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Research Report

Remote Monitoring Technologies in Long-Term Care: Implications for Care Team Organization and Training

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Executive Summary

Introduction/Background

The current health care delivery model in the U.S was not developed to manage care needs associated with extended life expectancy and growing rates of chronic conditions. Remote monitoring programs aim to enhance the patient's and provider's surveillance of chronic conditions in order to anticipate and identify exacerbations, thus avoiding unnecessary emergency room visits, re-hospitalizations, surgeries, premature death, and excess costs to the health care system. This study examines how remote monitoring programs are preparing and leveraging the health care workforce to manage patients with chronic illness and long-term care needs who are living at home.

Methods

Literature Review: A preliminary search revealed that remote monitoring technologies are used for numerous high-burden conditions in a variety of settings. We sorted the technologies by the types of chronic conditions for which they are used, and selected 4 conditions with high prevalence among those at risk for institutionalized care, which carry high risk of hospitalization and re-hospitalization, and for which remote technologies have shown some evidence of benefit.

Case studies: We conducted 20 semi-structured interviews with health care providers, managers/administrators, and technicians who are part of care teams that utilize remote monitoring technologies, and with authors of research trials investigating remote monitoring technologies.

Findings

Literature review:
Across the 4 chronic conditions – CHF, DM, COPD, and CKD – much of the same type of clinical remote monitoring data was collected and positive outcomes were achieved across the conditions. A multidisciplinary team approach was associated with more positive biometric and health care system outcomes. Remote monitoring

models that incorporated subjective symptom questionnaires with biometric data were more often associated with positive findings compared with studies that solely examined subjective symptom or biometric data in isolation.

Case study review:

Because RNs' experience allows them the independence to perform assessments while simultaneously communicating and acting upon data, they are the primary health professionals involved in remote monitoring programs, with allied health professionals providing support. Remote monitoring programs partially substitute for RN home visits, although this depends on each program's funding structure. The VA's Home Telehealth program is the most widespread, best developed, and longest-running remote monitoring program in the U.S. The VA's program is a model that can be disseminated widely and for multiple chronic conditions.

Conclusion

Patient-centered monitoring technologies have the potential to improve the efficiency, cost, and accountability of chronic health care delivery and will require appropriate medical professional support, training, and role distinction. A range of clinical experience and skills are critical for successful telemonitoring programs. Nurses must rely on critical thinking skills and their ability to verbally assess patients, ask the right questions, and make clinical judgments. Protocols that include customizing parameters to the patient, close monitoring, and case management with input from the whole care team appears to be the best approach.

Policy Implications

Telemonitoring will never fully replace hands-on clinical care, however to fully achieve the potential of remote monitoring, programs should invest robustly in training. An expanded effort to share information across remote monitoring programs would accelerate learning and enhance success. Additional research is needed to identify best practices and standards for alerts and intervention. As health care organizations face greater pressure to improve the quality of care while controlling costs, they will need to accurately determine the costs of each of the components of remote monitoring programs and assess their value.

Remote Monitoring Technologies in Long-Term Care: Implications for Care Team Organization and Training

This study assesses the health workforce implications of the growing use of remote monitoring technologies to manage persons with chronic illnesses and long-term care needs. The report provides detailed information about remote monitoring technologies now in use in long-term care settings in the United States, including in-depth case studies of how organizations utilizing telemonitoring have configured and prepared their workforce. The information is summarized in a Research Brief.

Background

Chronic conditions are increasingly recognized as the health care epidemic of the 21st century. By the year 2020, the United States is projected to see an additional 15 million Americans with hypertension, 12 million with diabetes, 4 million with coronary heart disease, 2 million with stroke, and 2 million with heart failure. [1,2] Accounting for half of the U.S. adult population, 86% of health care costs, and the deaths of 70% of US adults, the impact of chronic conditions on the health care economy is enormous.[3,4] While the prevention of health risk behaviors remains an important focus for decreasing the incidence of chronic diseases, a stronger emphasis on disease management for the 146 million people currently living with chronic impairments – and the additional 16 million projected to join by 2020 – is a critical priority.[5]

The current care delivery model in the U.S. was not developed to manage care needs associated with extended life expectancy and growing rates of chronic conditions.[4] Low adherence to medical recommendations and poor control of treatable conditions, demonstrated by high re-hospitalization rates, indicate a missing component in health care delivery. Remote monitoring programs seek to enhance patient and provider surveillance of chronic conditions in order to identify exacerbations, and avoid emergency room (ER) visits, re-hospitalizations, operations, premature deaths, and unnecessary costs to the health care system. By engaging patients and offering a new modality of care, emerging technologies are proving themselves part of the solution.[4]

Telehealth utilizes electronic communication and information processing technologies – such as short message service (SMS), audio, video, "wearables," and internet applications – to remotely monitor, diagnose, treat, and consult with patients from a distance.[6] Remote monitoring is based on the transmission of

patient medical data from his or her location to a responsible health care provider or institution. The most common monitoring model for patients residing at home is for registered nurses (RNs) or other health professionals, such as physicians and pharmacists, to review data reported by monitoring devices and contact patients if the data suggest that the patient's treatment plan needs to be adjusted.

Remote monitoring and structured telephone support have been found to improve health outcomes for persons with chronic obstructive pulmonary disease (COPD), congestive heart failure (CHF), hypertension (HTN), and hyperlipidemia.[7] By offering a mode of care delivery that integrates health care providers into patients' day-to-day lives, remote monitoring not only informs providers about changes in patients' clinical states, but also compels patients to become managers of their care.[4] These features of remote monitoring technologies hold the potential to support individuals to live at home with greater levels of independence.

This study examines how remote monitoring programs are preparing and leveraging the health care workforce to care for patients with chronic illness and long-term care needs who are living at home. The study identifies best practices in utilization of technology, team composition and organization, and training. This information is intended to guide health care organizations, educators, and agencies that provide training funds, such as the U.S. Bureau of Health Workforce, in their efforts to enhance existing programs and to develop new strategies to optimally incorporate remote monitoring technologies. Adjusting our health care delivery model to include patient-centered monitoring technologies has the potential to improve the efficiency, cost, and accountability of chronic health care delivery and will require a workforce prepared to effectively use such technologies.

We sought to answer 4 core questions:

1) What models of remote monitoring are being implemented in home-based settings of the United States?

2) How are different types of health professionals involved in remote monitoring?

3) How do health professionals who provide remote monitoring interact with health care workers who provide care in the home?

4) What are the training and support needs for health care providers working with remote monitoring technologies?

Literature review

Methods

A review of the literature informed the identification of remote monitoring programs and individuals with remote monitoring expertise to serve as key informants for semi-structured interviews.

A preliminary search was conducted to identify the types of remote monitoring technologies currently in use in the United States. Searches were performed using PubMed, CINAHL, Google Scholar, Cochrane, and PLOS databases to identify relevant publications. Search terms included "remote monitoring," "in-home monitoring," "telemonitoring technologies," "telemedicine chronic condition," "remote telehealth," "telehealth management," and "remote disease management." Bibliographies from related studies and articles were reviewed to identify additional applicable studies and articles. A review of the grey literature surrounding remote-monitored care and telehealth technologies was conducted concurrently. More than 3 dozen articles and reports were identified and reviewed.

The preliminary search revealed that remote monitoring technologies are used for numerous high-burden conditions in a variety of settings. Common devices include blood pressure monitors, pulse oximeters, glucose monitors, high-precision scales, camera systems, and medication dispensers, and these can be found in homes, skilled nursing facilities, adult day care centers, and assisted residential living communities. We sorted the technologies by the types of chronic conditions for which they are used. In order to focus both the literature review and qualitative interviews, we selected 4 chronic conditions with high prevalence among those at risk for institutionalized care, have high risk of hospitalization and re-hospitalization, and for which remote technologies have shown some evidence of benefit. These conditions are congestive heart failure (CHF), diabetes mellitus (DM), chronic obstructive pulmonary disease (COPD), and chronic kidney disease (CKD) (Table 1).

We then conducted a more detailed search of the same sources using search terms "remote monitoring," "in-home monitoring," "telemonitoring technologies," "telemedicine chronic condition," "remote disease management," in conjunction with "CHF," "diabetes mellitus," "congestive heart failure," "chronic kidney disease," and "chronic obstructive pulmonary disease" to identify existing remote monitoring technologies with the greatest potential to improve in-home management, evidence that such technologies are effective, and information about staffing configurations and training associated with each technology and condition.

Table 1. Prevalence and economic impact of chronic conditions with remote monitoring potential.

Condition	Prevalence	Readmission Rate	Potentially Preventable Hospitalizations	Total Costs	Cost Per Capita
CHF	30.7%	24.2%	27.3%	$76B	$28.4K
DM	42.1%	21.5%	-	$34B	$15.7K
COPD	25.9%	23.4%	14.5%	$54B	$25.7K
CKD	14.8%	24.0%	-	$31B	$26.5K

CHF = congestive heart failure; DM = diabetes mellitus; COPD = chronic obstructive pulmonary disease; CKD = chronic kidney disease. Sources: Prevalence and potentially preventable hospitalization (PPH) figures are from 2003-2005.[8] Readmission rates and costs per capita are from 2014.[9] Readmissions rates are expressed as the percentage of all hospital admissions that occurred within 30 days of discharge from an acute care hospital, by condition. Total costs are from 2005.[10]

Literature identified in the search was reviewed for applicability to this study. The review criteria required that studies pertain to one or more of the 4 chosen chronic conditions (CHF, DM, COPD, or CKD) and remote monitoring of adults, and were published in English-language journals. Articles that focused on the role of health care disciplines in remote monitoring technologies were also retained, regardless of whether they focused on one of the 4 chronic conditions. Studies using multiple care modalities were included when the primary intervention concentrated on remote patient monitoring.

