

Chapter 2

Experience with Telemedicine Systems in Chronic Illness: What Can We Learn

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Introduction

The American Telemedicine Association describes telemedicine as the use of electronic transmission of medical information from one place to another to help improve patient care [1]. The devices and applications used for exchange of information have evolved significantly as society becomes increasingly more technologically advanced. Examples range from simple telephone monitoring to remote electronic monitoring devices or mobile phones transmitting data over a secure Internet server [1]. Health management and interventions through telemedicine have been examined not only in the context of provider-to-patient communication but also through provider-to-provider scenarios. There is an extensive body of research evaluating the role of telemedicine in clinical practice. With a steady growth in the elderly population, and vast increase in the health-care burden of chronic disease coupled with physician shortage, there is a need for enhanced and innovative methods for monitoring and managing patients [2]. Many postulate that telemedicine can help enhance long-term management of chronic diseases and thereby reduce the financial burden of care while improving outcomes.

Telemedicine interventions date back to the late 1950s. A Nebraska group utilized interactive television (IATV) for telepsychiatry consultation from an academic center to a remote psychiatric hospital [3]. These early methods were not sustainable, however, and with the conversion to digital technology and creation of the World Wide Web, telemedicine interventions became a more viable option with increased opportunity for its use in clinic practice [3]. Modern technology now allows for the use of smartphone data collection and transmission via Bluetooth to a secure Internet server for remote review by clinicians. In addition, videoconferencing for provider-to-provider teleconsultation and applications for patient self-management

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and empowerment are also a present reality. Telemedicine has been studied in several chronic diseases, and the data suggest that incorporation of this technology improves outcomes, quality of life, and could potentially decrease health-care cost in the future [4]. This chapter will review the current literature on the use of telemedicine in the context of management for several chronic diseases including asthma, chronic obstructive pulmonary disease (COPD), diabetes, heart failure (HF), hypertension (HTN), inflammatory bowel disease (IBD), irritable bowel syndrome (IBS), and hepatitis C.

Telemedicine and Chronic disease

Asthma

The Center for Disease Control (CDC) estimates that over 18 million adults in the USA have a diagnosis of asthma—incurring over 14 million physician office visits, more than 1 million emergency room (ER) visits, and billions of dollars in health-care costs [5]. Standard treatment strategies are aimed at reducing exacerbations, improving patient functional status, and preventing death [5, 6]. Management challenges encompass medication nonadherence and poor patient recognition of symptoms leading to delays in seeking medical care [7]. The goal of telemedicine is to improve patient education concerning their disease pathology, increase medication adherence, and prevent unnecessary hospitalizations, ER visits, and absenteeism of work/school [6, 7]. A 2009 non-blinded randomized study conducted in the Netherlands by van der Meer et al. utilized an Internet-based self-management (IBSM) model in addition to usual care and compared results to usual care alone [8]. Study participants included 200 patients with a diagnosis of asthma, age 18–50 years old, with at least a 3-month prescription of inhaled corticosteroids. The IBSM comprised a web-based profile in which patients reported symptoms electronically on a daily basis and completed an Asthma Control Questionnaire (ACQ) that was submitted weekly via their personal password-protected page. The Internet group received instant weekly feedback based on their ACQ for step-up or step-down treatment strategies. After a 12-month monitoring period, this study showed a significant improvement of quality of life, symptom-free days, lung function, and overall asthma control in the Internet group as compared to usual care [8].

In 2011, Mclean et al. performed a Cochrane review of 21 randomized control trials (RCTs) that evaluated telehealth management strategies of asthma. Interventions included provider phone calls, text messages, video conferencing, or other Internet monitoring. The studies evaluated various endpoints including quality of life, ER visits, hospital admissions, medication administration technique, peak flow recordings, and symptoms. They found no significant difference in quality of life or ER visits. However, there was a statistically significant reduction in hospital admissions in patients that received telehealth services evidenced by a relative risk ratio

of 0.25 [9]. The authors do acknowledge that in many of the studies, patients that were randomized to control arms received “enhanced face-to-face care,” as opposed to standard care, which could diminish the apparent effect of the intervention [9].

