2018

The effectiveness of mI SMART: A nurse practitioner led technology intervention for multiple chronic conditions in primary care

Jennifer A. Mallow PhD
West Virginia University, jamallow@hsc.wvu.edu

Laurie Theeke
West Virginia University, ltheeke@hsc.wvu.edu

Elliott Theeke
West Virginia University, etheeke1@hsc.wvu.edu

Brain K. Mallow
Sovern Run, bkmallow@gmail.com

International Journal of Nursing Sciences 5 (2018) 131–137

HOSTED BY

Contents lists available at ScienceDirect

International Journal of Nursing Sciences

journal homepage: http://www.elsevier.com/journals/international-journal-of-nursing-sciences/2352-0132

Special Issue: Advanced Practice Nursing

The effectiveness of mI SMART: A nurse practitioner led technology intervention for multiple chronic conditions in primary care

Jennifer A. Mallow [a, *], Laurie A. Theeke [a], Elliott Theeke [a], Brian K. Mallow [b]

[a] West Virginia University, School of Nursing, United States of America
[b] Sovern Run, LLC, United States of America

ARTICLE INFO

Article history:
Received 31 October 2017
Received in revised form
14 March 2018
Accepted 27 March 2018
Available online 31 March 2018

Keywords:
Health disparities
mHealth
Multiple chronic conditions
Nursing informatics
Rural

ABSTRACT

Aims: Used as integrated tools, technology may improve access and outcomes of care. A new intervention that integrates multiple technologies called mI SMART has been developed, implemented, and evaluated by Nurse Practitioners. The aim of this paper is to present the initial effectiveness of a web-based, structure of sensors and mobile devices designed to overcome the known health determinant of access to care for rural, chronically ill patients by using technology.

Methods: The study was conducted at a community primary-care clinic that provides free healthcare to impoverished adults. Adults with at least one chronic condition, a minimum of 3rd grade reading level, and without dementia/psychosis were recruited. Participants were given a Nexus7 tablet and Bluetooth self-monitoring devices. The intervention lasted for 12 weeks. Blood glucose, blood pressure, and weight were collected using the provided Bluetooth devices and means were evaluated with paired-samples t-tests before and after the intervention.

Results: Thirty participants were majority female, white, married, high-school educated or less, earning less than $20,000 per annum, and had multiple chronic conditions. Pre-intervention glucose, systolic blood pressure, diastolic blood pressure, weight and Body Mass Index were all reduced after the 12-week intervention.

Conclusions: The mI SMART intervention is efficacious for use in improvised adults living in rural areas with multiple chronic conditions. As previously reported, the intervention was also shown to be feasible and acceptable to patients. The next step is a larger randomized controlled trial.

1. Introduction

People living with chronic conditions experience poor health, disability, and premature death [1]. Chronic conditions, such as heart disease and diabetes, are the leading cause of mortality in the world [2]. It is estimated that over half (117 million) of US adults have a chronic conditions, and 1 in 4 adults have multiple chronic conditions [3]. Furthermore, most health-care expenditures in the United States are due to chronic conditions [4]. Individuals with multiple chronic conditions often have difficulty achieving treatment goals because treatments are complex, advice for each condition can be conflicting, and multiple chronic conditions co-exists with social, physical and behavioral health disparities [5–8]. In addition, rural primary care practices are overburdened and care is often sought only for emergent issues where treatment cannot be centered on preventative or health maintenance services. Due to unique training, Nurse Practitioners (NPs) have an opportunity to develop, implement, and evaluate innovative interventions to improve the experience of chronic conditions for individuals experiencing health disparities and decrease burden for both patients and healthcare providers.

There is true potential for improving care of multiple chronic conditions for those living in rural areas through the integration and use of cost effective technology. The available literature on individual technology interventions is promising but there have been limited studies that provide evidence for improved outcomes, cost effectiveness, and cultural relevance [9]. Integrating empirically based technological interventions with effective workflow processes in rural health systems may allow for increased access, a shift to prevention and maintenance, and improved self-

* Corresponding author.
E-mail addresses: jamallow@hsc.wvu.edu (J.A. Mallow), ltheeke@hsc.wvu.edu (L.A. Theeke), Etheeke1@hsc.wvu.edu (E. Theeke), bkmallow@gmail.com (B.K. Mallow).

Peer review under responsibility of Chinese Nursing Association.

https://doi.org/10.1016/j.ijnss.2018.03.009

management ability [6,10]. Current gaps in the literature have been identified as; non-integration of data into existing systems and healthcare records, limited reimbursement for technology interventions, poor understanding on how such interventions will affect work-flow processes, and the ubiquitous yet disjointed technology interventions. All of these identified gaps decrease use and increase complexity for both healthcare systems and patients. During development of technology interventions, the NP should focus on combining empirically tested interventions though the use of technology that are cost effective, culturally relevant, minimally disruptive to current workflows and that improve outcomes.