Results

Overview of literature on remote monitoring, its impact, and workforce implications

Our review included 10 articles with all study designs, including randomized controlled trials (RCT), quasi-experimental studies, observational cohort studies, and pilot studies. While the newness of remote monitoring for chronic disease management limits the volume of published research on the technology's effect on the health care workforce and health outcomes for the selected chronic conditions (CHF, DM, COPD, CKD), we identified dozens of relevant studies, and several patterns emerged. Many studies focused on the outcomes of re-hospitalization rates, ER visits, biometric data, and mortality, as well as patient and health care professional satisfaction. Several studies included the outcomes of medication adherence and office appointment attendance. Across the 4 conditions, remote measurement and digital transference of vital signs – heart rate (HR), blood pressure (BP), temperature, and respiratory rate (RR) – was common. Additional variables commonly measured were oxygen saturation, body weight, blood glucose

(BG), pain level, subjective symptoms (via daily questionnaire), and physical activity. Some programs also utilized video conferencing and telephone call technologies.

Data transference

The frequency of health data transference varied greatly across the studies, ranging from near real-time transfer to weekly or biweekly export. In some cases, patients or their caregivers were called, emailed, or text-messaged with a reminder to export their metrics from an application or website portal,[6] whereas more sophisticated systems automatically transferred health data to receivers.[11-18]

Data recipients

The literature revealed significant variance in data receivers; models ranged from pharmacists or physicians (e.g., endocrinologists) interpreting digital data and adjusting medication dosages accordingly,[6,14,16,17] to clinical nurses viewing data and triaging to advance practice nurses, physicians, or pharmacists based on specified parameters.[11-13,15,18] Several of the studies utilized pharmacist case managers. Remote monitoring programs that implemented triage systems were more often associated with positive outcomes than those that did not. We did not find an obvious relationship between the data reviewer's occupation and the likelihood of positive findings, although studies utilizing a multidisciplinary team-based approach were more likely to have positive outcomes than single-discipline studies (e.g., endocrinologists only, respiratory therapists only, clinical nurses only, etc.).

Remote monitoring data

Across the 4 chronic conditions, we saw significant overlap in measures indicative of health status deterioration. Remote monitoring of body weight, HR, and in-home blood pressure monitoring were included in the majority of CHF, COPD, and CKD studies and were associated with positive outcomes in patients.[11-13,15-18] The majority of CHF and CKD studies with positive health outcomes included daily body weight recording, although studies solely measuring body weight did not typically yield positive outcomes for patients diagnosed with CHF, CKD, or DM. A positive pattern was also observed for studies that combined various biometric data measurement with subjective symptom questionnaires, medication recordings, or video/voice consultations.[6,11,12,14-18].

Workforce in remote monitoring. Remote monitoring programs were frequently coordinated by registered nurses,[11] with the involvement of home health aides, information technologists, and licensed practical or vocational nurses (LPNs/LVNs). Nurse coordinators and nurse managers often receive referrals from physicians when the monitoring program is part of an integrated health system. Within home health agencies, the coordinator often receives the referral from an intake specialist, who is frequently also a registered nurse.

If the patient is a good candidate for the remote monitoring program, the coordinator orders delivery of the remote monitoring technology. Programs vary in how they deliver and install remote monitoring devices. Most programs arrange to have a technician,[11,12] or home health aide hand-deliver the technology and assist with its setup, although some programs assign this to nurses.[13] Where home health aides are responsible, they usually have specific training and access to a telephone support line in case technical problems arise. The person installing the technology usually provides instruction in its use, as well as information about whom to contact if there are problems with the technology.

In addition to basic instruction in the use of remote monitoring devices, patient education about the disease or chronic condition being monitored is essential to the success of the monitoring. This is usually done by a registered nurse (often the coordinator).[11,12] The education component typically focuses on the nature of the disease or chronic condition, the vital signs and symptoms that are being monitored, the reasons these vital signs and symptoms are important, and the actions patients can take at home to control exacerbations in vital signs and symptoms.

In most of the remote monitoring programs described in the research literature, registered nurses received the remote data, assessed the data, and determined whether intervention was needed.[11,12,14,15] However, some programs assign this work to other health professionals, including physicians[6,16] and pharmacists,[16,17] and some have computer systems that triage patients to a health professional based on pre-established parameters.[13] Some programs include automated telephone reminder systems or text messages to remind patients to record data.[6,14] Case managers – usually nurses – often called patients on a regular or as-needed basis to discuss new data, remind patients to use the monitoring devices, or provide instructions if symptom exacerbations occurred.[11,12,14,17] In some programs, home health aides and nurses can access the data from the monitoring device and contact the coordinator if needed.[12] In many cases, physicians and/or advanced practice

nurses were available on-call for consultation,[11,12] and some programs included regular meetings with the nurse coordinators, physician specialists, and other care providers to review patient cases and discuss any general issues with monitoring.[11]

Remote monitoring for congestive heart failure

Present in nearly 5 million Americans, CHF is responsible for 11 million physician visits per year and accounts for more hospitalizations than all forms of cancer combined.[19] Several studies demonstrate that remote patient monitoring is effective in reducing CHF hospitalizations, hospital length of stay, and 30-day hospital readmissions.

In a randomized controlled trial (RCT), Weintraub et al. (2010) explored the use of an automated health monitoring (AHM) system for reducing hospitalization rates in 188 patients with heart failure.[11] Participants were divided into the control heart failure disease management group or the intervention group, which used both the disease management program and the AHM system. The disease management program began with an enrollment education session with a CHF nurse manager who emphasized awareness of CHF disease states, dietary and medical compliance, and methods of self-monitoring. Medications were also optimized at this time. Over the 90-day study, ongoing disease management included weekly calls by the patient's nurse manager, a weekly conference with the CHF team (including a CHF physician and nurse managers), and 24/7 access to a nurse manager. An on-call CHF cardiologist was available for clinical consultation with nurse managers if needed. The AHM intervention began with in-home installation of the technology by a technician within 2 weeks of randomization. During installation, the technicians taught participants how to use the system. The AHM device measured body weight, heart rate, and blood pressure and transmitted these values by telephone line to a central server for interpretation. The "Health Buddy" appliance delivered subjective surveys to participants and the "Health Hero Network" utilized an interactive communication system to provide text information about symptoms, functional status, and adherence to medications.[11] Nurse managers reviewed the health data and text messages daily, which were categorized into high-, intermediate-, and low-risk responses. Participants with vital sign values that exceeded the pre-specified parameters were called by nurse managers to discuss the number and the need for intervention. A 50% lower hospitalization rate was seen in participants randomized to the AHM intervention group compared with the disease management control group [95% confidence interval (CI) 0.25-0.99; P=0.05].

Another RCT examining the effect of remote monitoring on hospitalization rates for 249 patients with CHF or CHF symptoms found a 61% reduction in hospital length of stay (*P*=0.04) and a 51% decrease in angina symptoms (*P*=0.02) for the intervention group (n=124).[12] Intervention group patients with CHF also spent an average of 28 fewer days in the hospital compared with the usual care control group participants. Patients with CHF or CHF symptoms were randomized into the remote monitoring intervention or usual care study groups. For the intervention group, the in-home monitoring equipment was set up by a technician within 48 hours of discharge and patients were educated on its use. The in-home program included weekly video conferencing with a nurse, daily electronic transmission of body weight and BP, and periodic transmission of an in-home electronic 12-lead echocardiogram (ECG) (conducted by the participant). Tailored patient education and progress assessments were emphasized during the video conferences with nurses. All data were transmitted by telephone line to a central station for interpretation. Triage protocols were developed to ensure consistent reactions to clinical symptoms (e.g., shortness of breath). Additionally, home health nurses had access to the direct line of an advance practice nurse if needed.

A meta-analysis from Columbia University, which included 33 RCTs (n=7,530, average age=69 years) assessing the effectiveness of telehealth on CHF patients, found substantial positive results.[20] The researchers discovered that telehealth had a significant effect on reducing all-cause mortality [relative risk (RR)=0.76, 95% CI 0.66-0.88; *P*=0.001], CHF-related hospitalization (RR=0.72, 95% CI 0.61-0.85; P<0.001), and CHF-related length of hospital stay (mean difference=-1.4, 95% CI–2.4 to –0.4; *P*=0.007). The review also uncovered several interesting patterns regarding remote monitoring tools. Controlling for age, the researchers found that remote symptom questionnaires could reduce mortality risk by 34% and CHF-related hospitalization by 15%, and the use of an HR detector could reduce mortality by 40% and CHF-related hospitalization by 43%. Lastly, the meta-analysis revealed that remote monitoring programs demonstrated a tapering effect on mortality reduction, becoming less effective as length of follow-up increased.

Remote monitoring for diabetes mellitus

Today, 29.1 million, or 9.3% of the U.S. population, has DM.[21] Accounting for direct medical costs of $176 billion, medical expenditures for people diagnosed with DM are on average 2.3 times higher than people without DM.[21] Though rarely implemented by health care systems, remote monitoring has proven to be more effective for diabetes management than standard clinic care.[14] A combination of

telehealth interventions including self-reported blood glucose (BG), online diabetes education modules, SMS medication reminders, BG reminders, and proactive health care provider phone calls has proven successful.

