintain and promote their own health.

Telehealth offers new methods to connect individuals to the health provider community as well as a means to deliver ongoing, specific health education. Digital telecommunication lines and the Internet allow individualized, home-based, low-cost connections between individuals and the medical community on a 24-7-365 basis. Such communication ubiquity may alter traditional provider-patient relationships, as individuals become increasingly responsible for their own health status. Self-directed leadership and the concomitant vested interest in personal health could promote adherence or compliance to prescribed health enhancing activities. The new paradigm has medical providers serving as health consultants, as the onus of health responsibility is placed on the shoulders of the individual. These new roles should benefit society by improving individual and population health.

Areas for Future Research

Telemedicine disease management interventions need additional and expanded analyses. This investigation included a review of glycosylated hemoglobin for representation of the health status of study participants. The clinical marker, although an important component of diabetic health, is not a *sine* *qua non* predictor of health. Obviously, longitudinal assessment of health status is necessary to adequately judge clinical effectiveness in the chronically ill DM patient. The benefits of maintaining blood sugars and controlling blood pressure and lipid levels are an improved quality of life. Indeed, compliance with medical care plans may delay or eliminate consequences of uncontrolled diabetes, such as retinopathy, renal failure, and peripheral neuropathy with foot ulcers. Additional clinical markers to improve the validity of health assessment and health improvement could include lipid levels, blood pressure, and urine microalbumin, as well as behavioral outcomes as measured by the SF-36 or Quality-Adjusted Life Years (QALY) and the Perceptual Wellness Survey (PWS) (Adams, Bezner & Steinhardt, 1997).

Follow-up investigations could analyze and measure specific compliance with medical care plans such as the percentage of days an individual failed to check blood sugar levels or to administer the correct dosage of insulin. Detailed analyses of areas of compliance or noncompliance could direct more focused intervention efforts, if needed. Ongoing reviews of blood sugar levels are essential to determine if the preliminary results can be sustained or even improved. Also, questions such as "can individuals be *weaned* from the device without recidivism?" need to be investigated. Furthermore, as this particular study only reviewed diabetic-related admission criteria, an expansion of the study to include all admissions or encounters with the healthcare system could offer significant insights on the efficacy of behavioral attempts to develop a patient-centered medical focus.

A reduction in facility utilization was construed as an indicator for improved health. However, even when reduced utilization is coupled with reduced measures of glycosolated hemoglobin, additional markers are needed. Studies on cultural usage of particular healthcare settings, such as the emergency room, are necessary to ascertain if reduced utilization and improved health co-occur. If there is such a co-occurrence, what factors are involved to create this health usage pattern? In particular, is there a correlation between the absence of an assigned primary care physician and emergency room use? Does the length of time between physician visits influence emergency room use? Does payer source influence emergency room use? How many visits to the emergency room by the population cohort were deemed truly critical, as opposed to using emergency rooms as a routine point of access to the health system?

Although the hospital system described all study participants as unfunded or underfunded, the financial payer, (including out-of-pocket expense in the form of co-pays), may be an important variable to investigate in future studies. Several regression analyses discovered a significant influence of various payer sources to charge per day or cost per individual. In this study, payer classification was merely documented and not formally analyzed. This variable may have influenced the seeking of care from some settings. In particular, the emergency room setting may be a desired location to receive health care because of the payment arrangement. Additionally, future studies could investigate if a change in payer classification over time alters the site or frequency of care as sought by an individual.

Studies of economic impact are necessary to gauge the long-term benefits of the intervention and the impact on health policy. The determination of actual expense to the health care system, absent grant supplementation, is an important consideration for an analysis and should be clarified in future studies. Nevertheless, preliminary data analysis of the effects of telehealth and disease management intervention, as tied to clinical efficacy and cost savings, appear promising. Ratner (1997) suggested additional economic healthcare outcome measures for DM. They include (1) cost benefit ("Within budgetary limits, how can the most good be done for the largest number of people?"), (2) cost effectiveness ("Which system costs less for a given outcome?"), and (3) cost utility ("Is the additional benefit worth the additional costs?"). These additional measures will be helpful in analyzing new telehealth interventions and will inevitably become a staple for analysis of all future healthcare interventions.

Obviously, study design and validity of the investigation are critical issues for any kind of applied research. Analysis of the efficacy of the delivery process, such as refinement of the directed messages and dialogues to better enhance clinical outcomes, is fundamental for evolution of the new delivery paradigm. Refined statistical testing will allow an enhanced assessment of short-term intervention efficacy.