The mI SMART intervention was created by an NP using a model for developing complex nursing interventions [11], to improve primary care access and outcomes of care for rural and underserved individuals living with multiple chronic conditions. The completed technology intervention combines a Health Insurance Portability and Accountability Act (HIPAA) compliant, web-based, structure of mHealth sensors (portable health monitors) and mobile devices to treat and monitor multiple chronic conditions. Different from what currently exists, mI SMART integrates NP care of multiple chronic conditions into one technology intervention. The mI SMART technology intervention allows patients to track diagnoses, medications, lab results, receive reminders for self-management, perform self-monitoring, obtain feedback in real time, engage in education, and attend visits through video conferencing. The technology intervention displays a record database to patients and NPs and provides a process for using such a technology intervention within the primary care setting. Integration into existing Electronic Health Records is in progress. The development, feasibility, and acceptability have been published separately [12,13]. The purpose of this paper is to present the initial effectiveness of mI SMART for biophysical outcomes in persons with multiple chronic conditions who are living in rural areas of health disparity.

2. Theoretical underpinnings

Two theoretical models were chosen to direct this project. The first was the Quality Health Outcomes Model which was developed by the American Academy of Nursing's Expert Panel on Quality Health Care in 1996 as an expansion of Donabedian's structure-process-outcome framework. The model has four major concepts, the system, the interventions, the patients, and the outcomes that have been operationalized in this study. The system is a free healthcare clinic, the intervention used is the mI SMART platform, the patients are low-income patients with multiple chronic illnesses, and the outcomes of interest were access to care, glucose, blood pressure, and body weight. The model describes the reciprocal relationship that occurs among patients, the system where care is provided, and interventions that impact desired outcomes [14]. Outcomes are also connected to the interactions of a patient with the particular healthcare system and with delivered interventions [15].

To further direct the development and implementation of mI SMART, the Chronic Care Model [16] was used with the intention of making patient-centered, evidenced based care easier to achieve. The model involves six interconnected system changes in the health system, community support, self-management support, decision support, clinical information systems, and delivery system design. This model is operationalized through a prepared NP delivering planned interactions they helped develop, intensive patient self-management support, effective use of community resources, integrated decision support for the NP, and available information technology support. These concepts are designed to work together to strengthen the provider-patient relationship, improve communication, and improve health outcomes [16].

3. Materials and methods

3.1. Design, aims and ethical considerations

The study design was a prospective, pre/post design using a convenience sample of people attending a free clinic between December 2, 2014 and December 8, 2015. The three following aims were accomplished by studying a sample of adults attending a free clinic experiencing multiple chronic conditions: (1) to describe the population of participants willing to use technology to treat multiple chronic conditions in rural areas; (2) to evaluate the initial effectiveness of mI SMART for improving biophysical outcomes of multiple chronic conditions; and (3) to begin to understand the interaction between characteristics of patients in rural areas and the use of technology to impact outcomes. The aims presented three corresponding research questions, as follows. 1) What are the baseline characteristics of individuals living in rural areas that experience multiple chronic conditions and are willing to use technology to receive primary care? 2) What are the differences between the participants baseline and post intervention biophysical outcomes (blood pressure, blood glucose, and weight)? 3) What are the relationships between rural patient characteristics and intervention outcomes? Before the study commenced, this research protocol was reviewed and approved by the Institutional Review Board (IRB) in accordance with 46 CFR 46.101b (Protocol # 1501534474).

3.2. Setting

The setting for enrollment in the study was Milan Puskar Health Right, a primary care clinic providing health care at no or low cost to uninsured or underinsured, low income, adults aged 18–64 living in West Virginia. The clinic provides direct healthcare, health education, medications, and social services for this patient population. The clinic has more than 28,000 patient encounters annually. Patients traveled to the clinic for initial enrollment into the study and then received care via technology for the remainder of the intervention. Our previous pilot studies using the EMR of the rural healthcare clinic where the intervention took place have identified that mean travel distance to this clinic for patients is 21 miles [17].

3.3. Subjects

The population construct for the initial trial was people who were experiencing health disparities due to known determinants of health such as low income and lack of insurance. The target population was patients for whom attending frequent clinic visits was difficult due to a lack of transportation, or working hours that were not conducive to regular office visits, or burdensome travel to clinic. The accessible population were patients who qualified to attend the free clinic based on the clinic guidelines for low income. Potential participants were identified through the recommendations of NPs in the clinic. The sample was recruited from the accessible population based on the following inclusion criteria: being an adult over the age of 18, diagnosis of chronic conditions that could be monitored and treated using the mI SMART technology intervention. For example, participants could live with any combination of diabetes, obesity, hypertension, depression, or hyperlipidemia. Exclusion criteria included participants who did not speak or read English at a 3rd grade reading level, or those with dementia or psychosis that would prevent understanding of educational materials and study communications.