Morrison et al. performed a systematic review in 2014 of articles that explored telemedicine in asthma management via interventions through the use of tablets/smartphones, computers, or a “purpose built electronic device,” as compared to usual care [6]. Of the studies included, usual care ranged from no intervention to enhanced care with multiple face-to-face teaching sessions and in some cases intermittent use of the intervention [6]. They evaluated ten review articles, including 19 unique RCTs, which included children and adults less than age 65. Primary outcomes in these studies included quality of life, activity limitations, lung function, medication use, and symptoms [6]. They determined that telemedicine techniques might be useful in improving medication compliance, patient knowledge and awareness, quality of life, and function. However, many of the studies used enhanced usual care as previously mentioned, which could confound the gravity of the effect of telehealth interventions in these studies. The authors also noted that exact mechanisms of technology use were vague and many studies did not discuss cost-effectiveness, patient accessibility, or socioeconomic status. Recognizing the limitations of the available data, telemedicine interventions certainly show promise in the chronic management of asthma; however, more studies are needed to determine its true impact and cost-effectiveness [6].

Chronic Obstructive Pulmonary Disease

COPD is defined by the American Thoracic Society as “a preventable and treatable disease state characterized by airflow limitation that is not fully reversible [10].” In 2010, the National Heart, Lung, and Blood Institute (as cited in *CHEST*) projected that COPD would incur approximately \$29.5 billion in direct health-care costs in the USA annually, generating a substantial financial burden on the American population [11]. A hallmark of the disease course in patients with COPD is exacerbation of symptoms leading to decompensation requiring ER evaluation and treatment, medical or intensive care admission for management, and a resultant negative impact on the patient’s quality of life [11, 12]. There have been several studies and initiatives which incorporate telehealth monitoring for COPD patients. McLean et al. reviewed ten randomized control clinical trials that implemented telehealth strategies for COPD management in 2011. Primary endpoints evaluated over a 12-month period included number of ER visits, quality of life (measured by the St. George’s Respiratory Questionnaire [13]), number of COPD exacerbations, and death [14]. This review concluded that the use of telemedicine is associated with a significant reduction in ER visits (odds ratio 0.27), hospital admissions (odds ratio 0.46), and improvement in quality of life [14]. There was no statistical difference in mortality rates among groups.

In contrast, a randomized, multicenter, researcher-blinded study conducted by Pinnock et al. in 2013 reported no difference in outcomes with telemedicine management, including the number of exacerbations, quality of life, or hospital admissions [15]. This UK-based study included 256 patients diagnosed with COPD, with 128 patients randomized to telemedicine or standard care. Patients within the intervention arm had a home telemonitoring system installed with instructions on recording symptoms and pulse oximetry. A remote team would monitor electronically and provide treatment advice based on a standardized algorithm. After a year of monitoring and data collection, they concluded there was no significant clinical difference in telemedicine monitoring and usual care for chronic COPD management [15].

In 2014, Tabak et al. conducted a randomized pilot study that implemented a telehealth program based on four points of monitoring which included web-based exercise programs, an electronic activity monitor and smartphone for activity goals, online self-management modules instructing patients on how to treat exacerbations, and web-based teleconsultation options providing a venue for patients to ask questions of a physiotherapist [12]. Interventions were centered on improving physical activity and modifying behaviors. Out of 29 patients, 15 were randomized to the intervention group and 14 patients to usual care. While no clinical differences were demonstrated, the study was limited by a small sample size and high dropout rate of the control group. Despite this, there was a reported increase in patient satisfaction in the telehealth group.

Currently, the data on telehealth strategies in COPD management are largely inconclusive [12, 15, 16]. Many studies had small sample sizes, short duration of follow-up, and lack of standardization of telehealth methods resulting in insufficient evidence to support clinical use of telemedicine in COPD management [16]. Further research with larger RCTs is necessary before telehealth can be instituted into standard clinical practice for COPD long-term management.