A 6-month pilot RCT conducted by researchers at Duke University in 2016 studying 50 Veterans Affairs (VA) patients with DM found improvements in glycated hemoglobin (HbA1c) (P=0.05), self-care measures (P=0.047), systolic BP (P=0.035), and diastolic BP (P=0.013) compared with individuals in usual care who received an education packet and no other intervention.[14] In this model, participants self-reported glucose levels before meals and at night, receiving automated evening telephone calls reminding them to relay their data through the interactive voice system and telephone keys. Every 2 weeks, telehealth nurses called the participants to review BG submissions, reconcile medications, and assess diabetic medication adherence. Participants completed biweekly self-management education modules during these telephone encounters. Nurses created an EHR-based report summarizing participants' self-monitored BG levels and medication adherence, and reconciled medications for physician review. Adjustments to medications made by physicians were relayed to participants via telephone call with their study nurse.

Validating these findings, a 2015 study examining HbA1c levels in 70 diabetic patients found telemonitoring to be effective in significantly reducing HbA1c levels at 3 months (7.1±1.0%, P<0.001) and 6 months (6.9±0.9%, P<0.001).[6] This study also found a reduction in monthly hypo- and hyper-glycemic episodes and decreased financial costs for patients living 1,000 km from their providers. Patients were encouraged to transmit BG levels (taken at least 4 times a day) to a modem, which triggered SMS or email messages to be sent to patients by endocrinologists if medication dosage modifications were recommended.

Remote monitoring for chronic obstructive pulmonary disease

Affecting 30 million Americans, COPD is a highly prevalent condition with substantial health care resource consumption and expenditures driven mainly by exacerbation-related hospitalizations.[22,23] Our review of the literature indicates that BP, HR, oxygen saturation, exercise, body temperature, and peak expiratory flow are important indicators of COPD patient health status.[13,15]

In a compelling study from 2014, nurses set up in-home technology and educated 30 patients to collect vital sign, pulse oximetry, and spirometer measurements.[13] Values were transmitted to a clinical monitoring center and categorized as green, yellow, or red. Patients were then triaged to the appropriate health care

professional accordingly – green values warranted no intervention, yellow values triggered a call by a nurse, and red values were escalated directly to a pulmonologist. The pulmonologist's interpretation of the data determined the level of intervention: a phone call, home visit, or recommendation to visit the ER. After 7 months, there was a significant reduction in intervention group ER visits (20 vs. 57), hospitalizations (12 vs. 33), length of hospital stay (105 vs. 276 days), and non-invasive mechanical ventilation (0 vs. 8), all statistically significant ($P<0.05$). Time until the first severe acute exacerbation of COPD increased from 77 days in the control group to 141 days in the intervention group ($P<0.05$). Additionally, there was a high level of patient satisfaction, with no participation withdrawals related to the technology.

Additionally, in a 2013 RCT of 71 patients with COPD, nurses reviewed remotely recorded vital signs (submitted by 36 patients via telephone and exported daily to a website), finding a decrease in ER visits, hospital admissions, and hospital length of stay compared with the control group.[15] The substantial reduction in health services for the telehealth group resulted in an annual cost savings of $2,931 per patient compared with the controls.

Remote monitoring for chronic kidney disease

Accounting for more than 20 million Americans – one in 10 American adults – CKD costs the U.S. more than $40 billion a year.[21,24] CKD remote monitoring research consistently recommends in-home BP monitoring as a cost-effective gold standard tool for managing the disease. Currently, variation exists regarding the most appropriate medical discipline for CKD in-home BP management – some studies utilize physicians, while others turn to clinical and case management pharmacists.

In a rigorous RCT from 2013 involving 450 patients with uncontrolled BP or CKD, in-home BP telemonitoring and pharmacist case management led to better controlled BP compared with usual care during the 12-month intervention, and the effects were sustained after 6 months of post-intervention follow-up.[17] Pharmacist case managers met patients in person for 1 hour to provide BP education and explain the BP telemonitoring system. Patients reported six BP measurements each week (3 in the morning and 3 at night), and attended biweekly phone calls with pharmacist case managers where lifestyle changes and medication adherence were emphasized. If less than 75% of BP measurements met the patient's goal BP, medication adjustments would be made by pharmacist case managers. The study reported an average reduction in systolic BP of –9.7mmHg ($P<0.001$) at 12 months and –6.6mmHg ($P<0.004$) at 18 months in the intervention group over the control group.

An additional RCT from 2013 with 43 participants studying the effect of real-time wireless BP monitoring found a significant improvement in systolic BP (*P*=0.05) with a median drop of 13mmHg compared with 8.5mmHg in the control group receiving usual care.[16] BP values were delivered from a Bluetooth enabled device through the internet (cellular modems were provided to participants) to a secure website. Study physicians and pharmacists had access to this data and would review the participants' BP values together each week. If a patient was experiencing consistently high BP values, a physician or pharmacist would call the patient to discuss the values, provide counseling, and adjust medications if needed.

While in-home BP monitoring has proven effective for controlling BP levels in CKD patients, its effectiveness for decreasing ER visits, hospitalization rates, skilled nursing facility admissions, mortality, and health care costs is undetermined.[18]

CASE STUDIES

Methods

Semi-structured qualitative interviews were conducted with health care providers (e.g., physicians, nurses, home health aides), managers/administrators, and technicians who are part of a care team utilizing remote monitoring technologies. We also spoke with authors of research trials utilizing remote monitoring technologies. A snowball sampling method was used to identify case study sites and interviewees based on the formal literature review and a review of grey literature, including case studies from LeadingAge Center for Aging Services Technologies and recipients of the Most Wired awards.[25,26] An email invitation was sent to each potential participant (n=30). A second wave of recruitment emails was sent 3 weeks following the initial email. A total of 8 organizations responded with interest in the study, resulting in a total of 20 interviews with 26 interviewees from July 26, 2016 through September 22, 2016 (Table 2). All interviewees except one were involved directly in a remote monitoring program; one interviewee was a researcher who has studied the use of technology for older populations in general and remote monitoring in particular.

Table 2. Profile of interview participants.

Organization	Type of Organization	Location	Interviewees	Conditions Monitored
Veterans Health Administration	Health System	National	Director, Manager, Nurse Managers	Several Chronic Conditions
Minneapolis VA Medical Center	Research	Minnesota	Physician/PI	CKD, DM
Duke University / Durham VA Medical Center	Academic Research	North Carolina	Physician/PI, Nurses	DM
Geisinger Health System	Health System	Pennsylvania	PI, Researcher, Director, Nurses	CHF, COPD, CKD, DM
Visiting Nurses Association of the Rockford Area	Home Health	Illinois	Nurse Manager, Physician, Nurse	CHF, COPD, DM
Windsor Place	Home Health	Kansas	Director, Nurses, Coordinator, Field Installer	CHF, COPD, DM
UCLA/UC Davis	Academic Research	California	Physician/PI, Nurse	CHF

CHF = congestive heart failure; DM = diabetes mellitus; COPD = chronic obstructive pulmonary disease; CKD = chronic kidney disease. PI = Principal Investigator. UC = University of California. UCLA = University of California, Los Angeles. VA = US Department of Veterans Affairs.

Verbal consent was obtained at the time of the interview. Four interview guides were designed for interviewees based on their role: (1) health care provider, (2) administrator, (3) technician, or (4) researcher. The semi-structured interview guides covered experiences working with remote monitoring technology, who interacts with the technology, how staff has been trained to use the technology, if there are any changes to patient care or workflow as a result of the technology, and other questions related to the workforce implications of remote monitoring technologies. The interviews were conducted by telephone and were of 22-54 minutes duration (38 minutes on average). Interviews were analyzed to identify common themes across all sites and distinct themes associated with site characteristics (e.g., type of health worker, type of technology, etc.) using ATLAS.ti 7 (ATLAS.ti Scientific Software Development, Berlin FRG). Institutional Review Board (IRB) approval (#16-18838) for this study was obtained through the University of California, San Francisco.

Description of case study organizations' remote monitoring programs

Veterans Health Administration

The Veterans Health Administration's (VHA) Home Telehealth program was one of the first remote monitoring programs established in the US. Around the year 2000, the VHA first piloted the idea of a remote monitoring program in a few VA Integrated Service Networks (VISNs) to see if this kind of program could stem the excessive use of health services among a small percentage of "frequent flyers" – veterans with many hospital admissions, ER visits, and multiple scheduled and unscheduled clinic visits. The results of these pilot studies indicated that remote monitoring of basic vital signs (e.g., BP, weight) plus patient education and engagement could save the VHA money, open up space in the medical centers, and improve patient health. By 2005, the Home Telehealth program had expanded to all 21 VISNs across the US, and the VHA's Office of Connected Care had adopted 2 other telehealth modalities: Store-and-Forward (for sharing digital radiology, e.g., tele-retinal exams and tele-dermatology) and Clinical Video Telehealth (virtual visits utilizing videoconferencing).

In the Home Telehealth program, veterans are typically referred by their physicians or are self-referred into the program for management of a wide variety of diagnoses and chronic conditions. It began with a limited number of conditions (HTN, CHF, COPD, DM) but has since expanded to over 19 conditions, including behavioral and mental health disorders, smoking cessation, and weight management, all of which are associated with a Disease Management Protocol (DMP). The DMPs are condition-specific algorithms that identify the questions that will be asked, and, if the patient's data deviates from set parameters, what alerts and decision points are needed to guide the follow-up care. To qualify for the program, patients must meet eligibility criteria (e.g., certain HbA1c or blood pressure readings) and be identified as high risk for not managing their chronic conditions well (e.g., a certain number of clinic visits in a year, ER visits, or hospital admissions) or having high costs of care. Home Telehealth staff can also find local cases on their own by searching the VA database for eligible patients and reaching out with a phone call. Patient recruitment typically includes a phone call, a voicemail message, and a postal letter, if patients were difficult to reach. If after 2 weeks following the last attempted contact the patient has still not contacted the Home Telehealth team, the referral is closed and the patient's physician is notified.