3.4. Study enrollment procedures

After the potential participants were identified by NPs in the clinic, they were contacted by the front desk staff and invited to participate in the study. These individuals were scheduled to come into the clinic to meet with the study team. The intervention was explained by one NP, and after the individual agreed to participate, informed study consent was obtained. All but one invited participant agreed to be part of the study. The sampling goal for this one group feasibility study was 30 participants and a total sample of 30 participants were enrolled. The sampling design was based on recommendations for sample size for feasibility studies [18].

3.5. Delivering the mI SMART intervention

The mI SMART technology intervention looks like an application (app) (See Fig. 1). However, mI SMART is actually web based in order to be usable with any mobile device and operating system. The patient side of mI SMART combines synchronous and asynchronous patient education, reminders to perform self-management, a record of self-monitoring readings with automated and personal responses from clinicians, notifications of medications due, secure asynchronous messaging portal, video conferencing for routine appointments, access to laboratory results, and research survey links. The full description of the mI SMART platform can be found in a previous publication of the feasibility and acceptability of the technology intervention in a rural state with patients who experience health disparity [13]. Each consenting participant was given Bluetooth enabled self-monitoring devices such as a scale, glucometer, blood pressure cuff, a Nexus 7 tablet, and three months of internet data service. The participants kept the equipment after the study period. Each participant used the mI SMART platform for 12 weeks to obtain healthcare from their location instead of traveling to the clinic. The period of twelve weeks was chosen to overcome the potential for Hawthorne effect, allowing participants to establish a routine of usual chronic condition monitoring and follow-up.

During the initial enrollment visit, each participant was given in person verbal and hands on instruction by one NP on how to use the tablet, the mI SMART platform, the self-monitoring devices, and personalized expectations from their NP of how often to use the self-monitors. Each participant was given a written copy of the instructions, recorded demonstrations were also available within mI SMART for the participants to view at any time, and contact information for study personal for live technical support. Study staff was available to answer any questions before the participant returned home to begin their 12-week intervention. During the 12 weeks, each participant used the video conferencing system to see their NP. The times of the video visits were arranged by the patients and the NP at their mutual convenience and the patient's need for care. Education videos related to care of their specific chronic conditions and live video conferencing with a health educator via the mI SMART platform were provided. The content of the videos and education were dependent on the unique combination of chronic conditions of the participant. Frequency of obtaining self-monitoring readings varied by participant based on NP recommendations. Patients received individualized automated reminders for using the self-monitoring devices and taking medications. All self-monitoring readings received automated immediate feedback through mI SMART, and critical self-monitoring values were reviewed by a registered nurse. Appropriate referral was given when necessary.

Fig. 1. Image of mI SMART Web application.

3.6. Instruments and measures

At study enrollment, data was collected for baseline variables using pre-intervention questionnaires with the tablets. This initial data collection method was used to verify that participants could use the equipment prior to returning home.

3.6.1. Demographics

Using the provided electronic tables, participants answered self-reported demographic questionnaires at the time of enrollment. Age was collected as a continuous variable as years at the time of enrollment. Gender was collected as a dichotomous variable, male or female. The following demographic information was collected as categorical data with the categories listed separately in parenthesis: ethnicity (White, Hispanic, African American, Native American, Asian/Pacific Islander, other); marital status (single, married, separated, divorced, widowed, significant other) education level (less than high school, high school/GED, some college, 2-year college degree (Associates), 4-year college degree (BA/BS), Master's degree, Doctoral degree); income level (less than $20,000, $20,000-$34,999, $35,000-$49,999, $50,000-$74,999, $75,000-$99,999, $100,000 or more); employment status (employed for wages, self-employed, out of work and looking for work, out of work but not currently looking for work, homemaker, student, military, retired, unable to work). Number of unique diagnosis was collected from the chart as a continuous variable.

3.6.2. Quality of life

The Medical Outcomes Trust Short Form-36 Health Survey versions 2.0 (SF-36v2), was used to measure quality of life. The SF-36v2 is a 36-item questionnaire that reflects eight general health concepts including physical functioning (10-item), physical functioning (4-item), bodily pain (2-item), mental health (5-item), emotional functioning (3-item), social functioning (2-item), vitality (4-item), and general health (5-item). Each item is coded with a numerical value, summed, and transformed to a scale ranged from 0 to 100 (the higher score, the better state of health). Reliability and validity of the SF-36 is supported by many studies. For diverse populations, item-internal consistency is 97% and item-discriminant validity is 92%. Reliability coefficients ranged from a low of 0.65 to a high of 0.94 across scales (median = 0.85) [19]. The instrument is easy to administer in 5–10 min. Participants were asked to take this survey prior to intervention during enrollment and after 12 weeks of care while at home.

