
Literature Review: The Triple Aim and Home Telehealth for Patients with Chronic Diseases

I. Introduction

The United States' health care system is currently undergoing the most dramatic transformation since the creation of Medicare. With the implementation of the Affordable Care Act (ACA) set to occur within the coming months, there continues to be a quest to seek out how to do more in ways that will utilize our limited resources more efficiently. A central element of the ACA is the Triple Aim, which is an approach aimed at optimizing the performance of the health care system. The three goals in the Triple Aim are the need to (1) improve health outcomes in the population (2) improve the quality of care, and (3) reduce the cost of health care. One method of obtaining one or more of these goals is telehealth.

Telehealth is the use of technology to deliver health services, education and public health from a distance. Telehealth is viewed as having three major service delivery components: (1) services delivered synchronously via live video in real time (Live Video); (2) services delivered asynchronously, or not in real time such as sending information in the form of electronic data to a specialist who will send back a diagnosis and/or course of treatment (Store & Forward); and (3) remote patient monitoring, where there is some regular monitoring of a patient from a distant site (RPM). Mobile Health (mHealth) which involves the use of mobile technology such as APPs and smart phones to render services is considered a part of telehealth, but is still an evolving area.

There is a vast array of literature related to the application of telehealth to meet the needs of the Triple Aim. We have chosen to concentrate this literature review on the management of chronic diseases using home telehealth to meet each of the requirements of the Triple Aim. Chronic disease was chosen because chronic disease patients pose a major cost to the healthcare system. About 83% of the health care cost in the United States is from people with chronic conditions.¹ The cost of medical care for chronic conditions was \$470 billion in 1995, and it is estimated that by 2040 the cost could rise to \$864 billion.² Telehealth could be an option to help control these conditions and costs. Additionally, better management of chronic disease will prove beneficial to patients, resulting in meeting the other two goals of the Triple Aim of better health and improvement in quality of care.

Telehealth

Telehealth is viewed by many as a way to mitigate health care costs, while at the same time improving outcomes and quality of care. California's Telehealth Advancement Act of 2011 captures the idea of telehealth best by describing it "as a mode of delivering health care services and public health utilizing information and communication technologies to enable the diagnosis, consultation, treatment, education, care management and self management of patients at a distance from health care providers." Home telehealth (also known as telecare or telehomecare) commonly includes, but is not limited to, remote patient monitoring (also known as telemonitoring) of patient symptoms and vital

¹ Alliance for Aging Research. The Silver Book. See <http://www.silverbook.org/fact/30> (last checked 11 May 2009).

² Robert Wood Johnson Foundation. Chronic Care in America: A 21st Century Challenge. See <http://www.rwjf.org/files/publications/other/ChronicCareinAmerica.pdf> (Qast checked 11 May 2009)

signs by skilled healthcare professionals at a distant site, as patients are in their homes and go about their daily lives. Home telehealth programs can also include video or telephone consultations, in which patients report their health status and symptoms to healthcare professionals from the home (which can be synchronous or asynchronous), and internet education programs. Due to the variety of studies referenced in this literature review, there will be several different terms used such as telemonitoring or telehomecare. However, all these terms refer to “home telehealth”.

Methodology

Key word searches for “telehomecare”, “telecare”, “remote patient monitoring” and “chronic disease” were conducted on PubMed and Google Scholar from June – July 2013. The search was instituted to uncover studies, books and articles, including peer-reviewed journal articles, related to home telehealth and chronic disease management and its ability to address the three arms of the Triple Aim. The search parameters included articles that were published in English, are United States focused, and were published between January 2007 and June 2013.

Limitations

Although the literature in this review has been categorized by the goals of the triple aim, one should note that most articles have applications to not only one goal, but all three. Understanding the manner in which telehealth brings together all three Triple Aim goals is important to recognize. Also, many of the studies found are limited by a small sample size, which affects the ability of the literature to yield meaningful results. Given the direct relation to the Triple Aim goals and the US health care system, this literature review was limited to only studies conducted in the United States. In our search, we found several examples of studies conducted in foreign countries, but did not include them in this review. Finally, while there are a wide array of studies and articles which address outcomes related to chronic disease management and home telehealth, there are not as many that address quality and costs. In order to balance the content of the various sections, the researchers were more selective in choosing articles related to outcomes, in comparison to the other sections.

II. Health Outcomes

The goal of improved health outcomes within the Triple Aim means the improvement of the population’s overall health. A central question within this goal is: What can be done differently to improve the health of a patient? This may be achieved in a variety of ways that go beyond clinical services. For example, improved health outcomes can be achieved by better education of patients or greater investment by patients in their own health.