Care Coordinators work with the patient and his/her physician and Patient Aligned Care Team (PACT) to set value ranges for vital signs and other data that may be monitored. Depending on the patient's needs, a wide variety of peripheral devices

(e.g., BP cuffs, scales, pulse oximeters, etc.) can be added to the central messaging device that is used to communicate data to the VA. Each patient's specific parameters are customized and will change as their health status changes; however, the type of data monitored for each condition and the health education modules that are sent through the devices are standardized.

The VHA's Home Telehealth program continues to evolve and demonstrate the power of a remote monitoring program. The program works so well that they report that they are "getting calls from the DoD (US Department of Defense), the private sector, etc., for support… the influx of requests for information has exponentially grown." The program's success appears to be linked to the VHA's strong clinical infrastructure and programming, not the sophistication of the technology itself.

> *"We've seen an … increased access to care and timeliness of care. We've seen all kinds of reduced clinical indicators, from lowering of blood pressure and weight and diabetic factors, just to reducing hospitalizations and emergency room visits and clinic visits. We've just seen so many utilization indicators go down. We've seen so much in terms of improved patient satisfaction and provider satisfaction with it… You really have to have a good clinical infrastructure in which to place your technology and your program. If you build your program around a piece of tech, a device, or a system, or a platform, sometimes you can get into trouble, instead of taking a clinical program you have infrastructure with and embedding that tech inside of an already established program." – VHA Office of Connected Care Administrator*

With the prevalence of chronic conditions rising, demand for the Home Telehealth program is expected to rise, too.

Minneapolis VA Health Care System

Findings from pilot projects and randomized control trials (RCTs) at the Minneapolis VA Medical Center have informed adjustments to the VHA's Home Telehealth program. The first was an RCT in 2011 designed to assess usual VA care versus case management for 556 DM patients with the goal of increasing the percent of patients at goal levels for lipids, BP, and HbA1C.[27] The 2 Case Managers were an RN and an NP and the intervention was closely modeled on the VHA's Home Telehealth program. After a year, a greater proportion of patients assigned to case management had all 3 outcome measures under control compared to the usual care group (21.9% vs. 10.1%, $P<0.01$), indicating the effectiveness of case management for DM patients.

A second RCT in 2016 targeted 601 CKD patients and provided "comprehensive in-home care" with asynchronous data transference with more peripherals (BP cuff, scale, glucometer, pulse oximeter, stethoscope, and web camera) attached to the telehealth devices (touch screen computers) and a larger, multidisciplinary care team. All visits with providers occurred remotely via video streaming from the telehealth device. After a year, the study showed no differences in health outcomes or utilization and has since ended. It is hypothesized that some individuals in the control arm of the study may have been enrolled in the Home Telehealth program and were already closely managed by Telehealth Case Managers, and the duration of the study may not have been sufficient to see changes in care utilization.

Duke University / Durham VA Medical Center

The Advanced Comprehensive Diabetes Care (ACDC) RCT from 2016, described in the literature review, at the Durham VA Medical Center was a comprehensive approach to DM management, comparing usual VA care to telemonitoring, self-management support, and medication management. Researchers used the VHA's existing Home Telehealth infrastructure but tried to provide more direct and aggressive treatment of DM, and patients were asked to submit blood glucose (BG) readings several times a day through their telehealth device (a central messaging device that enabled 2-way communication). Nurse Care Coordinators reviewed the data, consulted with an endocrinologist to determine if care plan changes were needed, and implemented changes. An attempt to recreate the ACDC study processes in a different setting was just completed and relied on patients to enter their own BG data into a patient portal or use a BG meter integrated with an iPod, which would automatically upload data into the patient's EHR. The results of this study are forthcoming.

Geisinger Health System

Geisinger Health System, a network of hospitals and clinics in northeastern and central Pennsylvania, has 2 main telehealth programs that were developed in 2008: one focused on CHF and the other on post-discharge monitoring programs. The CHF monitoring program was developed in partnership with AMC Health (their telehealth vendor), and includes both a Bluetooth-enabled weight scale and an interactive voice response (IVR) system to collect self-reported signs and symptoms as well as to monitor medication adherence. The post-discharge program only uses an IVR system to assess patients' signs and symptoms for those identified at high risk of hospital readmission for a growing number of chronic conditions, including HTN, COPD, DM, and CKD. To enroll eligible patients in either of these programs, the clinical informatics team can search for patients eligible for case management

services using claims data or a variety of other data sources, or providers can refer patients to these programs. Once enrolled in the programs, Nurse Case Managers work in conjunction with the patient's providers to customize and set the appropriate value ranges for any monitored data.

For the CHF monitoring program, patients are instructed to weigh themselves first thing in the morning on the Bluetooth scale. Three days a week, shortly after the weight measurement has been submitted, patients get an automated phone call reminding them to complete the IVR assessment. For the post-discharge IVR program, an initial assessment is scheduled within 24 to 48 hours of discharge to onboard the patient to the program, and then automated phone calls are scheduled for once a week and are customized to the patient's schedule.

Abnormal data or responses (e.g., if the patient gained more than 2 pounds in 24 hours or 5 pounds in a week) trigger a message in red font in the online EHR system. These messages are reviewed daily by nurse RN Case Managers who decide if the issue can be managed over the phone, if a patient needs to be seen, and/or if adjustments to the patient's care are warranted. The Case Managers can titrate medications according to pre-established protocols. They also respond to phone calls from patients to answer questions and address problems. The Case Managers may also be embedded in the patient-centered medical home model and seeing patients in the clinic, including monitored patients, which enables better coordination of data and care for the patient. Some Case Managers are in the community setting, not in a Geisinger clinic, and focus their care on patients who are not as integrated in Geisinger's delivery system but perhaps only use insurance offered by Geisinger.

Visiting Nurses Association of the Rockford Area

The Visiting Nurses Association (VNA) of the Rockford Area is a patient-centered home health agency that has incorporated a Heart and Vascular remote monitoring program for CHF patients. The program began in 2009 and today monitors 100 patients. Prior to 2012, VNA realized that there was insufficient oversight of the program and many nurses were monitoring data of these CHF patients inconsistently due to competing priorities for their clinical patients. The VNA administration shifted the monitoring responsibility to a single Telehealth Manager charged with managing and coordinating care for the total cohort of monitored patients. In this role, the Telehealth Manager, a registered nurse, monitored data daily and could act upon abnormal data more immediately than nurses in clinical care. The Telehealth Manager also adjusted the monitoring program to include

diagnoses beyond CHF, including COPD and DM, and patients identified at high risk for readmission based on the LACE index scoring tool.[28]

The VNA of the Rockford Area partnered with Mercy Health System to enroll and provide monitors to all patients discharged from the hospital with a diagnosis of CHF. Referrals for patients with other conditions are received from other hospitals and clinics.

> *"…if they're eligible and in need, the telemonitor comes out and they are also enrolled in home health so they have the nurses coming out, too. There are a few patients that are not considered home-bound who wouldn't qualify for home health but we still put the telemonitor in so we can keep close tabs on them;… but they're not billed for it at all… because insurance-wise they are not considered home-bound, …they don't need nursing care so it's just a service that we like to utilize more so to prevent readmission, as a more cost saving [more] than anything."* – CHF NP

For all patients, the Telehealth Manager works in partnership with the patient's providers to set clinical data ranges and, for CHF patients, to develop and implement a diuretic titration protocol. Parameters are standardized based on best practices, although customized data ranges can be set depending on physicians' orders. The monitors include a Bluetooth weight scale and a BP cuff which broadcasts a daily reminder asking patients to take their measurements, typically in the morning. The monitor can also be set to the patient's schedule and needs, e.g., the Telehealth Manager may request that patients log measurements both before and after taking their medications. If any data are received that are outside of set bounds, the Telehealth Manager will contact patients by phone and will also assess any follow up care, if needed, with the patient's providers or with home health nurses.

The stated benefits of the program have been numerous. The monitoring identifies problems sooner and triggers care that is proactive and preventive rather than reactive to acute exacerbations of their chronic conditions.

> *"Well, I think it allows us to catch problems sooner. For whatever reason, sometimes patients are just hesitant to call with a problem or they wait too long to call. So, this gives us the opportunity to be a little more proactive, that if they are gaining weight we can get on top of that right away and it's a lot easier, I always tell them, to get off 3 pounds than it is to get off 10 pounds. The sooner we can intervene, identifying the problem, the better off they'll be….. I think it's helped keep people out of*

> *the hospital… A lot of times I've seen some tele-monitoring programs where someone is looking at the information but not necessarily acting on it or not being quite as aggressive. Maybe calling the patient and telling them, "You know you should call the doctor's office." The patient may say, "Okay sure," and they may hang up and say, "Maybe I'll wait until tomorrow." So this way nobody can kind of escape us when we are able to act on information right away." – CHF NP*

The transition to telemonitoring has, again, both enhanced the ability to more quickly assess a patient's health (e.g., with medication changes) and encouraged patients to learn self-management skills, which empowers them to take control of their chronic conditions.

> *"Every time they go into the hospital, the medications get changed, the doses are changed. We don't really know how they're going to do unless it's monitored at home. Prior to the telehealth, we saw them twice a week or something, then nothing's happened other than on those days that we saw them….. We weren't really able to make a good assessment about their care and what was working and what wasn't working. [Telehealth has]It's made a tremendous difference. Not only are we able to monitor their response to their medication changes, it also makes them take responsibility for their health care management and understand the symptoms to report instead of waiting until they can't breathe and they're having chest pain and they end up going to the ER." – Home Health Nurse*

According to the Telehealth Manager at the VNA of the Rockford Area, "the potential of this technology is not being tapped into nearly as much as it could be," although the hospitalizations prevented as a result of this program have clearly proven its value.