Future studies should address evaluation methods for telehealth interventions. An area of potential weakness for this study was control of selection bias, especially since the selection process was predetermined in the field by clinical practitioners prior to data collection. Matched control and test groups would improve validity and reliability. Usability research is needed to assess nonparticipation impact, particularly why certain individuals declined to participate. Investigation as to why participants chose to drop out of the study or were removed from the study because of noncompliance could also provide valuable insights.

An area not addressed by this study was the educational background of the participants. Although study individuals were presumed to have a relatively low education level, as correlated to their indigent or underfunded, underserved classification, the extent of education may provide insights about the individual applicability of this type of intervention. Another demographic issue could center on a review of participant age; is there a correlation between a particular age bracket and "best use" for the intervention? Also, is there a gender difference for clinical improvements and resource use?

Research to separate the medium from the message—telehealth as distinct from aggressive "traditional" disease management where a nurse is assigned to an individual—could help to quantify or otherwise assess the true value of the communication channel. However, in realistic terms, as voiced by Shea et al. (2002), the means must include the practical capability to reach a significantly greater population, and to do so in a 24-7-365 format.

Improving the perception of the patient community toward the health system is an objective of many institutions. Specifically, health systems desire an improved "connection" with constituents in managing disease. Many health systems wish to develop a "partnership" with the community whereby individuals take responsibility for their own health and work with the healthcare system to obtain the most favorable outcome possible. Therefore, research is needed to determine if telehealth intervention is judged favorably by the patient community, or is possibly seen as an ineffective intrusion of privacy. Ongoing analysis of individual perceptions regarding their respective quality of life status, as measured on both physical and mental scales, may prove insightful. Finally, investigation as to the effect of social marketing on primary care physicians and their staff, in addition to the community, may provide insights on methods to impact overall participation and compliance.

APPENDIX A

Study Participant Demographics

AGE Female Controls	
Mean	57.39583
Standard Error	1.873608
Median	58
Mode	66
Standard Deviation	12.98074
Sample Variance	168.4996
Kurtosis	-0.60112
Skewness	0.005742
Range	55
Minimum	32
Maximum	87
Sum	2755
Count	48
Confidence Level(95.0%)	3.76921

AGE Female Test	
Mean	53.92381
Standard Error	1.102835
Median	54
Mode	48
Standard Deviation	11.30069
Sample Variance	127.7057
Kurtosis	-0.16511
Skewness	-0.15752
Range	51
Minimum	25
Maximum	76
Sum	5662
Count	105
Confidence Level(95.0%)	2.18696

AGE MALE CONTROLS	
Mean	54.59091
Standard Error	2.777974
Median	53.5
Mode	41
Standard Deviation	13.02985
Sample Variance	169.7771
Kurtosis	-0.67699
Skewness	0.394109
Range	47
Minimum	34
Maximum	81
Sum	1201
Count	23
Confidence Level(95.0%)	5.777114

MALE TEST	
Mean	55.21429
Standard Error	2.512065
Median	53.5
Mode	64
Standard Deviation	13.2926
Sample Variance	176.6931
Kurtosis	-0.8542
Skewness	-0.05596
Range	49
Minimum	30
Maximum	79
Sum	1546
Count	28
Confidence Level(95.0%)	5.154327

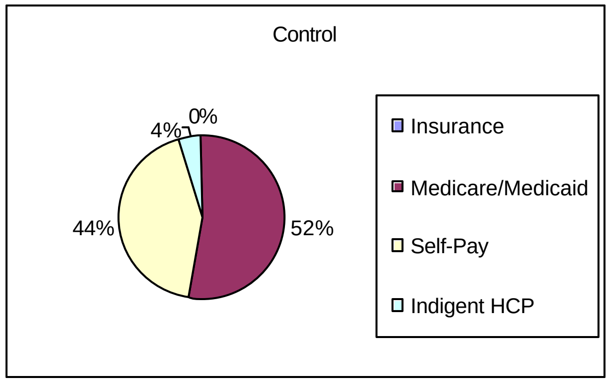
FEMALE DROPS	
Mean	58.16667
Standard Error	6.539198
Median	56
Mode	
Standard Deviation	16.0177
Sample Variance	256.5667
Kurtosis	0.381889
Skewness	0.922975
Range	43
Minimum	42
Maximum	85
Sum	349
Count	6
Confidence Level(95.0%)	16.80952