Meta-Analysis Studies

In order to understand the vastness of the existing research related to home telemonitoring and its resulting patient outcomes, Pare et al conducted a study, focusing on four chronic illnesses: pulmonary conditions, diabetes, hypertension and cardiovascular disease. Using a keyword search, they examined 65 empirical studies between 1990 and 2006, in an attempt to synthesize them, providing needed evidence of the effect of home telemonitoring on health outcomes for policymakers. In addition to limiting the examined literature to the four chronic diseases mentioned above, they also limited their

research to studies with an experimental design utilizing direct data. Their results varied by illness. With the exception of hypertension, they found that patients suffering from the remainder three illnesses had decreased hospital admissions, less emergency department visits and reduced hospital length of stays when receiving home telemonitoring. They also found that diabetes and hypertension studies consistently showed more significant decreases in blood pressure and glucose levels and cardiac studies show improved quality of life with the use of home telemonitoring. However, due to the inconsistency of the results across the illness groups, the study found home telemonitoring's effect on patients' conditions to be inconclusive. Pare et al suggest future studies on outcomes, cost effectiveness, service utilization and health care providers' willingness to accept and use technology would be beneficial. The authors' inability to draw a consistent conclusion, may be due to the age of the studies used in their review, which are now more than ten years old. In a field that is moving so quickly, as technology rapidly advances, these results may no longer have validity.³

In contrast, DelliFraine and Dansky conduct a meta-analysis of 29 articles which studied the effect of home telehealth and clinical care outcomes published between 2001 and 2007, comparatively newer studies than those used by Pare et al. They limited the meta-analysis to studies in English and those which took place in the home or residential setting. Also unlike Pare et al, they did not limit themselves to a fixed number of diseases, instead striving for a variety of disease categories which included, but are not limited to, hypertension, heart disease, diabetes, asthma, multiple sclerosis and arthritis. Nineteen of these studies included a data monitoring element. Other types of home telehealth intervention included in the studies were telephone, video monitor and internet components. While their analysis did not find a link between home telehealth and diabetes outcomes, it did indicate a positive relationship between home telehealth and heart failure outcomes. Likewise, home telehealth intervention for psychiatric conditions was also seen to have a positive effect on medication adherence, self-reported mental health status, hospital re-admission and emergency visits. They conclude that home telehealth has a moderately positive effect on clinical outcomes. A limitation of this study is publication bias, because studies with more significant findings are more likely to be published than those without, making it more likely for the meta-analysis to yield results. Also, it is difficult to know which type of telehealth intervention was the most effective, as the study included asynchronous, synchronous, internet and telephone monitoring technologies. DelliFraine and Dansky suggest the usefulness of future research on cost effectiveness of telehealth, which is an area to be addressed later in this literature scan.⁴

Inglis et al authored yet another meta-analysis on home telehealth's effect on patient outcomes. Their inclusion criteria limited studies to randomized controlled trials which used telephone and telemonitoring intervention for chronic heart failure (CHF) patients. The purpose of the study was to evaluate the outcomes of patients that received this home telehealth intervention to those that received usual care. Twenty-five peer reviewed studies were selected based on the criteria, resulting in the inclusion of a total of 8323 patients. Telephone support and telemonitoring were found to reduce CHF related hospitalizations, indicating a positive relationship between home telehealth and outcomes.⁵

³ Pare, Guy and Mirou Jaana, Claude Sicotte. "Systematic Review of Home Telemonitoring for Chronic Diseases: The Evidence Base." *Journal of American Medicine Information Association*. (May-Jun 2007) 14(3): 269-277.
<http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2244878/#bib6>

⁴ DelliFraine, Jami and Kathryn Dansky. "Home-Based Telehealth: A Review and Meta-Analysis." *Journal of Telemedicine and Telecare*. (2008) 14: 62.

⁵ Inglis, SC and RA Clark, FA McAlister, J Ball, C Lewinter, D Cullington, S Stewart, JGF Cleland. "Structured telephone support or telemonitoring programmes for patients with chronic heart failure." *Cochrane Database Syst Review*. (Aug. 2010) 4;(8).