Windsor Place

Windsor Place began as a single nursing long-term care facility in 1992 and is now a full-fledged home health agency with remote monitoring programs included in its suite of services. In 2006, Windsor Place received a grant through the Kansas Department for Aging and Disability Services to conduct remote monitoring of patients with 4 chronic conditions: CHF, COPD, DM, and HTN. The results of the pilot test were positive, reporting reduced hospitalizations and ER visits, so the pilot was extended for an additional 3 years. At the end of the pilot phase in 2010, Kansas' Medicaid agency decided to cover remote patient monitoring for its frail elderly population as a Medicaid benefit. Because of the unique payment model,

most of Windsor Place's monitoring clients are referred from 1 of the 3 Managed Care Organizations in Kansas. The remote monitoring team at Windsor Place coordinates care with case managers through the state of Kansas (either nurses or social workers) to enroll and onboard eligible clients. The eligibility criteria include 1 or more chronic disease diagnoses and at least 2 ER or hospital admissions in the last year. The care team is interprofessional, and a Care Coordinator develops a care plan based on information from the case manager and the client's physician, who might provide specific directives and additional information (e.g., medication reconciliation, clinical data parameters). RNs review the diagnoses and decide what equipment is warranted to monitor the client's health. The monitoring device, made by Philips, can incorporate a range of peripherals including blood pressure cuffs, pulse oximeters, weight scales, and glucometers, all of which can be connected to Windsor's monitoring center via landline, cell phone, or the internet.

Once decisions have been made about the appropriate remote monitoring equipment, the Coordinator makes an initial phone call to discuss the patient's health conditions and capabilities (e.g., if they are steady enough for a traditional weight scale) and to let the client know a Field Installer will be calling to set up the equipment, typically within 5 days of the phone call. The Coordinators also handle the billing, inventory, and faxing monthly reports to case managers, physicians, and others as warranted.

The monitoring and continuous education offered by the Windsor Place program allows early intervention and has been shown to reduce ER utilization, hospitalization, and costs.[29] Windsor Place has growing partnerships with the University of Kansas and the Kansas Heart and Stroke Collaborative as well as United Healthcare to implement new programs to increase the capabilities of the technology. Examples of such initiatives are adding videoconferencing capabilities via tablets, developing a mobile clinic to reach "medically unengaged… [yet] high cost]" clients, and employing Health Coaches to enhance client engagement. The Health Coaches are RNs but the focus is less on the daily monitoring, although that is part of the job, and more on engaging with the client twice a month over the phone, coordinating services, and avoiding potentially preventable hospitalizations.

UCLA / UC Davis

A multi-site RCT in California was designed and launched in 2011 to target hospitalized CHF patients and enroll them in a remote monitoring program (N=1,437). The intervention included pre-discharge CHF education, a monitor hub with a Bluetooth-enabled weight scale, heart rate (HR), and BP device peripherals, and regularly scheduled phone calls with study nurses. Patients enrolled in the

study arm (n=715) were instructed to provide daily measurements, which were reviewed by study nurses who also had scheduled calls with the patients to provide education and case management. If data were returned outside of set ranges, an alert was triggered in the EHR system and a study nurse called the patient to follow up. At that point, the nurses decided if a change in medication was needed or if patients needed to be seen by a provider. CHF providers were notified in either scenario, and patients were encouraged to contact their providers. The study team realized early on that the protocol generated far too many alerts to manage and monitor patients in a sustainable fashion.

Researchers also discovered that care was not easily coordinated among various care providers across the various sites, creating more uncompensated work for the study nurses.

> *"This program was not set up to work directly with home health, but we found patients who had 2 home health agencies working with the patient for different conditions. It would be better to have coordination between systems that interact with the home… These technologies would work better if the care was more directly intertwined with the primary care practices. Because of where our systems were, we definitely saw a lot of differences in how that communication can work out. UC Davis had really good Epic system with many providers on it, so communication was easy. But with Cedars-Sinai, it was a lot harder because their providers were on different systems… The coordination really came down to nurses spending a lot of time on the phone. CMS does not reimburse properly for this. When we looked at sustainability, the amount of money offered by CMS can pay for the phone line, and that's about it." – UCLA Physician/PI*

One of the study sites had a CHF clinic that remotely monitored patients with implanted CardioMEMS™ devices, a pulmonary artery pressure monitoring device. The procedures in place to monitor patients with these devices are very similar to procedures to monitor vital signs. Patients must transmit data from the device to a web portal where a CHF NP or RN reviews data daily. If readings are outside of set clinical ranges, the NP or RN calls the patient and does an assessment over the phone to see what's going on and potentially titrate medication. The limitation to this device is that it is a snapshot of data, not continuous monitoring, and it often required patients to come in for a clinical visit.

> *"We still had to interact with the patient and or physically examine the patient. That's something with HF -- you can't manage heart failure over the phone or remotely without eventually having to see the patient. Even if they're having arrhythmia, you have to see the patient, you have to see the arrhythmia, and see what their symptoms are to see if they're having heart failure exacerbations… – you can't tell over the phone no matter how much data you collect from a remote device. This certainly does not replace standard of care, it's just an additional data source." – CHF Nurse*

Findings from case studies

Role of telemonitoring in the context of home-based care

Across the case study sites, 2 care modalities emerged: total remote monitoring and remote monitoring coupled with home care. In most scenarios, patients were referred to or enrolled in the telemonitoring program, equipment was installed, and patients were trained on how to upload or enter data either at clinic visits or in their homes. From there, communication and interactions occurred primarily via telephone. On some occasions, patients who enrolled in telemonitoring programs also qualified for home care, which enabled nurses and other care workers to visually assess patients and their home conditions.

Almost all interviewees saw remote monitoring technologies as another tool in their toolbox to engage and activate patients to take control of their health. In nearly every program, providers were case managers who worked with their patients to help manage their health conditions, and not simply a person monitoring data. This offered patients the opportunity to better understand their health conditions and the reasons why their data may fluctuate depending on their lifestyles. The end goal of these programs is to prevent hospitalizations and save costs; however, the emphasis is on patient engagement and empowerment, two factors seen as critical to adherence and behavioral change.

> *"It used to be that it was this is the technology, I'll look at your data and call you whenever I have to. It's become more and more and more about we're in this together, how can I support you, I'll call you whenever you need me, you call me whenever you need me and more of this collaborative process. Continuing to reinforce that bond, really the more engaged the care coordinator and patient relationship is, the more successful the outcomes are for the patient." – Telehealth Manager in a large health system*

The importance of remote monitoring as a complement to regular care, rather than a replacement was emphasized by the PI who has studied the aging process and health technology for decades:

> *"The findings are clear in the literature that people don't want telehealth to replace human contact, they want it to augment. They want regular care plus. From a health care efficiency perspective is not what the system wants. We need to be cognizant that we don't replace contact or home visits. Telehealth visits cannot do everything. When you walk in a home you'll see a fall hazard you won't see in a video conference." – PI*

Composition and roles of remote monitoring care teams

Most remote monitoring programs utilize teams of providers. For example, in the Veterans Health Administration program, most of the time Care Coordinators who oversee remote monitoring of patients are RNs, but the VHA has expanded the role to include NPs, social workers, registered dieticians, and physical therapists, depending on the needs of the patient.

> *"When we rolled out nationally, you had to have a licensed clinician, health care professional. That could be a registered nurse, a nurse practitioner, a social worker, a dietitian. We have rehab therapists, we have psychologist, we have pharmacists. You have to have a licensed clinician who is responsible for being the Care Coordinator, who takes the information provided by the different types of technologies, looks at it, makes clinical judgments based on that data and then collaborates with the patient's healthcare provider, and now with our Patient Aligned Care Teams or our PACTs." – VHA Office of Connected Care Administrator*

In the VHA, the Care Coordinators are often supported by other allied health professionals, such as health techs and LPN/LVNs, who may arrange enrollment packets, identify and track consults, set up the enrollment appointment, or even review the monitored data and triage patients for the RNs. Due to changes in accreditation standards, Home Telehealth RNs are no longer allowed to visit patients in their homes, but assistance can be requested from other programs within the VA (e.g., Home-Based Primary Care) or externally (e.g., home health agency).

The Minneapolis VA has tested 2 variations of the VHA's program. In one, the 2 Case Managers for DM patients were an RN and an NP. In the other program, for CKD patients, the team included a nephrologist, social workers, dieticians, a

pharmacist, and a psychologist. Home health technicians also were involved in the latter program, installing technology and teaching patients to use it. The nephrologist and nurse Case Managers collaborated to set renal-specific goals, and then the Case Managers reviewed data daily. In retrospect, the study researchers thought the primary physician in the study should have been the patient's primary care provider (PCP) instead of a specialist.

The remote monitoring study at the Durham VA Medical Center and Duke University brought additional care providers into the team, including pharmacists. This was facilitated by the VA's integrated health information technology (HIT) system. HIT system integration could also allow different providers to take on the role of medication management, like NPs or pharmacists, instead of physicians to provide more cost-effective care. Because Care Coordinators were already involved in the VHA's Home Telehealth program, the only piece of training that was required for the ACDC study was reviewing and refining the educational modules that were to be delivered over the phone. Researchers credit much of the success of the ACDC program to the highly-trained and capable VA nurses and the thorough procedures in place, as well as the information technology system that supports communication between care providers.