Diabetes

Diabetes is a chronic disease that affects billions worldwide. The CDC estimates that approximately 29 million Americans have diabetes, of which about 8 million are undiagnosed [17]. Those affected experience significantly increased morbidity and mortality due to effects on multiple organ systems. In addition, diabetes contributes to substantial financial costs totaling over \$200 billion in the USA alone [17–19]. Several studies support telemedicine management in diabetes evidenced by improved glycemic control demonstrated through a reduction in hemoglobin A1c (Hgb A1c).

Marcolino et al. performed a meta-analysis of 15 studies in 2013 aimed at determining the effectiveness of telehealth management in addition to usual care in type 1 and type 2 diabetics. Interventions ranged from nursing phone calls to full home telemonitoring devices that could transmit blood glucose values and blood pressure measurements to medical personnel [19]. They found a significant reduction

in Hgb A1c, with a greater reduction in the first 6 months as compared to the 1-year follow-up. Secondary points included low-density lipoprotein (LDL) and blood pressure monitoring; however, no significant reduction was noted in these outcomes. A greater reduction of Hgb A1c was noted in the subgroup analysis for type 1 diabetics, which could be associated with age, as these patients tended to be younger and more technologically savvy, as opposed to the type 2 population [19].

In a meta-analysis by Zhai et al. in 2014, a statistically significant reduction in Hgb A1c was demonstrated among type 2 diabetic patients in the telemedicine intervention groups. They analyzed 35 RCTs, 19 of which employed an Internet-based module for telemonitoring. The remaining studies used telephone-based interventions [20]. The absolute reduction in Hgb A1c was actually reported to be small. Moreover, a slightly higher absolute reduction of A1c was noted in the studies that used telephone-based models (calls or text messages) in addition to usual care, as opposed to the use of Internet-based modules. The mean age of study participants in the trials included ranged from 42.5 to 70.8 years in the intervention groups and 42.3–70.9 years in the control group [20]. It is not clear why there was a difference between telephone and Internet-based modules; however, age could be a factor given that type 2 diabetic patients are typically older and more likely to be familiar with telephone-based communication compared to web-based methods.

Cassimatis et al. conducted a meta-analysis that reviewed the effect of telehealth interventions not only in terms of glycemic control but also examined dietary adherence, physical activity, and medication compliance in patients with type 2 diabetes [21]. Telehealth interventions utilized in the studies consisted of scheduled telephone calls from trained staff in addition to diabetes education, and one study also used periodic cell phone video messages on diabetes self-care topics. Glycemic control, physical activity, and dietary compliance were significantly improved in the telehealth groups [21].

Overall, current data suggest that implementation of telemedicine strategies in patients with type 1 and type 2 diabetes improves glycemic control, physical activity, and adherence to dietary restrictions [19–21]. However, although many studies report a statistically significant reduction in A1c, the actual reduction was less than 1% in many of the studies reviewed; thus, the clinical relevance of these interventions has yet to be determined and warrants further investigation [21]. Cost-effectiveness was rarely addressed in these studies, and thus the data available are not widely applicable to draw a definitive conclusion in terms of overall economic effect.

Heart Failure

The American Heart Association reports that approximately half of all patients with HF will die within 5 years of diagnosis [22]. As a result, significant research efforts have been dedicated to the optimization of its management, producing several landmark trials delineating treatment regimens that reduce morbidity and mortality. As with any chronic disease, patients with HF are prone to exacerbation of symptoms,

prompting investigation into the role of telehealth management implementation. Goldberg et al. published an RCT in 2003, which included 280 patients and reported a 56.2% reduction in mortality at 6 months within the intervention group that utilized a telemonitoring system (AlereNet system). However, no significant difference in hospitalization rates was found [23].