Chronic Heart Failure Studies

Chronic heart failure studies make up a large percentage of the literature on home telehealth's relationship to outcomes. Dansky et al examine a telehomecare program for patients with heart failure. They measure outcomes in terms of hospitalization rates, emergency department use, mortality, symptoms related to sodium and fluid intake, medication use and physical activity level. They define telehomecare as "a telephone-based technology that enables individuals to transmit, electronically, health-related data to nurses and other health providers." Patients in their study were split into a treatment group that received a telehomecare system for their home health services and a control group that did not. Data was collected for 120 days. Patients were able to transmit appropriate measurements of blood pressure levels, pulse and weight to the home health agency. The program also included a synchronous video component and digital stethoscope, which allowed for two way interaction between a nurse and patient. Their sample size included 284 Medicare eligible patients with heart failure and relied on a logistic regression to determine telehomecare's effect on patients' use of hospital facilities and linear regression to assess its impact on patients' self reported symptoms. They found that patients in the telehomecare groups were less likely to be hospitalized or visit the emergency room than those in the control group. Patients who used telehomecare also had a greater reduction in symptoms than those in the control group. They reported the reason for this as being the ability of the monitoring equipment to alert home health care nurses to situations where an intervention is immediately necessary. Hence, not only does this equipment improve outcomes, but results in more responsive and therefore a higher quality of care. Dansky et al note that study limitations include a small sample size and there being no control for the type of telehomecare system used.⁶

Gellis et al conducted a study looking at telemonitoring's impact on homebound older adults with heart or chronic respiratory failure. Their method included a randomized controlled trial over the course of 12 months which consisted of 51 participants in the intervention and 51 participants in the control groups. The type of intervention included the use of a home health device which monitors weight, blood pressure, pulse, oxygen saturation and temperature. A nurse would do an initial in home visit to set up and train the patient on the use of the equipment. Subsequently, the nurse would then review the incoming patient data daily and contacted patients if they found concerning patient data. The most common reason a patient was contacted in the program was due to weight gain, blood pressure and shortness of breath. During follow up appointments, the telehealth intervention group reported greater increases in health and social functioning as well as improvements in depression. In contrast, the control group had more visits to the emergency department.⁷ As with the previous study, better outcomes are not the only arm of the Triple Aim that can be observed. The fast response time to patients' changing conditions indicates a higher standard of care in the telehealth group than in the control group.

Chaudhry et al also looked at patients receiving telemonitoring who suffer from heart failure. Their study included 1653 patients, half of which receiving telemonitoring and the other half received usual care. The telemonitoring included telephone based on an interactive voice response system which collected daily information about symptoms and weight. Readmissions to the hospital and deaths were measured at 180 days. Additionally, hospitalization due to heart failure, number of days in the hospital

⁶ Dansky, Kathryn and Joseph Vasey, Kathryn Bowles. "Impact of Telehealth in Clinical Outcomes in Patients with Heart Failure." *Clinical Nursing Research*. (2008) 17:182.

⁷ Gellis, Zvi, and Bonnie Kenaley, Jean McGinty, Ellen Bardelli, Joan Davitt and Thomas Ten Have. "Outcomes of a Telehealth Intervention for Homebound Older Adults with Heart or Chronic Respiratory Failure: A Randomized Controlled Trial." *The Gerontologist*. (2011) Vol. 52, No. 4, 541-552.

and number of hospitalizations were also measured. While telemonitoring did not yield adverse effects, there was no difference found between the two groups for any of the measures outlined above.

Veterans Health Administration Studies

Darkins et al describe and review the success of one of the most touted home telehealth programs in the country, the Veterans Health Administration's Care Coordination/Home Telehealth (CCHT) program. The program includes between 21,000 and 32,000 chronic care management patients. A patient that is enrolled into the program meets with a care coordinator who selects the appropriate home telehealth technology and trains the patient or caregiver on its proper use. The care coordinator also reviews incoming telehealth monitoring data and provides active care and case management, communicating with the patient's physician when necessary. There is no other program in the US with the size and complexity of the VHA's CCHT program. By examining the effects of this program, Darkins et al are able to provide one of the largest data sources for telehealth research with a cohort of 17,025 CCHT patients. They have reported CCHT patients as showing a 25% reduction in numbers of bed days of care and 19% reduction in number of hospital admissions.⁸ The reduced bed days and hospital admissions points to improved health outcomes for CCHT participants.

Chumbler et al's study on CCHT patients with cancer reaffirms Darkins et al's findings. Their experimental group consisted of 43 patients, while their control group had a sample size of 82. They used a quantitative Poisson multivariate regression model. Their results indicate that participation in CCHT leads to significantly fewer preventable services, including reduced bed stays for hospitalization, hospitalization related to chemo therapy, as well as clinic visits.⁹ Due to the small sample size of this study, on its own it is not that significant, but in combination with Darkins et al's findings, it is quite complimentary.

The CCHT program is also examined by Jia et al in terms of the program's ability to reduce preventable hospitalizations for veterans with diabetes mellitus. The study included a sample size of 387 for both their experimental group and control group. They used a generalized linear mixed model to evaluate the effect of the program on preventable hospitalizations over four years. During the first 18 months of the study, CCHT enrollees were considerably less likely to be admitted into the hospital for preventable diseases; however the difference between the experimental and control group hospitalization rates diminished over the remainder of the four year period.¹⁰ This suggests that home telehealth has greater short term effects, than long term effects.