> *"One of the good things about the VA Project was that the pharmacy system is all integrated with the medical record and everything. …You could communicate with PCPs just with a simple addendum." – Physician/PI*

Geisinger's remote monitoring program is centered on RN Case Managers, but other providers have been integrated into these programs, including non-clinical and medical assistants and community health workers (CHWs). When the programs first started, the non-medical assistants made the now-automated symptom assessment phone calls to patients. MAs are used to help enroll patients and process equipment orders, and CHWs have been used to monitor triggers in low-risk patient populations and see patients in their homes, helping with equipment setup if necessary. If CHWs are used to respond to red triggers, they are required to transfer the phone call to the Case Managers if the issue is clinical; however, they can also help weed out false-positive triggers and triage patients to the Case Managers for follow-up. Pharmacists are often integrated into the monitoring programs to routinely adjust medications, automatically adjusting warfarin or insulin based on the monitored data, for example. These processes are coordinated through the Case Managers, who are "always reaching out to people to help coordinate … transition of care or prevent a readmission." The RN Case Managers

provide general case management services and respond to patient questions as needed. In some patient-centered medical home sites, the Case Managers see patients in clinic settings. Similar to other remote monitoring programs, the success of Geisinger's monitoring programs is not just dependent on the technology to monitor vital signs and symptoms but is also highly dependent on the clinical assessment skills of the Case Managers and their ability to coordinate and empower patients to self-manage their health and chronic conditions.

The Rockford Area VNA program is led by a Telehealth Manager, who coordinates with patients' other care providers, including home health nurses. The program covers patients who are seen by a variety of health professionals including RNs, NPs, physical therapists, occupational therapists, speech therapists, and home health aides. The Telehealth Manager can ask for an in-home assessment by home health providers.

> *"So if a patient was out of bounds in weight gain, the physician's orders allowed us to increase the diuretic and check in again in a few days including bloodwork. This cut down on phone calls a lot since we had the protocol in place." – Telehealth Manager*

The remote monitoring team at Windsor Place is comprised of 2 Coordinators, 4 Telehealth Nurses, and a team of Field Installers across the state. They work with case managers who identify clients and refer them to the program. The Coordinator prepares the client files, communicates with physicians, and works with Telehealth Nurses to determine the equipment the client needs, and then schedules installation by a Field Installer. Ongoing monitoring is done by the Telehealth Nurses.

Across all case study sites, RNs were the most common data monitors, primarily because this allows them to work at the top of their scope of practice and make assessments based on remote monitoring data. The programs at Geisinger, the VNA of the Rockford Area, Windsor Place, Duke University/Durham VA, and UCLA/UC-Davis relied upon RNs to receive, interpret, and act on data. In most states, RNs can adjust medications according to a written protocol. Coordination of care and escalation of abnormal data typically followed a standardized protocol. Data ranges and clinical parameters were either customized to a patient's particular needs or were defaulted to value ranges set by the device manufacturer or external expert agencies and organizations (e.g., American Heart Association). If patient data were near or outside of the set bounds, data monitors had thorough policies and procedures to guide action on the data. These protocols could include physician

directives to follow a diuretic titration protocol for CHF patients or for adjustments to insulin for DM patients.

For example, many CHF clients in the Windsor Place program have established diuretic titration protocols from their physicians that RNs can use to help clients manage their signs and symptoms. At the same time, the protocol for handling abnormal data also often involves contacting clients and encouraging them to see or contact their physicians. This may be supplemented with a phone call or a fax to the client's physician.

> *"One of the things we try to do, another option would be if what they find, we want to get the patient in contact with their doctor. Now, we're willing to call the doctor, but we would rather do that secondarily. We would rather have the patient talking to their doctor."- Executive Director*

Several of the people we interviewed noted that RN education and experience provides them with the clinical judgment skills to assess and determine the course of action for abnormal readings. When asked what kinds of skills and experiences are required for telehealth monitors, independence, critical thinking, and assessment skills were uniformly noted. Providers also rely on nurses monitoring the data to know when to get a provider involved.

> *"I think mainly the good assessment skills. We can teach them how to draw blood. We can teach them to apply wound care. They need to be able to have good assessment skills, to be able to work on their own… Assessment skills, the ability to work independently, to manage their own work flow, those kinds of things. In terms of the telehealth, that's the simple part of it." –VNA of the Rockford Area Home Health Nurse*

Some interviewees suggested that nurse practitioners/advanced practice nurses (NP/APNs) and LVN/LPNs also could serve as data monitors. The benefit of replacing RNs with NP/APNs is the NP/APNs' ability to write orders to adjust medication right away without strict adherence to a protocol. The VA's Home Telehealth program, a broad and extensive national program, has incorporated social workers and registered dieticians as data monitors (in addition to registered nurses) to follow patients with particular health concerns that may not require an RN's knowledge set.

> *"As a case manager, they [RNs] really work to the top of their license. Really consider to be one of members of the care team, serving as an extension of that provider… Then they also really, they really utilize their*

clinical skillset and they do diuretic saturation protocols, they can start COPD rescue kits. They really manage those signs and symptoms and work closely with the provider." - Telehealth Director in a health system

Within the VHA, the main reasons why RNs and NPs are preferred data monitors include their clinical judgment abilities and their scope of practice. Medical Assistants (MAs) and LPN/LVNs are not permitted to make assessments. NPs can unburden providers by making adjustments themselves but they are more costly. Multiple interviewees suggested that a mix of RN and NP Care Coordinators would be ideal so that more medically complex patients can be cared for immediately by an NP, whereas a more stable patient population could be monitored by an RN. However, some programs reported that as the number of clients continues to grow, the initial monitoring might be shifted to LPN/LVNs who would monitor the data for any red flags and alert the RNs when they receive abnormal data.

In the UCLA/UC Davis study, all monitoring was conducted by nurses, but the number of alerts generated by the protocol suggested that a triage system involving other health workers may have been preferred.

"We learned that the number of alerts is way too much. We got probably 3 times more alerts than we expected. This is not sustainable if this requires a call back on every perturbation. You need other technologies to determine whether something truly is an emergency or not, or you'll have to use lower-level personnel. …[r]ight now the systems are not that smart …." – Physician/PI

Managers interviewed at Geisinger reported that they prefer nurses who come from backgrounds in Progressive or Intensive Care Units or home health because of the level of independence required in their jobs, whereas "traditional inpatient Care Managers doing resource coordination and discharge planning is not usually the right skill set." Leadership at Windsor Place also pointed to a nursing background in home health or mental health being preferred over ER or Intensive Care due to the assessment skills honed in the former environments.

Geisinger accepts diploma nurses but is moving toward a Bachelor's degree minimum with the requirement of having their Certified Case Manager certification within 2 years of hire. The VHA prefers that Care Coordinators have a Bachelor's degree and at least 2 years of nursing experience with a strong background in independent clinical assessment. Windsor Place leadership reported that critical thinking skills and case management experience were the top 2 traits recruiters look for when seeking Care Managers.

> *"We're looking for people who have been out there practicing, who have been working within the system and working as a team member and know how to do that and are comfortable in their own clinical judgment skills. We look for a number of things, but I would say those are the things that come to mind as the strongest things, besides interpersonal skills and being good teammates, having enough experience not to be a novice and then also being a good critical thinker." – Administrator in a large health system*

Installation of equipment and training patients

Remote monitoring programs vary regarding who is responsible for installing remote equipment in patients' homes and teaching the patient to use the equipment. Technological challenges in the initial setup may be encountered but these are usually minimal and simple to troubleshoot.

In the Veterans Health Administration, Telehealth Care Coordinators determine which equipment is needed. Devices are typically either mailed to the patient and the Care Coordinators orient patients to the device over the phone or delivered in-person at the hospital or clinic. If the patient is eligible for Home-Based Primary Care, home health nurses can train patients on the equipment during a home visit. The Minneapolis VA has tested programs in which home health technicians installed technology and trained patients.

The VNA of Rockford Area uses CNAs or home health aides to set up equipment in the home. The Telehealth Manager has trained the nursing assistants and home health aides with educational materials to help train patients on how to use the equipment and answer any questions they may have in their home. Home health nurses may be deployed to the patient's home as needed as well, although the number of visits scheduled for monitored patients has sharply decreased with the introduction of the monitoring program (These used to be scheduled 3 times per week for the first few weeks post-discharge for CHF patients.)

At Windsor Place, Field Installers set up and demonstrate how to use the equipment. Test measurements are taken and sent to the Care Coordinator to confirm receipt of data. At the home visit, the Field Installer also runs through a checklist prepared by the Telehealth Nurses to gather information about the client's care and to make an assessment of the home conditions.

> *"[We try to get] things like who keeps track of their medications, when they take their measurements … [T]he state of the home – are they ambulatory, do they need a walker, are they in a wheelchair, ... Any extra information that we can get that is relevant, they would like us to get." – Field Installer*

Between 7 and 10 days after the installation, the Field Installer visits the client at home to answer follow-up questions and troubleshoot issues with the equipment.

> *"We do that [follow-up visit] in person …. We found out by having the installer make the second visit 7 to 10 days after install, the compliance and utilization went up significantly." – Executive Director*

After these 2 meetings, the Field Installer is on call for any tech support issues in the home.

Leadership at Windsor Place reported that Field Installers must have at least a high school diploma with a Bachelor's degree preferred. Softer skills, like customer service and how to communicate well with clients, were often cited as the most important skills required for telehealth work.

> *"If you know how to plug phone cords into things, and put batteries into things, and plug things into a power strip, then hooking this up is not necessarily difficult - the actual technology part. I think that that part is less important in terms of prior knowledge than how to work with people. The softer skills are the more important things to have skills in in terms of my job because we do the face-to-face visits with the client more than anything else."* – Field Installer

Caseload size

The programs that reported a caseload ranged from 200 per Case Manager (Geisinger) to 200-250 per day per program (with multiple monitoring personnel). At Windsor Place, the estimated total patient census is around 1,600 with about 250 of those patients enrolled in the remote patient monitoring program.