In 2010, *The New England Journal of Medicine* published the Tele-HF trial, a large, multicenter RCT aimed at evaluating the effectiveness of telemonitoring in HF patients [24]. Over 1600 patients underwent randomization, and 826 were included in the intervention group. In addition to usual care, these patients received a Pharos Tel-Assurance device that gave them access to an automated phone messaging system to record their daily symptoms. The results were reviewed by clinicians every weekday, and any unusual symptoms prompted the clinician to call the patient and recommend further intervention if deemed necessary. The remaining patients included in the usual care group were given regular physician follow-up, HF educational material, and a scale for weight monitoring. Overall, the median age of study participants was 61, and over 70 % of participants had an ejection fraction less than 40 % with largely New York Heart Association (NYHA) class II and III symptom manifestations [24]. After 6 months of evaluation, there was no statistically significant difference found in time to readmission for HF, all-cause readmission, number of readmissions, hospital days, or mortality. It should be noted that the adherence rate in the telemonitoring group dropped from ~90 % in the first week to ~50 % by week 26, which is comparable to “real-life” adherence rates [24]. Additionally, no difference was noted in subgroup analyses including NYHA class, gender, age (<65 or ≥65), race, or ejection fraction. A German trial, TIM-HF, published in 2011, used mobile devices for blood pressure, weight, and electrocardiogram (EKG) monitoring and also found no difference in all-cause mortality in “remote telemedical management,” [25] as opposed to usual care.

A meta-analysis by Clark et al. reviewed 13 studies in 2011 that evaluated the effectiveness of telemedicine in HF management. Out of the studies evaluated, 10 used mortality as a primary endpoint, and 5 of these showed a reduction in mortality favoring telehealth monitoring [26]. These studies consisted of a reasonable study group size of at least greater than 80 patients [23, 26]. Overall, the meta-analysis showed no difference in hospitalization rates with the use of telehealth monitoring, although the power to detect a difference may have been limited by a significant drop in admission rates in the beginning of the study period, although this eventually tapered off. Patients in the telemonitoring groups were reported to have significant improvement in quality of life, as measured by the Minnesota Living with Heart Failure and Short Form questionnaires [26–28].

In 2014, Feltner et al. reviewed 47 trials regarding the use of transitional care strategies in the management of HF which included home visits, structured telephone support, telemonitoring, and clinic-based follow-up. A significant reduction in mortality and HF-specific hospital admission rates was identified over the 6-month study period in patients that received structured telephone support [29]. Overall, the data for the use of telehealth strategies in HF management have not demonstrated reproducible improvements in hospitalizations and readmission rates in this population. However, the possibility of mortality benefit and improvement

in quality of life using telehealth warrants more investigation in this area. Standardization of techniques employed will be necessary to gain conclusive information.

Hypertension

HTN affects approximately 32.5% adults over the age of 18 in the USA [30]. It has been well documented that uncontrolled HTN is associated with significantly increased cardiovascular risk and morbidity/mortality related to end-organ damage [31]. It has been identified as the “silent killer,” battled by primary care clinicians every day. Blood pressure values fluctuate with stress, anxiety (white coat HTN), pain, and discomfort; therefore, in-office readings may not provide the most accurate depiction of blood pressure control, thus establishing a specific role for home blood pressure monitoring and telehealth interventions [31].

Abudagga et al. reviewed 15 studies on this topic, including ten RCTs, with a range of telemonitoring devices including self-blood pressure monitoring and phone reporting, blood pressure monitoring devices that link to web-based technologies accessible by clinicians, and 24 ambulatory devices [31]. Study durations ranged from 8 weeks to 2 years, and participant mean ages ranged from 51 to 76. The authors concluded that telemonitoring resulted in significant improvement of blood pressure, with reductions in systolic blood pressure by at least 10 points in six of the studies reviewed. Unfortunately, there are several limitations to these studies. Compliance with use of the monitoring devices was noted to decline over time, medication compliance was not addressed and could not be adequately assessed in many studies, and cost-effectiveness was largely not studied. Four of the aforementioned investigations addressed quality of life as a secondary end point and noted no significant difference [31]. A 2010 systematic review by Pare et al. on telemanagement of chronic diseases that included 17 HTN studies, also reported that research favors improvement in HTN management with the use of telehealth technology evidenced by reduction in systolic and diastolic blood pressure [4].