Retroactive Studies

In yet another article on the VHA's telemonitoring program, Chumbler et al focus on patients with diabetes. Their sample size included 387 patients in the experimental group and 387 in the control

⁸ Darkins, Adam and Patricia Ryan, Rita Cobb, Linda Foster, Ellen Edmonson, Bonnie Wakefield and Anne Lancaster. "Care Coordination/Home Telehealth: The Systematic Implementation of Health Informatics, home Telehealth, and Disease Management to Support the Care of Veteran Patients with Chronic Conditions." *Telemedicine and e-Health*. (Dec. 2008) pg. 1120.

⁹ Chumbler, NR and R. Cobb, L. Harris, LC Richardson, A. Darkins, M. Sberna, N. Dixit, M. Donaldson, GL Kreps. "Healthcare Utilization among veterans undergoing chemotherapy: the impact of cancer care coordination/home-telehealth program". *Journal of Ambulatory Care Management*. (2007 Oct-Dec) 30(4): 308-17.

¹⁰ Jia, Huangang, Ho-Chih Chuang, Samuel Wu, Xiping Wang, Neale Chumbler. "Long Term Effects of home telehealth services on preventable hospitalization." *Journal of Rehabilitation Research and Development*. (2009) Volume 43, No. 5, 557-566.

group. The study followed patients for four years using a multivariate regression and was retrospective. Each patient in the experimental group used a messaging device, such as Health Buddy, a device that gathers specific information on vital signs from a patient and transmits the data back to a health care provider, to report on their symptoms and health status. The study found that the telemonitoring program was associated with a reduced 4 year mortality rate, suggesting that telemonitoring does indeed lead to more positive outcomes for patients.¹¹

Ria et al took a slightly different slant to home telehealth and outcomes. The purpose of their research was to find out if early adherence to home telehealth for older veterans with heart failure would lead to a difference in patient outcomes. Their research was retrospective utilizing secondary data from the VA database. Their sample consisted of 248 older veterans based at five Southern California and Nevada medical centers who used the Health Buddy. Patients log on each day and answer questions about their condition. Nurses are expected to contact at risk patients, whose conditions are particularly alarming. Ria et al found there to be no relationship between early adherence to the home telehealth device and outcomes.¹²

Self-Monitoring

Another effect of home telehealth is the potential impact of creating greater awareness and education among patients regarding self-care. In an article that was published in 2007 in the *Journal of Cardiovascular Nursing*, author Kathryn H. Bowles noted that, “Positive results have been achieved with diabetic patients who improved in their self-management when using telehomecare as opposed to traditional home care support.”¹³ Better self-management of one’s chronic diseases will reduce the risk of further complications with their condition or potential hospitalization and/or medical visits. Patients will better recognize habits that may lead to exacerbation of their condition or warning signs of potential issues. However, the evidence that home telehealth does improve self-management has not been explored as extensively and would require more study before it can be definitively linked to improved outcomes.

III. Quality of Health Care

The quality of care can be difficult to discern from outcomes, since many studies that examine quality use the same indicators as those which examine outcomes: re-hospitalization rates, mortality rates, and lengths of stay, for example. According to Donabedian, there are three possible approaches to assessing the quality of care. First, one can take an outcomes approach, in which the above indicators are used to evaluate the quality of care. However, since the purpose of this section is to separate out quality from outcomes, this will not be the focus of the section. A second approach is to evaluate adequacy of the medical facilities in which the health care is taking place. The assumption is made in this approach that given proper settings and instruments, good medical care will result. However, this approach is

¹¹ Chumbler, Neale, Ho-Chih Chuang, Samuel Wu, Xinping Wang, Rita Kobb, David Haggstrom and Huanguang Jia. “Mortality risk for diabetes patients in a care coordination, home-telehealth programme”. *Journal of Telemedicine and Telecare*. (2009) 15: 98-101.

¹² Ria, Jenice Guzman-Clark, Gwen van Servellen, Betty Chang, Janet Mentes, Theodore Hahn. “Predictors and outcomes of early adherence to the use of a home telehealth device by older veterans with heart failure”. *Telemedicine and e-Health*. (March 2013) Vol. 19, No. 3.

¹³ Bowles, Kathryn H., Amy C. Baugh. “Applying Research Evidence to Optimize Telehomecare.” *J Cardiovasc Nurs*. 2007; 22(1): 5-15.

challenged by the relationship between structure and process or structure and outcomes, as quality of care depends on more elements than simply adequate facilities.