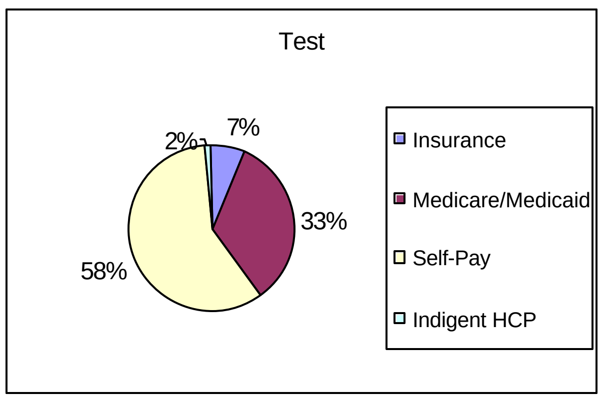
MALE DROPS	
Mean	57
Standard Error	8.18E-15
Median	57
Mode	
Standard Deviation	
Sample Variance	
Kurtosis	
Skewness	
Range	0
Minimum	57
Maximum	57
Sum	57
Count	1
Confidence Level(95.0%)	

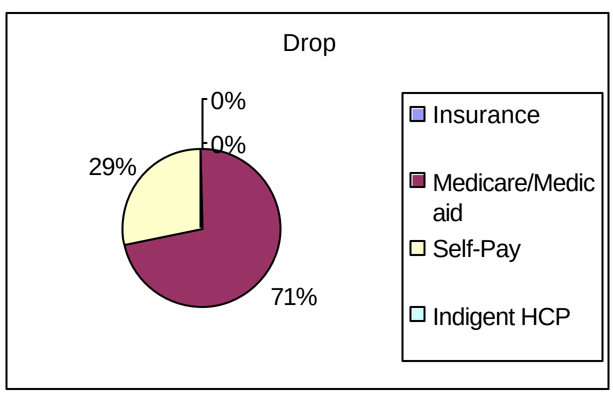
Payor Classifications

Financial Class	Control	Drop	Test
Insurance	0	0	9
Medicare/Medicaid	37	5	44
Self-Pay	31	2	78
Indigent HCP	3	0	2

Payor Classifications







APPENDIX B

Sample Admitting Codes

CODES	Description
2500	diabetes mellitus without mention of complications
25000	diabetes mellitus without mention of complications, Type II (NIDDM)
25001	diabetes mellitus without mention of complications, Type I (IDDM)
25002	diabetes mellitus without mention of complications, Type II uncontroll
25003	diabetes mellitus without mention of complications, Type I uncontrolle
2501	diabetes with ketoacidosis
25010	diabetes with ketoacidosis, Type II (NIDDM)
25011	diabetes with ketoacidosis, Type I (IDDM)
25012	diabetes with ketoacidosis, Type II uncontrolled
25013	diabetes with ketoacidosis, Type I uncontrolled
2502	diabetes with hyposmolarity
25020	diabetes with hyposmolarity, Type II (NIDDM)
25021	diabetes with hyposmolarity, Type I (IDDM)
25022	diabetes with hyposmolarity, Type II uncontrolled
25023	diabetes with hyposomolarity, Type I uncontrolled
2503	diabetes with other coma
25030	diabetes with other coma, Type II (NIDDM)
25031	diabetes with other coma, Type I (IDDM)
25032	diabetes with other coma, Type II uncontrolled
25033	diabetes with other coma, Type I uncontrolled
2504	diabetes with renal manifestations
25040	diabetes with renal manifestations, Type II (NIDDM)
25041	diabetes with renal manifestations, Type I (IDDM)
25042	diabetes with renal manifestations, Type II uncontrolled
25043	diabetes with renal manifestations, Type I uncontrolled