As previously mentioned, uncontrolled HTN negatively affects various disease processes, significantly impacting morbidity. The relationship between HTN control and diabetes and how it correlates with risk reduction is well documented, and current guidelines support more intensive control in this group of patients with these chronic diseases [32]. A Canadian study published in 2012 included 110 diabetic patients who were randomized to self-care support, that is, telemonitoring ($n=55$) or control ($n=55$). This study utilized 24 ambulatory devices that submitted blood pressure data over Bluetooth to a smartphone. Patients in the intervention group, in addition to usual care and regular follow-up, received electronic messages alerting them if their blood pressure was in the target range, and if values were outside the range, they would be prompted to contact their clinician. Subjects were monitored for 1 year. In this study, telemonitoring was associated with a mean decrease of 7.1 mmHg in systolic pressure compared to controls ($p<0.005$). Furthermore, 51% participants in the self-monitoring group reached their target blood pressure of $<130/80$ as compared to 31% of control subjects [33].

The data regarding telemonitoring, as related to HTN management, support the notion that these interventions are efficacious in reducing blood pressure. Of the literature reviewed, little data speak to the cost-effectiveness of these strategies. In an outpatient Scottish study in 2013, the clinical benefit of telemonitoring in blood pressure management was also confirmed, but with an associated significant increase in cost as compared to usual care [34]. That said, the duration of the study was brief (6 months) and cannot speak to future, long-term implications regarding decreased health-care costs as a result of risk reduction from improved blood pressure control.

Inflammatory Bowel Disease

IBD encompasses two disease entities, Crohn's disease and ulcerative colitis (UC). It is estimated that 1.4 million Americans suffer from IBD [35]. The disease course includes periods of remission and times of exacerbation, which can be extremely distressing to patients and diminish their quality of life. [36]. Multiple treatment regimens are available; however, medication noncompliance is a recurrent challenge in this population, resulting in high rates of relapse and increased health-care resource utilization [36]. Cross et al. published a pilot study in 2007 that included 25 patients to evaluate the feasibility of Home Automated Telemanagement (HAT) utilization [37]. Patients were required to do weekly self-testing in the form of a symptom diary via multiple-choice testing on a secure server. Data alerts were set to notify clinicians based on symptom scoring. In addition to self-monitoring, their software also included educational facts related to their disease from the Crohn's and Colitis Foundation, with related follow-up questions. This study reported 91 % of patients were compliant with the technology. The authors noted a decrease in the clinical disease activity using the Harvey Bradshaw Index [38] as well as a decrease in serologic inflammatory markers at 6 months follow-up. An improvement in quality of life was also reported, demonstrated by an overall increase in IBD-specific quality of life scores as measured by the Short Inflammatory Bowel Disease Questionnaire (SIBDQ) [37, 39].

In 2010, Elkjaer et al. conducted a study that utilized a web-based self-management and treatment approach as opposed to standard of care for 12 months [40]. The study was based in Ireland and Denmark and included 333 patients with mild to moderate UC. Only 135 patients completed the study. In the Danish arm, web subjects were more adherent with acute treatment, demonstrated improved knowledge of their disease and quality of life. There was no difference in disease activity, flare rates, or hospitalizations between the groups; however, intervention patients experienced shorter duration of relapses than the control patients. In the Irish arm, the results were similar; however, there was no difference in quality of life between groups, and the relapse rate was higher in the web group than controls. Web group patients underwent fewer routine and urgent visits; conversely, web group patients

generated more emails and telephone calls. Overall, it was determined that web-based telemanagement strategies improved adherence to acute treatment and quality of life and decreased the amount of clinic visits [40].

Cross et al. published an RCT, UC HAT, in 2012 that included 47 UC patients, randomized to telemanagement ($n=25$) or best available care (BAC, $n=22$); only 14 patients in the HAT group and 18 in the BAC group completed the study. This study population was 66% female and 53% Caucasian. The intervention group received HAT monitoring, consisting of weekly recording of symptoms and medications which prompted a customized action plan based on symptoms [41]. Participants were monitored for 1 year. While the study revealed no difference in adherence, quality of life, or disease activity, there was a significant improvement in disease specific quality of life [41] in the HAT group as compared to the BAC group after adjusting for baseline differences between the groups.