A final approach to assessing the quality of health care is to examine the process of care, in order to know if “good” medical care has been applied. Donabedian describes it as:

“Judgments are based on considerations such as the appropriateness, completeness and redundancy of information obtained through clinical history, physical examination and diagnostic tests; justification of diagnosis and therapy; technical competence in the performance of diagnostic and therapeutic procedures, including surgery; evidence of preventive management in health and illness; coordination and continuity of care; acceptability of care to the recipient and so on.”¹⁴

This section will use the third approach when examining the quality of care home telehealth provides for its patients.

Response Times

Dansky argues that telehomecare improves not only outcomes, but quality of care, because it allows clinicians to be alerted to changes in patient’s condition allowing for faster intervention.¹⁵ One of the most promising medical specialties telehealth is demonstrating its usefulness in improving quality of care is in cardiovascular care. For example, Artinian explains that sensor technology can now be used to monitor heart failure patients from a long distance. These monitoring devices have proven useful in monitoring trends during the patients’ daily lives. It is the early detection of problems, due to constant monitoring, that improves the quality of care, and can prevent rehospitalizations.¹⁶

Likewise, Landolina et al hypothesized that remote monitoring could provide more complete information about patient’s changing conditions and faster response times to patient needs. To test this, Landolina et al did a study on heart failure patients with implantable cardioverter defibrillators or an ICD for resynchronization therapy. The trial included a sample size of 200 patients, split into two groups; one which received remote monitoring and the other received standard patient management care with scheduled visits. They measured the program’s success by the rate of emergency department or urgent in office visits for heart failure, arrhythmias or ICD related events. The study lasted 16 months. Over the course of the study, visits were 35% less frequent with patients in the remote monitoring program. This was attributed to a reduction in time that an ICD alert was reviewed by a clinician from 24.8 days in standard care to 1.4 days in remote care. This faster response time for patients participating in the remote monitoring group indicates the higher quality of care being provided, than in the usual care group.¹⁷

A similar study was conducted by Crossley et al, who examined remote monitoring’s effect on the lag time between a clinical event and clinical decision related to arrhythmias and cardiovascular disease.

¹⁴ Donabedian, Avedis. “Evaluating the Quality of Medical Care”. *The Milbank Quarterly*. (Dec. 2005). 83(4): 691-729.

¹⁵ Dansky.

¹⁶ Artinian, Nancy. “Telehealth as a tool for enhancing care for patients with cardiovascular disease.” *Journal of Cardiovascular Nursing*. (2007) Vol. 22, No. 1, pp. 25-31.

¹⁷ Landolina, Maurizio and Giovanni Perego, Maurizio Lunati, Antonio Curnis, Giuseppe Guenzati, Alessandro Vicentini, Gianfranco Parati, Gabriella Borghi, Paolo Zanaboni, Sergio Valsecchi, Maurizio Marzegalli. “Remote Monitoring Reduces Healthcare Use and improves Quality of Care in Heart Failure Patients with Implantable Defibrillators.” *American Heart Association* (2012) 125:2985-2992.

They named their 15 month study CONNECT (Clinical Evaluation of Remote Notification to Reduce Time to Clinical Decision). Their method was a multicenter, prospective, randomized evaluation with 1997 patients from 135 clinical sites, all of whom had implantable cardioverter-defibrillators. They collected data pertaining to related hospitalizations, emergency department visits and clinical office visits for a group receiving wireless remote monitoring with automatic notifications and a control group. The results indicate that remote monitoring does indeed reduce the time to a clinical decision from 22 days in traditional office care to 4.6 days for remote monitoring patients. Remotely monitored patients also experienced a decrease in their length of stay at the hospital from 4 days to 3.3 days. These results show that remote monitoring significantly reduces the time to a clinical decision, which indicates better care and results in more positive outcomes.¹⁸

Telemonitoring's ability to improve care quality extends to more than cardiovascular care. For example, in their previously discussed meta-analysis Pare et al found positive effects of telemonitoring on the overall process of care, particularly for those with pulmonary conditions. Telemonitoring was proven to support immediate intervention and result in avoiding exacerbation. A diabetes study also revealed a decline in hemoglobin A1c and better blood glucose control with the use of telemonitoring.¹⁹

In an article by Wakefield et al, they evaluate the efficacy of telephone and videophone home telehealth interventions. They measured self efficacy, satisfaction with care and knowledge of and compliance with prescribed medication regimens. The study sample included 148 patients, 49 of which received usual care, while 52 received care through videophone and 47 through telephone. At 90 days, there were no significant differences between medication compliance, self efficacy or satisfaction between the two groups, indicating that the quality of the varying methods of treatment is equal. However, the intervention group patients (videophone and telephone group) were more likely to have their medications adjusted during the first 90 days, possibly leading to delayed time to readmission relative to control patients. This adjustment of medication for telephone and videophone patients indicates that the routine monitoring of symptoms by study nurses led to better treatment, again pointing a higher quality of care, than the usual care patients received. Wakefield et al mention that due to their small sample size, a larger study should be conducted to verify these results.²⁰