The VHA has developed and continues to refine a panel size calculator for determining caseload based on the amount of time needed for each DMP. The caseload can range from about 60 for more complex patients with high needs to about 125, and the average length of stay in the program is between 3 and 9 months.

Duration of Enrollment in Remote Monitoring Program

For the VHA program, it was not unusual for patients to be on the program for more than 10 years until the focus of the program tightened to get patients in the program with clearly defined goals, achieve those goals with a short stay in Home Telehealth, and discharge them to make room for new patients. The focus became more on patient engagement and activation to help patients better manage their chronic conditions on their own.

At the VNA of Rockford Area, patients are typically enrolled in the program for about 30 days to get them in the habit of checking their weight, signs, and symptoms daily and knowing when to call the nursing staff for assistance.

Staff training

Staff training for remotely monitored care consisted of a combination of on-the-job, program-specific training, manufacturer-led training, module-based online training, and preceptorship/shadowing of more experienced staff. It was not uncommon for interviewees to suggest that full onboarding of new staff could take up to 1 year depending on their skills and experience. For nurse data monitors in particular, case management experience was identified as a key skill.

The VHA's staff training has developed over time to be a robust combination of online module competency-based trainings, on-the-job shadowing with a preceptor, and specialized Master Preceptor trainings for experienced Care Coordinators. An initial 40 hours of training through the national VHA office presents the technology, installation, business practices, veteran-centered care, etc., as well as position-based competencies for the various Care Coordinator backgrounds (e.g., nurses, social workers, dieticians). This national training program was developed in-house by subject matter experts (e.g., telehealth, business, clinical condition) and thoroughly vetted prior to implementation. Additional trainings are required at the local level and with the technology vendor. Annual updates and trainings are required for all Home Telehealth staff at all levels (Lead Care Coordinators, Care Coordinators, Program Support Staff). In addition to trainings, new staff shadow a preceptor for their first 4-6 weeks, although it is reported to take up to a year before staff are thoroughly oriented.

VHA training has evolved from concrete, skill-based competencies to health coaching, how to engage patients in the health care process, and how to best collaborate with the patient. The Master Preceptor program was designed as a way

to share best practices among high-functioning Care Coordinators and to educate and train existing and new Care Coordinators.

> *"We found that nurses who are new to the whole nursing genre don't really do as well as care coordinators who are seasoned nurses who have more experience under their belt because in this Home Telehealth program, there is a lot of functioning independently. They need to have experience to draw on." – Home Telehealth Manager*

For the Minneapolis VA's programs for DM and CKD, the study team had about 6-9 months for training. This included reviewing algorithms that were designed to set both individual and group data parameters and the protocols to follow for medication management as well as when to elevate issues to providers. The Case Managers were VA nurses who were already trained on VA procedures, although none of them were then part of the Home Telehealth program. The health technicians were taught on-the-job how to take baseline and follow-up measurements, including BP, weight, height, drawing blood, collecting urine, and specimen handling, although there were no licensing requirements.

Geisinger's onboarding process for new hires takes 8 to 12 weeks and involves shadowing with preceptors, classroom time, online modules, and hands-on training. A large component of the training includes health education and disease processes to better understand the complexity of care required for the monitored patients.

The Telehealth Manager of the VNA of the Rockford Area has developed training competencies for new hires, which includes classroom-style education, on-the-job practice and training, and shadowing preceptors. The orientation also involves situational learning due to the dynamic nature of home visits. The nurses must also be very knowledgeable about various disease processes, and this plays a role in both recruitment and training.

The training requirements for Windsor Place's telehealth care team includes on-the-job and vendor training. Philips, the vendor, and the Coordinators are typically onsite for Field Installer training, which is a 3-day orientation. The training covers the history of the program and its effects on cost savings as well as an in-depth review of the equipment, concluding with a pilot installation of equipment with clients who have volunteered to act as new clients. After the pilot installation, the staff debriefs and share best practices. For Coordinators and Telehealth Nurses, the training was less intensive and structured but involved shadowing experienced staff members and reviewing materials from the vendor. On the nursing side, there was not much additional training beyond the technology itself and the institutional

protocols, although some nurses were trained more extensively with Philips when the program was first developed.

The UCLA/UC-Davis study involved nurses who were trained on phone care management and motivational interviewing; however, researchers thought shadowing or simulation technology might be helpful to run through scenarios and tighten protocols. Backgrounds in home health or health coaching seemed to be beneficial experience for the study nurses as "it's an art to figure out on the telephone how sick somebody really is."

A researcher who has examined remote monitoring for more than a decade emphasized the importance of not underestimating the amount of time required to both train patients and providers and also troubleshoot technological needs and barriers. Patients in remote settings may have reception issues that need to be accounted for. Home settings are also non-standard and many unforeseen issues may come up that the care team may not be prepared to handle (e.g., low lighting, incompatible electrical outlets). Piloting training materials and procedures can be helpful to identify misunderstandings and any gaps in the staff's understanding of the program. Further, training both providers and emphasizing patient and caregiver training are significant components not to be understated.

> *"People pay too little attention to training… We can improve on training, design of the equipment and interventions. Not everybody has a good human factors background."* – PI

Care providers' acceptance of remote monitoring

In the VHA, providers were initially apprehensive about the remote monitoring program, expecting more phone calls and follow-ups, but as time went on, providers seemed to appreciate the accurate data and trends and saw the Care Coordinators as "an extension of the nurses at the clinic."

> *"I think initial challenges had a lot to do with provider receptivity and getting them to understand that it wasn't more work for them to review information because it kept the patient out of their clinic, which would have been a visit, and that they would have additional slots open for people who … really needed to be seen."* – VHA Office of Connected Care Administrator

Geisinger trains their providers annually about the benefits of case management and what the remote monitoring programs can do for them and their patients. There is a perception among the Case Managers that they must build physician respect for and trust in the Case Manager, but once that trust is established, these

programs are seen as another "tool in their tool box" to better care for their patients.

> *"Once those providers have that trust in them, they can go to them and say, "Hey what do you think about doing a scale for this patient?" And working with them to determine what the weight setting should be. That kind of thing, or if the patient does trigger [in the AMC program], they know that the Case Manager will address those needs and that's just another tool in their tool box."*- Geisinger Telehealth Director

Leadership at the VNA of the Rockford Area agreed that buy-in is needed on the provider side. At first, they found that nurses were afraid the program might mean more work for them but this turned out to be false, and they were quickly highly responsive and supportive of the program. The Telehealth Manager has built relationships and rapport with physicians, nurses, and allied staff to ensure coordination and management of care for patients in the monitoring program.

Windsor Place staff report that occasionally physicians are less invested in the program since they are not directly tied to it. In these cases, the telehealth team tries to get the client and his/her caregivers more active and engaged in the care. More often, however, physicians and their clinical staff actively seek the wealth of information that the monitoring programs can provide to enhance patient care.

> *"We have called family and let them know that we've notified the physician and the physician is choosing not to do anything for us, so maybe if that family member needs to ask and they're usually more than willing to take over. We let them know that United Healthcare has hired us to keep their patients out of the hospital and we will let them know that they're not responding to information to help keep them out of the hospital. That usually wakes them up a little bit too."* – Telehealth Nurse

Patient acceptance of remote monitoring

Contrary to popular opinion and staff beliefs prior to implementation of remotely monitored care, interviewees reported very little resistance to the technologies from their patient populations. The challenge cited most often related to missed communication (e.g., patients not picking up the telephone, inconsistent phone numbers, etc.).

> *"Some are afraid of the technology – some of our monitors are Samsung Galaxy tablets. People say "I can't work with a computer." But once they are shown how to do it and do it a few times, they are quick to pick it up*

and have no issue. We have to get over that fright at first." – Telehealth Manager at a home health agency

Many telemonitoring providers we interviewed indicated that patients need time to adapt to remote monitoring technologies.

"…it takes a little while to get patients accustomed to using the device and incorporating it into their life. … [m]aybe we should've just had[a] 6-month run in period, where you just have a device and we'll slowly get you used to using it." – Physician/PI

Staff at the VNA of the Rockford Area report that they encountered some apprehensive patients who may have been intimidated by the technology, but these fears are typically assuaged with hands-on education and framing of the benefits of the program.

"We have to get over that fright at first… It's important how it's presented. If the home health aide or nurse doesn't go in with a very positive attitude and sell of the technology then uptake might be worse. We tell them the physician wants them to use it. It also gives us a chance to empower them – it gives the person the ability to control their disease rather than the disease controlling them. The patients are key members of the team. If they don't buy in to this, then they are eventually going to fall back into their old habits." – Telehealth Manager

Like other monitoring programs, Windsor Place staff thought clients would be wary of the technology, but devices that are simply designed and easy to use have helped to alleviate these fears. More challenging than the client's perception of the technology are barriers related to communication and reception in rural localities. Compliance has been a challenge with clients who may not answer their phones or have stopped taking measurements.

"[O]nce they start being non-compliant then they get a little bit harder to reach via phone too. One thing I have found is a lot of our client population are low income and frequently either run out of minutes on their phones or their phone numbers change" – Telehealth Nurse

Telephone communications were also a concern for Geisinger's remote monitoring program, which now uses fully automated phone calls. Case Managers were apprehensive of this change, fearing patients would not respond as well compared to the personalized phone calls. There are some patients who are not as

responsive, but Case Managers think the program's success hinges on education and framing of the program.

> *"What I've found through just using it that everybody will respond if you explain it correctly and you give them the information necessary. I think maybe in the beginning I personally wasn't explaining it enough and people would get these automated calls and they would just hang up and they wouldn't respond." – Nurse Case Manager*

The success of the remote monitoring program at Windsor Place, like other telemonitoring programs, centers on the ability of the care team to educate their clients on their chronic conditions and to help them self-manage their signs and symptoms.