CODES	Description
2505	diabetes with ophthalmic manifestations
25050	diabetes with ophthalmic manifestations, Type II (NIDDM)
25051	diabetes with ophthalmic manifestations, Type I (IDDM)
25052	diabetes with ophthalmic manifestations, Type II uncontrolled
25053	diabetes with ophthalmic manifestations, Type I uncontrolled
2506	diabetes with neurological manifestations
25060	diabetes with neurological manifestations, Type II (NIDDM)
25061	diabetes with neurological manifestations, Type I (IDDM)
25062	diabetes with neurological manifestations, Type II uncontrolled
25063	diabetes with neurological manifestations, Type I uncontrolled
2507	diabetes with peripheral circulatory disorders
25070	diabetes with peripheral circulatory, Type II (NIDDM)
25071	diabetes with peripheral circulatory, Type I (IDDM)
25072	diabetes with peripheral circulatory, Type II uncontrolled
25073	diabetes with peripheral circulatory, Type I uncontrolled
2508	diabetes with other specified manifestations
25080	diabetes with other specified manifestations, Type II (NIDDM)
25081	diabetes with other specified manifestations, Type I (IDDM)
25082	diabetes with other specified manifestations, Type II uncontrolled
25083	diabetes with other specified manifestations, Type I uncontrolled
2509	diabetes with unspecified complications
25090	diabetes with unspecified complications, Type II (NIDDM)
25091	diabetes with unspecified complications, Type I (IDDM)
25092	diabetes with unspecified complications, Type II uncontrolled
25093	diabetes with unspecified complications, Type I uncontrolled
44021	peripheral vascular disease (with DM admitting dxs.)
4254	other circulatory diag, wocc med (with DM admitting dxs.)
7071	skin ulcer (with DM admitting dxs.)
2449	endocrine disorder (with DM admitting dxs.)
43310	extra cranial vasc or proc (with DM admitting dxs.)
6826	cellultis, wo medical (with DM admitting dxs.)
7919	sgn/syp kdy/uri, 18+WO CCM (with DM admitting dxs.)
2138	foot procedure (with DM admitting dxs.)

APPENDIX C

Z-Proportionate Test

	p1	q1	p2	q2	n1	n2	Pooled S. D.	z-score=	
ip-t	0.4812	0.5188	0.3008	0.6992	133	133	0.058808	3.067606	sig at 0.05
ip-c	0.3521	0.6479	0.4366	0.5634	71	71	0.081716	-1.03407	NS at 0.05
op-t	0.8195	0.1805	0.7143	0.2857	133	133	0.051445	2.044905	sig at 0.05
op-c	0.7465	0.2535	0.7324	0.2676	71	71	0.07366	0.191421	NS at 0.05
er-t	0.3083	0.6917	0.2782	0.7218	133	133	0.055796	0.539464	NS at 0.05
er-c	0.1972	0.8028	0.1408	0.8592	71	71	0.062719	0.899254	NS at 0.05

zProb	z for alpha .05-onetail	z for alpha .1-onetail
0.06616785	1.645	1.282
0.06616785	1.645	1.282
0.06616785	1.645	1.282
0.06616785	1.645	1.282
0.06616785	1.645	1.282
0.06616785	1.645	1.282

APPENDIX D

Utilization by Setting

Emergency Room Utilization

DM Utilization	1999 *ER Total Pop.*
Encounters	*530*
MR# (Individuals)	*477*
Total Charges	*$388,691*
Charge/Encounter	*$733*
Encounters/MR#	*1.11*
Charge/MR#	*$815*

DM Utilization	*Pre ER Test group*	*ER Test group*
Encounters	*63*	*57*
MR# (Individuals)	*41*	*37*
Total Charges	*$69,296*	*$56,189*
Charge/Encounter	*$1,100*	*$986*
Encounters/MR#	1.54	1.54
Charge/MR#	*$1,690*	*$1,519*

DM Utilization	*Pre ER Control*	*ER Control*
Encounters	18	12
MR# (Individuals)	*14*	*10*
Total Charges	*$14,687*	*$10,337*
Charge/Encounter	*$816*	*$861*
Encounters/MR#	1.29	1.20
Charge/MR#	*$1,049*	*$1,034*

Inpatient Utilization

DM Utilization	1999 *IP* *Total Pop.*
Encounters	*2351*
MR# Seen (Individuals)	*1747*
Population (MR#)	*4662*
% Received Care	*37.47%*
Total Charges	*$33,644,171*
Charge/Encounter	*$14,311*
Encounters/MR#	*1.35*
Charge/MR#	*$19,258*

DM Utilization	Pre *IP* *Test group*	Post *IP* *Test group*	% Change
Encounters	*103*	*55*	46.60%
Individuals	*64*	*40*	37.50%
Population (# of Individuals))	*133*	*133*	0.00%
% Received Care	*48.12%*	*30.08%*	37.50%
Total Charges	*$1,087,393*	*$543,707*	50.00%
Charge/Encounter	*$10,557*	*$9,886*	6.36%
Encounters/Individual	*1.61*	*1.38*	14.56%
Charge/Individual	*$16,991*	*$13,593*	20.00%
Total LOS (Days)	*519*	*271*	47.78%
Charge per Day	*$2,095*	*$2,006*	4.24%
Average LOS/Encounter	*5.04*	*4.93*	2.21%
Average LOS/Individual	*8.11*	*6.78*	16.45%