Patient Adherence

As with self-monitoring noted above, a potential non-clinical effect of home telehealth that can improve the quality of care is to inspire patients to take better care of themselves through adherence to treatment regimens. Chan et al conducted a one year study to determine whether home asthma telemonitoring with store and forward technology could be used to improve outcomes and is comparable with the quality of in-person office based visits. Their sample size included 120 patients ages 6-17 years old who suffer from asthma. Each patient was randomly assigned either an office based or virtual program. While the office based group received traditional in-person case management and education, the virtual group used internet connections in their home for case management and education. Outcome measures included quality of life, utilization of services and symptom control. The

¹⁸ Crossley, George and Andrew Boyle, Holly Vitense, Yanping Chang, Hardwin Mead. "The CONNECT (Clinical Evaluation of Remote Notification to Reduce Time to Clinical Decision) Trial." *Journal of the American College of Cardiology*. (2011) Vol. 57, No. 10.

¹⁹ Pare

²⁰ Wakefield, Bonnie and John Holman, Annette Ray, Melod Scherubel, Trudy Burns, Michael Kienzle, Gary Rosenthal. "Outcomes of a home telehealth intervention for patients with heart failure." *Journal of Telemedicine and Telecare*. (2009) 151: 46-50.

study found virtual care to be comparable to office visits. Both groups were found to adhere to their therapeutic plan and medications. Additionally, the virtual care group was found to be more dedicated to daily asthma symptom diary submissions.²¹

Patient Satisfaction

An important indicator when evaluating the quality of care home telehealth can provide, is the patient's perception of the care they are receiving. Young et al examined the patient perception in regards to VHA's CCHT program. Patients were asked to complete a standard survey and were then interviewed. Their results indicated high patient satisfaction with the CCHT program. Patients especially appreciated the access, education and monitoring components of the program. They were most frustrated by equipment problems, care coordination inaccessibility and slow response times.

Several other studies have indicated high patient satisfaction with the use of home telehealth. In Cryer et al's study on the Hospital at Home model (discussed further in the Cost Savings section), patients also reported high satisfaction levels. Likewise, in a study on home telecare for COPD and/or CHF patients, Whitton and Mickus tested patient's perception of the home telehealth program, among other things. Their experimental group of 83 participated in a combination of face to face and home telemedicine visits, while the control group (n=78) only received conventional visits. A mental health composite score and physical composite score was taken before and after the study to determine the effect of the program. This type of patient intervention did not prove to be a significant predictor of health or wellbeing, however patients' perception of the home telehealth experience was positive.²²

IV. Cost Savings

The examination of the final arm of the triple aim, cost savings, is a new and emerging area of study in the field of telehealth. Often, although cost savings data is not the primary purpose of research, the information is included. For example, in Darkins et al's research on the VHA's CCHT program, they estimate the cost of the program to be \$1600 per patient per year. This compares to the VHA's home based primary care services of \$13,121 per patient per year and market nursing home care rates of \$77,745 per patient per year. The considerably lower cost of the CCHT program indicates that the CCHT model is a cost effective way of managing chronic care patients. Similarly, a study conducted by Dimmick et al, gives researchers an idea of the magnitude of savings that could result from telehealth. They estimate that telehealth could reduce the overall cost of only Chronic Heart hospitalizations in the USA from \$8 billion per year to 4.2 billion per year. It should be noted that in most telehealth studies, if cost savings are an element, the savings examined are usually to the payer in a health system (insurers, state/federal government) or patients (savings from reduction in travel). Examined less often are savings health care providers may directly receive.

Cost Effectiveness

²¹ Chan, Debora, Charles Callahan, Virginia Hatch-Pigott, Annette Lawless, Lorraine Proffitt, Nola Manning, Mary Schweikert and Francis Maolone. "Internet-Based home Monitoring and Educaiton fo Children with Asthma is Comparable to Ideal Office-Based Care: Results of a 1-Year Asthma In-Home Monitoring Trial." *American Academy of Pediatrics*. (2007) 119; 569.

²² Whitten, Pamela and Maureen Mickus. "Home Telecare for COPD/CHF Patients: Outcomes and Perceptions." *Journal of Telemedicine and Telecare*. (2007) 13: 69-73.