> *"I think the most important part of what I do in making it successful is making sure that they understand, the client understands, what telehealth does for them. Nobody wants to be in the hospital, nobody wants to have to live in a nursing facility. Nobody wants that. People want to be in their homes where they're comfortable - their own environment…. And if they get to that point where they understand that this is what keeps me home, this is what keeps me out of the hospital, out of the nursing home, then they're in and they're not going to let it get away from them." – Field Installer*

A researcher with decades of experience in studying the aging process and health technologies echoes this sentiment: While remote monitoring programs are useful in their ability to divert care from the clinic and provide access to care for rural patients, their true power is the ability to guide patients in their understanding of their chronic conditions and to help engage patients in the care process.

> *"When you have symptoms like high blood pressure because there are no real symptoms and the medication often has side effects, it's hard to get people to adhere because they have no sense the medication is doing anything for them. The monitoring technology can be useful because you can set targets and get reaffirming feedback daily." – PI of multiple studies of remote monitoring*

Challenges to remote monitoring

Several of those we interviewed noted that adjusting to remotely monitoring patients is challenging to those used to face-to-face interactions. Leaders at the VHA noted that having some home visits allowed more information about the

patient's home care and the ability to assess the patient's conditions immediately without needing to ask several leading questions to get a picture of what was going on.

> *"…at first it takes a lot of skill to get the kind of information you need from somebody who is just not in your same physical space. You have to be really good about getting what you need and making the patient feel important and valued without it taking you a long time, because you're there trying to see multiple patients." – VHA Office of Connected Care Administrator*

Personnel in the Windsor Place program indicate similar concerns: It might be problematic to follow the diuretic titration protocol without having a full grasp of the client's condition due to reliance on self-reported signs and symptoms rather than direct observation. Overcoming this challenge requires strong investigative skills and rapport building to get the client's buy-in. If needed, the Field Installers and/or other home health nurses can visit with clients to get a better understanding of the client's situation, and new programs are adding videoconferencing capabilities to the devices.

The Minneapolis VA Medical Center's study of Home Telehealth for DM reported that they faced a challenge of patients not answering their phones when Case Managers called them to discuss worrisome data. This impeded close management of patients and undermined the effectiveness of the program.

Communication challenges among care team members can create barriers to the success of remote monitoring programs. A Minneapolis VA multidisciplinary care team for CKD patients tried to have daily huddles to discuss abnormalities, but this proved difficult to arrange due to logistical challenges.

For the VHA program, there appears to be a heavy burden of documentation on the Care Coordinators, which can takes up to 2 hours at enrollment. The VHA is working on remedying this but it remains a challenge to the Care Coordinators who view much of the additional paperwork as "repetitive information that's already in [the EHR]." There are also reports of difficulties with the monitoring equipment itself, although this can be alleviated by well-trained Care Coordinators. Lastly, there are still some administrators within the VA system who are not committed to the Home Telehealth program or have not seen the impact on the bottom line, so it continues to be challenging to get provider and administrator buy-in.

Conclusions

Several important patterns were uncovered in the literature review. First, across the 4 chronic conditions – CHF, DM, COPD, and CKD – much of the same clinical remote monitoring data was collected (e.g., BP monitoring), and positive outcomes were achieved across the conditions. Understanding how remote monitoring technologies may apply across multiple conditions is helpful for planning remote monitoring programs for the future. Second, the literature revealed that a multidisciplinary team approach – incorporating nurses (clinical and case), advance practice nurses, physicians, specialists, and pharmacists (clinical and case) – was associated with more positive biometric and health care system outcomes. Last, remote monitoring models that incorporated subjective symptom questionnaires with biometric data were more often associated with positive findings compared with studies that solely examined subjective symptom or biometric data in isolation. Pharmacist case management seems to be an effective model for the management of CKD and HTN, while a combination of nurse-managed and physician-led teams were more often seen for CHF, DM, and COPD. Generally, teams used multidisciplinary approaches, with the general exception being pharmacist case management teams for CKD.

Based on findings from case studies and interviews, nurses are the primary health professionals involved in remote monitoring programs. Allied health professionals provide support for programs, but the bulk of the monitoring, care coordination, and case management activities fall under RNs. The RNs' scope of practice allows them the independence to utilize assessment skills while simultaneously following well-defined policies and procedures to communicate and act upon data. Allied health professionals, such as LPN/LVNs, MAs, or CHWs, could initially review data for red flags, but any follow-up care would need to be deferred to a nurse or mid-level provider.

Remote monitoring programs partially substitute for home visits by RNs, although this is dependent on the funding structure of the program. The Joint Commission accreditation standards for home care do not cover the scope of care provided in most monitoring programs. In some instances, the needs of the patient can allow both care modalities to operate, but unless a patient has specific need for support in activities of daily living (ADLs), home health visits are usually not covered. To accommodate this, remote monitoring programs are branching out to incorporate videoconferencing capabilities to allow visual assessment of patients and their health conditions.

A range of clinical experience and skills are critical for successful telemonitoring programs. Nurses must rely on critical thinking skills and their ability to verbally assess patients, ask the right questions, and use this information in conjunction with monitored data to make clinical judgments as to the patient's health. Beyond this, clearly defined and logic-driven protocols must be established to set data parameters and decision points. Customizing parameters to the patient, close monitoring, and case management with input from the whole care team appears to be the best approach.

Successful integration of emerging remote monitoring technologies into the existing health delivery model requires appropriate medical professional support, training, and role distinction. Strategically and carefully planned coordination and communication of care, with buy-in from all care providers, is crucial to the success of any monitoring program.

The VA's Home Telehealth program is the most widespread, developed, and longest-running remote monitoring program in the U.S. As a national leader in the field, the VA's program has demonstrated its utility as a model that can be disseminated widely and for multiple chronic conditions.

> *"I think one of the biggest barriers to actually using telemedicine and stuff like that, monitoring technologies in practice is that there's just no infrastructure to do it. There's no way to pay for it. There's no way to hire people specifically to do it in most systems, so the VA to me is like head and shoulders above academic healthcare systems at least as far as being able to do telemedicine." – Physician/PI*

Limitations

Health technology is an emerging field with significant research under way. The newness of the field limits the volume of published peer-reviewed studies useful for gauging the long-term impact of remote monitoring technologies on health care costs and the health care workforce. While studies may measure biometric health outcomes, less often do they measure ER visits and economic impact. In several of the studies, it was not clear how research teams were trained or to whom certain tasks were allocated. Additionally, few studies discussed the process for determining triggers for abnormal biometric values and who was involved in this process.

The major limitation of this study is the small sample size of case studies and its inability to be fully representative of the use of remote monitoring technologies in the U.S.

Recommendations

Several recommendations can be drawn from the findings of this study.

1. Remote monitoring programs need to invest adequately in training of the professionals who will monitor the data, staff who will install equipment, providers who will educate patients, and other care team members who need to understand the value of the program. There was consistent agreement that those who receive, interpret, and act on data need strong assessment skills, and some of those with whom we spoke highlighted the value of motivational interviewing skills.

   As greater number of nurses become involved in case management, including remote monitoring, nursing education programs need to prepare new graduates with the skills required for this work.[30] However, efforts to develop and improve communication and critical assessment skills should not be limited to RN education. Many monitoring programs use home health aides or technical field installers to work with patients to install remote technologies and educate patients in how to use them. Strong "soft skills" are essential for success in this area of work.

2. An expanded effort to share information across remote monitoring programs would accelerate learning and enhance success. Additional research is needed to identify best practices and standards for alerts and intervention. The development of standardized approaches and protocols should be a long-term goal, following the leadership of the Veterans Health Administration which has one of the most well-developed remote monitoring programs in the U.S. Improved protocols also may enable expanded engagement of non-RN professionals in remote monitoring programs.

3. Analysis of the impact of remote monitoring needs to include assessment of the return-on-investment. As health care organizations face greater pressure to improve the quality of care while controlling costs, they will need to accurately determine the costs of each of the components of remote monitoring programs and assess their value. Such data can enable programs to compare different approaches and technologies to determine how to best

achieve the desired results. For example, Geisinger has been able to positively impact the efficiency and cost of their care with these programs, but the initial investments in the programs were costly.

4. Health care organizations must recognize that telemonitoring cannot replace hands-on clinical care. This was emphasized in many interviews, including that with a national research expert in this field.

Related Resources

Health Workforce Policy Brief

Acronyms Used in this Report

ACDC – Advanced Comprehensive Diabetes Care

ADL – activities of daily living

AHM – automated health monitoring

APN – advanced practice nurse

BG – blood glucose

BP – blood pressure

CHF – congestive heart failure

CHW – community health worker

CI – confidence interval

CINAHL – Cumulative Index to Nursing and Allied Health Literature

CKD – chronic kidney disease

CMS – Centers for Medicare and Medicaid Services

COPD – chronic obstructive pulmonary disease

DM – diabetes mellitus

DMP – disease management protocol

DoD – Department of Defense

ECG – echocardiogram

EHR – electronic health record

ER – emergency room

HCBS – home and community-based services

HR – heart rate

HTN – hypertension

IADL – instrumental activities of daily living

IVR – interactive voice response

LPN – licensed practical nurse

LVN – licensed vocational nurse

PLOS – Public Library of Science

MA – medical assistant

MEPS – Medical Expenditure Panel Survey

N – number

NP – nurse practitioner

PACT – patient aligned care team

PCP – primary care provider

PI – principal investigator

PPH – potentially preventable hospitalizations

RCT – randomized controlled trials

RN – registered nurse

RR – respiratory rate or relative risk

SMS – short message service

VA – Veterans Affairs

VHA – Veterans Health Administration

VISN – VA integrated service network

VNA – Visiting Nurses Association

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