DM Utilization	Pre *IP* *Control*	Post *IP* *Control*	% Change
Encounters	39	48	-23.08%
Individuals	*31*	*25*	19.35%
Population (# of Individuals))	*71*	*71*	0.00%
% Received Care	*43.66%*	*35.21%*	19.35%
Total Charges	*$493,546*	*$615,871*	-24.78%
Charge/Encounter	*$12,655*	*$12,831*	-1.39%
Encounters/Individual	*1.26*	*1.92*	-52.62%
Charge/Individual	*$15,921*	*$24,635*	-54.73%
Total LOS (Days)	*281*	*249*	11.39%
Charge per Day	*$1,756*	*$2,473*	-40.82%
Average LOS (days)	*7.21*	*5.19*	28.00%
Average LOS/Individual	*9.06*	*9.96*	-9.88%

Outpatient Utilization

DM Utilization	1999 OP Total Pop.
Encounters	*5982*
MR# (Individuals)	*3761*
Total Charges	*$2,383,745*
Charge/Encounter	*$398*
Encounters/MR#	*1.59*
Charge/MR#	*$634*

DM Utilization	Pre OP Test group	OP Test group
Encounters	578	*375*
MR# (Individuals)	*109*	*95*
Total Charges	*$164,612*	*$114,965*
Charge/Encounter	*$285*	*$307*
Encounters/MR#	5.30	3.95
Charge/MR#	*$1,510*	*$1,210*

DM Utilization	Pre OP Control	OP Control
Encounters	*200*	186
MR# (Individuals)	*53*	*52*
Total Charges	*$38,405*	*$67,592*
Charge/Encounter	*$192*	*$363*
Encounters/MR#	3.77	3.58
Charge/MR#	*$725*	*$1,300*

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VITA

Richard Fritz Nauert was born in Austin, Texas on October 13, 1955, the son of Rita Bird Nauert and Richard F. Nauert, DVM. After completing his work at Westlake High School, Austin, Texas, in 1973, he attended Southwestern University, Georgetown, Texas, from 1973-1975 and Southwest Texas State University, San Marcos, from 1975-1977. He was then admitted to one of the three physical therapy programs in the state and graduated in 1978 from The University of Texas Health Science Center in Dallas with a Bachelor of Science and a Physical Therapy Certification. As a licensed physical therapist he was employed by Scott & White Hospital in Temple, Texas from 1978-1982. He returned to graduate school in 1982 attending the University of North Texas, Denton, Texas. At UNT he served as a graduate teaching assistant and obtained a Masters of Science in Health Fitness Management in 1984.

Returning to Austin, Texas, he was employed as a Patient-Care Coordinator for a new rehabilitation agency, Associated Healthfocus, Inc. After one year as coordinator, he was promoted to become the Administrator of the rehabilitation agency and served in this capacity from 1985–1998, rising to the title of Regional Manager. The agency grew from a 2-person physical therapy organization to employ a staff of over 75 licensed physical therapists, physical therapy assistants, occupational therapists, occupational therapy assistants, speech language pathologists, licensed athletic trainers, and work capacity specialists. Physical rehabilitation services were delivered from outpatient clinics, hospitals, home-health agencies, long-term care facilities, and industrial settings. Therapy specializations included neurology, soft tissue, rheumatology, orthopedics, sports medicine, worksite and geriatrics. During this time frame he served as a board member of The Arthritis Foundation, as chairman of the Capital Area Nursing Homes Games, and was associated with the American Heart Association, the Multiple Sclerosis Telethon, and the Alzheimer's and Parkinson's Foundations.

In 1998, he began an interdisciplinary doctoral program at The University of Texas at Austin with areas of emphasis including health care informatics (information science), health administration, health education, and health policy. In 1999 he also entered a graduate program in Health Care Administration from Trinity University, San Antonio, Texas, and was awarded a Masters of Science in May 2001.

While attending the University of Texas, he has served as a graduate teaching assistant and has taught undergraduate and graduate-level courses in the area of health informatics. In 1999 he worked as a consultant and evaluator of a Telemedicine grant for a rural health clinic in Benavides, Texas. He is currently involved with a Telehealth disease management intervention in Laredo, Texas for underserved individuals afflicted with either congestive heart failure or diabetes mellitus. Honors from the University of Texas include the Mary E. Cleveland

Centennial Endowed Presidential Scholarship award in 2000–2001 and recognition as an *Arete* Citizen Scholar in 2002.

Permanent address: 1706 Camp Craft Road, Austin, Texas 78746

This dissertation was typed by Richard Fritz Nauert.