A 2012 study by Penderson et al. investigated the efficacy of web-based monitoring of disease activity in Crohn's patients for individualized scheduling of infliximab (IFX) maintenance therapy [42]. They enrolled 27 patients, 17 of whom completed 52 weeks and 6 patients who completed 26 weeks of follow-up. The study subjects recorded their disease symptoms weekly via a web-based portal, and their symptoms were graded using a standardized scale. Based on symptom scores, patients were instructed whether or not to contact their physician for an IFX infusion. They found that 50% of the patients were able to tolerate longer intervals (>8 weeks) between infusions, 36% required shorter durations (<8 weeks), and only 10% continued IFX infusions every 8 weeks. This study concluded that web-based monitoring is safe and effective for patient-based scheduling of IFX [42]. Additionally, Penderson et al. further investigated this concept in a 2014 study evaluating UC patients and web-based mesalazine treatments [43]. The study included patients with mild to moderate UC. Eighty six participants completed 3 months of web-based mesalazine therapy. Mesalazine treatment was individualized based on a disease activity index, which was a composite of clinical symptoms and fecal calprotectin levels. Use of the web application was associated with decreased disease activity scores and lower fecal calprotectin levels despite dose reduction in 88% of patients at week 12. They concluded that web-based methods of treatment improve adherence to treatment and offer individualized care [43].

A 2014 meta-analysis reviewed six RCTs regarding the efficacy of telemedicine or remote management in IBD [44]. Three trials used telemanagement strategies [40, 41], and the remainder used patient self-guided management strategies and open-access clinics. The authors concluded that in all studies reviewed, there are trends toward improvement in quality of life in the intervention groups and that there was a significant decrease in the number of clinic visits [44]. These results show promise for the use of telemedicine in IBD management and suggest its use can yield more cost-effective management. Further investigation is warranted to assess the effects of telemedicine on adherence, hospitalization rates, disease activity, and management.

Irritable Bowel Syndrome

IBS is a functional gastrointestinal disorder that has been shown to significantly decrease the quality of life in affected patients [45]. There is no current diagnostic test to confirm the diagnosis, but rather a clinical diagnosis is made with a standardized evaluation of symptoms guided by the Rome III criteria, which includes abdominal pain and changes in stool frequency and consistency [45]. This syndrome is not associated with increased mortality risk; however, it incurs over 15 billion dollars in health-care cost due patient distress and impairment. Treatment is aimed largely at symptom management, utilizing pharmacologic and psychological methods [45].

Telemedicine has not been widely studied in this population, but available data show promise for web technology utilization. Enak et al. used a web-based questionnaire to collect data on symptoms and quality of life in IBS patients [46]. This study allowed open-access to their evaluation form through a unique website and demonstrated that web-based data collection was feasible in this patient population, yielding data that were comparable to other methods. In 2010, Ljotsson et al. developed an Internet-based cognitive behavioral therapy (CBT) model and aimed to investigate its effectiveness in patients with IBS [47]. Study participants consisted of 85 self-referred patients, randomized to the treatment group ($n=42$) versus control ($n=43$), with a diagnosis of IBS based on Rome II criteria. Participants were excluded that described symptoms that would warrant a clinical workup for organic causes including <2 years of IBS, rapid weight loss, bloody diarrhea, diarrhea-predominant IBS without endoscopic workup, or severe psychiatric illness [47]. Patients in the treatment group received a 10-week, 5-step, web-based CBT-protocol that included mindfulness strategies and examined the psychological effects of IBS. Twenty-nine of the 42 patients in the treatment group completed all five steps. Patients randomized to the control group were given access to an online forum (separate from the treatment group) where general discussions regarding IBS were held weekly. Control subjects were also allowed to contact a student therapist if they desired; however, they were not given any CBT-based therapy [47]. Patients who received the web-based CBT treatment were noted to have a significant improvement of symptoms measured by the Gastrointestinal Symptoms Rating Scale for IBS (GSRS-IBS) [48] and improvement in quality of life as measured by the Irritable Bowel Syndrome Quality of Life Instrument (IBS-QOL) [49].

Overall, the investigation of telemedicine methods in the IBS population is limited; however, preliminary studies incorporating web-based technology show promise for future management efforts. Additional investigation in this area is warranted as this disease contributes to significant health-care costs, high economic burden due to nonproductivity and missed workdays, and the significant social impact on quality of life in those affected.