In Hasan and Paul's meta-analysis of telemonitoring studies, they found that in their search for articles, 12 studies reported cost efficacy, with nine showing savings of between 35% and 86% with the use of telemonitoring. However, in Pare et al's meta-analysis, they found very little evidence of cost minimization of telemonitoring. Again, this may be because their article inclusion criterion dates back to 1990, when telemonitoring equipment was likely more expensive.

Rojas and Gagnon conducted a review of literature focused on evaluating the cost effectiveness of telehomecare. They define telehomecare as including telephone monitoring and triage systems. They reviewed 23 studies which met their inclusion criteria. Their analysis indicates moderate evidence of the cost effectiveness of telehomecare applications. A downfall of their study, which they point out, is the lack of a common set of indicators for cost and effectiveness. For example, to calculate cost, some studies look at the cost of the purchase of equipment, total cost per patient or hospitalization costs, among others. They claim that a common set of indicators would be beneficial to future studies on the topic.²³

Recognizing the need for a common indicator, The Center for Technology and Aging and Center for Connected Health took a proactive step in measuring the financial viability of remote patient monitoring by developing a return on investment tool. This tool was developed and applied to five health care organizations to test its validity. According to the newly developed tool, the benefits of using remote patient monitoring with chronically ill patients were shown to outweigh the costs. The most common reason for return on investment was reduced hospitalization rates for four out of five organizations. The fifth organization, a home health agency, experienced return on investment due to reduced hospital rates and a reduction in the number of home care visits required for participating patients.²⁴

Savings to Public Programs

The Sacramento Bee reports that "the government expects to save \$8 billion over the next decade if Medicare patients can remain healthy and avoid repeat visits to the hospital because of relapsing conditions." Hence, programs which can cut costs are critical for the government's financial wellbeing. Dignity Health's Congestive Heart Active Management Program, which includes simple check-ups conducted over the phone by nurses who monitor symptoms and remind patients to adhere to their medication schedules have shown significant promise for reduced costs which can be translated to Medicare cost savings. The program has reported reduced readmission rates among patients with chronic health problems by 85%, with a total savings between 2004 and 2009 of \$19.5 million.²⁵

Newman and McMohan conducted a fiscal analysis of the potential impact of California's Telehealth Advancements Act of 2011, which expanded eligible locations and allows for reimbursement of remote patient monitoring, on Medicaid and Medicare. Newman and McMohan posit that if the law was implemented on the ground in its most liberal form, the potential savings from heart failure monitoring programs could be \$929 million a year. Potential savings from diabetes monitoring could reach \$417 million a year. The potential savings in Medi-Cal (California's Medicaid program) could be up to \$408

²³ Rojas, Stephanie Vergara and Marie-Pierre Gagnon. "A Systematic Review of the Key Indicators for Assessing Telehomecare Cost-Effectiveness." *Telemedicine and e-Health*. (2008).

²⁴ "Determining the ROI from Remote Patient Monitoring. Center for Technology and Aging. Fall 2011 (accessed Aug. 20, 2013) http://www.techandaging.org/ROI_Brief.pdf.

²⁵ Calvan, Bobby. "Medical Checkups by Phone Ring Up Savings." *The Sacramento Bee*. Jan. 30, 2011 (accessed Aug. 7, 2013) <http://www.megaheart.com/pdf/sacbee-healthbyphone.pdf>.

million a year and the federal government's share could be up to \$938 million per year.²⁶ These results point to significant cost savings for public programs, a large proportion of which is attributed to home telehealth and remote patient monitoring.

In a study by Baker et al, they examine the impact of care coordination through the Health Buddy Program for chronically ill Medicare beneficiaries. They compared two clinics in the US where the Health Buddy Program is being implemented to two control clinics without the Health Buddy Program. Baker et al found significant savings for patients who used the Health Buddy Telehealth program, with reductions of costs between 7.7-13.3% (\$312-542) per person per quarter. They also found that these programs may also have a connection to outcomes, as they found evidence to suggest that the intervention resulted in lower mortality rates.²⁷

The Hospital at Home model developed by Johns Hopkins University has also yielded promising cost savings results. The program accepts patients which require hospitalization for chronic conditions including exacerbations of congestive heart failure, chronic obstructive pulmonary disease, community acquired pneumonia, cellulites, deep venous thrombosis, pulmonary embolism, complicated urinary tract infection, nausea and vomiting and dehydration. Instead of being admitted into the hospital, eligible patients are enrolled in Hospital at Home care which involves daily physician and nurse visits as well as remote support from telehealth nurses. The telehealth units used have a blood pressure monitor, stethoscope, oximeter, glucometer and video connection. Patients in this program had better outcomes compared with inpatients, as well as higher satisfaction levels. This program was available to Medicare Advantage and Medicaid patients and resulted in 19% savings over the costs for similar inpatients. These costs were a consequence of lower average length of stay and fewer lab and diagnostic tests.²⁸