Hepatitis C

Hepatitis C is a viral infection that affects approximately 130 million people worldwide [50]. Chronic infections can lead to cirrhosis and hepatocellular carcinoma. This disease poses a major public health issue and financial burden producing an estimated US\$11 billion in health-care costs and upwards of US\$50 billion in projected cost due to loss of productivity from disability and death [51]. In developed countries it is often transmitted via injection drug use, high-risk sexual practices, and transfusion prior to screening efforts [50]. The developing world continues to struggle with transmission through contaminated blood products and medical equipment [50]. Antiviral regimens have been shown to sustain viral load suppression and reduce the risk of progression to cirrhosis and hepatocellular carcinoma, but with the dynamic evolution of antiviral therapy and the complexities of its management, these patients are often referred to tertiary academic centers, and access to care remains a significant obstacle. As described below, telemedicine has provided a means to connect providers in rural areas to specialists and improve access to care and overall management of hepatitis C patients in these underserved areas.

Project Extension for Community Healthcare Outcomes (ECHO) based out of University of New Mexico School of Medicine, utilizes a videoconferencing network that connects primary providers in rural areas to an interdisciplinary team including gastroenterology and infectious disease specialists, pharmacists, social workers, and psychiatrists [51]. Once a new partnership is established with a rural clinic, telemedicine experts install local unique hepatitis C virus (HCV) management software developed by the Liver Research Institute in Denver, CO. Clinicians participate in an orientation and training at the university [51]. Upon completion of training, rural clinicians participate in weekly telemedicine conferences, presenting patients in a case-based manner and discussing treatment options. A survey from 29 providers participating in the project demonstrated that the program increased their knowledge of the management of hepatitis C, 92 % felt competent in management practices, and many listed the availability of a specialist as a major benefit [51].

A 2012 Australian study by Nazareth et al. showed that telehealth clinics were equivalent to face-to-face management for the treatment of hepatitis C [52]. Researchers set up telehealth clinics in rural Australia, operated remotely by nurse practitioners (NP). Patients referred by general practitioners met the following inclusion criteria: non-pregnant and non-breastfeeding adult patients over age 18 with compensated disease. NP provided consultation, treatment initiation, and follow-up via videoconferencing technology. Fifty rural patients were referred and started treatment with pegylated interferon and ribavirin. After treatment for 4 years, there was no significant difference in sustained virological response (SVR) in the telemonitoring group when compared to face-to-face care. Rosario et al. performed a retrospective study in 2013 on 80 HCV patients treated via telemedicine in California. This study also demonstrated that HCV patients can be safely managed by telemonitoring as opposed to face-to-face management as demonstrated by equivalent SVR in both treatment and control groups [53]. Current data suggest that telehealth

strategies can improve access to care and provider competence of HCV management, telemedicine management is not inferior to face-to-face management, and this evidence shows that this technology can be utilized in the future to address the burden of disease worldwide.

Conclusion

Telemedicine incorporates the use of technology to enable clinicians to remotely manage medical illness. Current telehealth technology has evolved over the last 40 years to include smartphones, videoconferencing, web-based tools and applications [1]. The use of this technology is postulated to optimize patient care while concurrently decreasing health-care costs and economic burden. In this chapter, we have qualitatively reviewed current literature evaluating the application of telemedicine in various chronic disease states. In asthma, studies show that telemedicine can decrease the number of hospital visits and improve medication compliance and lung function [6–9]. The literature regarding telemedicine management of COPD is generally inconclusive but shows promise for reduction in ER visits, hospital admissions, and improving quality of life [12, 14–16]. In diabetes, studies collectively support telemedicine strategies for the improvement of glycemic control as evidenced by absolute reduction in Hgb A1c, although in many studies the degree of A1c reduction was not clinically significant [19–21]. The data are conflicting concerning the use of telemonitoring in chronic HF management. Overall, no significant difference is reported in hospitalization rates; however, some studies do recognize a significant mortality benefit in the telemedicine treatment groups [23, 26]. Telemonitoring intervention improves blood pressure control in chronic HTN management [4, 31, 34]. Initial data regarding the role of telemedicine in IBD reveal that these methods may improve quality of life and reduce provider visits [40–41, 44]. Conversely, the role of telemedicine in managing IBS has yet to be determined; however, initial studies show web-based CBT can improve quality of life and symptom control [47]. Multiple studies support the effectiveness of telemedicine via physician-to-physician and clinician-to-patient models in the management of Hepatitis C, extending the scope of practice and reaching underserved populations in rural areas [51–53]. The impact of telemedicine in the chronic disease processes reviewed in this chapter is summarized in Table 2.1.

While the overarching message in the existing literature supports the use of telemedicine in chronic disease management, there are some limitations in these studies, including small sample sizes, high dropout rates, lack of standardization of interventions which limits the determination of effect size and generalizability, and lack of cost-benefit analyses. The concept of age and technological awareness must be taken into consideration when assessing telemedicine systems as many of the patients with chronic illnesses grew up in a technological era that predates smartphone and web-based applications; thus, current interventions may need to be tailored accordingly due to limited scope of comprehension to help increase

Table 2.1 The outcomes of telemedicine in the management of chronic disease

Chronic disease	Study	Outcomes
Asthma	Morrison et al. [6]	Improved medication adherence, function, QOL
	van der Meer et al. [8]	Improved QOL, symptom-free days, asthma control
	McLean et al. [9]	Reduction in hospital admissions
COPD	Tabak et al. [12]	No difference in behavior modification or physical activity
	McLean et al. [14]	Reduction in ER visits and hospital admissions Improved QOL
	Pinnock et al. [15]	No difference in exacerbations, QOL, or hospital admissions
Diabetes	Marcolino et al. [19]	Reduction in Hgb A1c
	Zhai et al. [20]	Reduction in Hgb A1c
	Cassimatis et al. [21]	Improved Hgb A1c, physical activity, and dietary compliance
CHF	Goldberg et al. [23]	Reduction in mortality No difference in hospitalization rates
	Chaudhry et al. [24]	No difference in readmission rates, hospital days, or mortality
	Koehler et al. [25]	No difference in all-cause mortality
	Clark et al. [26]	No difference in hospitalization rates Improved QOL
	Feltner et al. [29]	Reduced mortality and HF hospitalization rates
HTN	Pare et al. [4]	Reduction in systolic and diastolic blood pressure
	AbuDagga et al. [31]	Reduction in systolic blood pressure No difference in QOL
	Logan et al. [33]	Reduction in systolic blood pressure
IBD	Cross et al. 2007 [37]	Decreased disease activity Improved quality of life Increased IBD knowledge
	Elkjaer et al. [40]	Improved adherence to acute treatment Improved QOL Decreased duration of relapses Decreased routine in urgent visits Increase in emails and telephone calls
	Cross et al. 2012 [41]	Improved disease activity Improved disease-specific QOL
	Huang et al. [44]	Improved QOL Decreased clinic visits
	Penderson et al. 2012 [42]	Individualized IFX treatment can be achieved without worsening clinical outcomes
	Penderson et al. [43]	Decreased disease activity scores Decreased fecal calprotectin levels Individualized approach to treatment resulted in decreased dose of mesalazine
IBS	Ljotsson et al. [47]	Improved symptoms and QOL
Hepatitis C	Arora et al. [51]	Improved physician competency and specialized resources
	Nazareth et al. [52]	No difference in treatment outcomes compared to face-to-face care
	Rosario et al. [53]	Equivalent SVR in treatment and control groups

COPD chronic obstructive pulmonary disease, *CHF* congestive heart failure, *HF* heart failure, *HGB* hemoglobin, *HTN* hypertension, *IBD* inflammatory bowel disease, *IBS* irritable bowel syndrome, *IFX* infliximab, *QOL* quality of life, *SVR* sustained viral response

acceptance of the technology and retention rates. Provider-to-provider utilization of telemedicine has resulted in improved evidence-based practice and thus widens the scope of practice to reach the underserved. Further research, using large-scale RCTs, evaluating telemedicine in management of chronic diseases is warranted to further define its role in chronic disease management and its economic impact. As technology continues to evolve into more user-friendly applications, this may help decrease dropout rates and increase interest in telemedicine applications, both among patients and providers.

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