Pekmezaris et al conducted a study with the purpose of understanding the impact of remote patient monitoring on heart failure patients hospitalization rates. One hundred-sixty-eight randomly selected subjects in the study received live nursing visits and video based nursing visits. The results of this group were compared to a matched cohort of 160 subjects who only received live nursing visits. The results indicated that hospitalization rates, time to first admission, length of stay and costs to Medicare, did not differ significantly at 30 or 90 days.²⁹ This study is one of the few examples of an instance where home telehealth did not prove effective in reducing costs to Medicare or improving health outcomes.

V. Discussion

Overall, the studies reviewed above found home telehealth to have a positive impact on health outcomes for patients, reducing preventable hospitalizations, admissions rates and lengths of stays for patients with chronic conditions. Studies focusing on chronic heart failure yielded some of the most promising results for remote monitoring. Additionally, studies focusing on the VHA's CCHT program for patients with chronic diseases also demonstrate how home telehealth can be effective on a large scale

²⁶ Newman, Matthew and Trisha McMahon. "Fiscal Impact of AB 415: Potential Cost Savings from Expansion of Telehealth." *Blue Sky Consulting*. (September 30, 2011).

²⁷ Baker, Laurence and Scott Johnson, Dendy Macaulay, Howard Birnbaum. "Integrated Telehealth and care management program for Medicare beneficiaries with chronic disease linked to savings." *Health Affairs*, (2011) 30, No. 9; 1689-1697.

²⁸ Cryer, Lesley and Scott Shannon, Melanie Van Amsterdam, Bruce Leff. "Costs for 'Hospital At Home' Patients were 19 Percent Lower, with Equal or better Outcomes Compared to Similar Inpatients." *Health Affairs*. (June 2012) 31:6.

²⁹ Pekmezaris, Renee and Kathleen Pecinka, Lesser, Swiderski, John, Richard Younker. "The Impact of Remote Patient Monitoring (Telehealth) upon Medicare Beneficiaries with Heart Failure." *Telemedicine and e-Health* (2012) Vol. 18, No. 2.

to improve patient outcomes. Two studies reviewed did not find a significant correlation between home telehealth and outcomes. However, the first, by Pare et al, used a meta analysis which consisted of outdated articles. The second, by Ria et al, is focused on whether early adherence to home telehealth makes a difference to health outcomes, as opposed to home telehealth in general. None of the studies found home telehealth to have an adverse affect on health outcomes and may have potential, non-clinical services benefits such as self-monitoring.

The quality of care can be distinguished from health outcomes by examining the process by which care is delivered. The majority of literature focuses on outcomes measures; however home telehealth has also been shown to have an effect on process by improving response times and increasing patient adherence to their medication regimen. The studies reviewed have revealed that home telehealth has a role in providing clinicians with more complete information on a timely basis leading to faster response times to alarming conditions. It has also led to changes in medications regimens that better suit the patient's condition. Additionally, studies which evaluated patient satisfaction and perception of home telehealth care showed positive results.

Regarding cost savings, most studies found savings resulting from reduced preventable hospitalizations, admissions rates and lengths of stays for patients with chronic conditions. With the exception of one study (by Pekmezaris et al), the remainder found significant cost savings for Medicare and Medicaid Programs. Newman and McMohan estimate the potential savings to California's Medicaid program, if telehealth is fully implemented in the state in accordance with AB 415, to be \$408 million a year and the federal government's share up to \$938 million per year. Meanwhile, Baker et al and Cyer et al found significant cost decreases for Medicare beneficiaries with chronic conditions when home telehealth interventions occur. Although studies found home telehealth to be cost efficient, Rohas and Gagnon mentioned the difficulty in finding a common way to measure cost efficiency for telehealth. The Center for Technology and Aging has sought to resolve this problem with a return on investment tool. However, more research may need to focus on finding a tool that can be universally used to calculate cost savings for public programs.

Ideas for further study include more of an emphasis on the quality of care, focused around the process of health care, instead of using outcome measures as the indicator. Additionally, there were significantly less articles focused on quality and cost efficiency to use, compared to outcomes for this literature review. More comprehensive studies are needed on these subjects. Research around how self-monitoring can contribute to the Triple Aim would also be advantageous. Most of the studies examined suffer from a small sample size, and hence larger scale studies would be beneficial to the field. Finally, studies which more clearly address the intersection of the three arms of the Triple Aim would help to comprehensively address how the goals of the Affordable Care Act can be accomplished through the use of telehealth.