3.6.3. Loneliness

The 20 item University of California, Los Angeles (UCLA) Loneliness Scale (version 3) was used to assess loneliness. It reflects a conceptualization of loneliness as a complex phenomenon with both emotional and social components. The current version,

version 3, appeared in 1996 and includes 11 positively worded and nine negatively worded items. All items can be answered using a Likert scale, with potential answers of "never," "rarely," "sometimes," and "often"; each answer is assigned a point value ranging from 1 (never) to 4 (often). Possible total scores range from 20 to 80, with 20 indicating no loneliness and higher scores indicating greater loneliness. Scores over 40 are generally considered to indicate loneliness. The scale has high internal consistency (Cronbach α of 0.89–0.94) and positive test retest reliability ($r = 0.73$) (Russell and Cutrona 1980). Participants were asked to take this survey prior to intervention during enrollment and after 12 weeks of care while at home.

3.6.4. Depression

The Patient Health Questionnaire (PHQ-9) is a 9-item multipurpose instrument for screening, diagnosing, monitoring, and measuring the severity of depression. The tool rates the frequency of depressive symptoms as well as the presence and duration of suicidal ideation. The PHQ-9 can be completed in a few minutes and can be administered repeatedly to assessed for improvement or worsening of depression. The tool has a sensitivity of 88% and a specificity of 88% for major depression. Scores of 5, 10, 15, and 20 represent mild, moderate, moderately severe, and severe depression (Kroenke et al., 2001). Participants were asked to take this survey prior to intervention during enrollment and after 12 weeks of care while at home.

3.6.5. Biophysical outcomes

The physical measures of body weight, blood glucose and blood pressure were used because these are commonly collected at clinic visits as measures of chronic illness control. Participants had body weight, blood pressure, and blood glucose obtained upon enrollment into the study by the provided blue-tooth enabled scales, blood pressure monitors, and glucometers. All study participants received a scale as body weight impacts all metabolic illness outcomes. Those participants with diabetes received a glucometer and those with hypertension received a blood pressure monitor. Most participants received all monitors due to their combination of diagnoses seen in this population. Then these Bluetooth-enabled devices sent the readings directly to the study database. Participants continued to perform these physical measures and have these measures recorded at home with provided equipment as often as directed by their NP. The mI SMART technology intervention also provides automated prompts to obtain readings along with automated immediate feedback for readings within normal limits and timely feedback from study nurses with appropriate referral for abnormal readings. Goals for self-monitoring are set by the NP, are patient specific, and are displayed as green for normal results, yellow for slightly low or high readings and red for critical values. Participant Body Mass Index (BMI) was calculated using the standard calculation using height and body weight.

3.7. Data analysis

Data were analyzed using Statistical Package for the Social Sciences 24.0. Methods for analysis included a comprehensive descriptive analysis of all study variables, followed by bivariate analysis for significant relationships and differences among the study variables or groups. An analysis of biophysical measures was initially conducted for within group mean comparisons using paired-samples t-tests before and after the intervention. Categorical data with less than 5 per cell were collapsed so that comparisons could be made: ethnicity (white and non-white), marital status (married and single), education (less than high school, high school/GED, Some College/2year degree, Bachelors or higher) income (Less than 20 k, 20 k–34.9 k, 35 k or greater). Mean comparisons of biophysical outcome measures (pre/post -blood pressure, glucose, and weight) were then compared based on the dichotomous participant characteristics (gender, ethnicity, marital status) using independent sample t-tests. Subsequently, mean comparisons of the biophysical outcome measures (pre/post -blood pressure, glucose, and weight) based on education and income were accomplished using one-way between-groups analysis of variance.

Pearson correlation was used to explore the relationships among the continuous participant characteristics (age, number of people in the home, number of chronic conditions, # self-monitor results sent, page hits, PHQ-9, UCLA, SF-36) and mean scores of biophysical outcome measures (pre/post-blood pressure, glucose, and weight). The research design included two data collection points for survey instruments to assess for depression, loneliness, and quality of life. However, a low post-intervention response rate ($N = 9$) did not allow for comparisons of these variables. The results for these measures are described at baseline. The level of statistical significance for all analyses was set at $P < 0.05$. Effect size for within group comparisons of biophysical measures was calculated using Cohen's d. Effect size for ANOVA tests between patient characteristics and biophysical measures was calculated using Eta squared. Confidence intervals were set at 95%.

4. Results

A total of 31 participants were asked to join the research study and 30 agreed to participate. The 30 participants were a mean age of 52 years (SD10.0, range 29–64). Of the initial 30 participants, 29 participants participated in the intervention for longer than the first week, the remainder participated for at least 12-weeks. Prior to intervention, three participants refused to complete all parts of the surveys. The majority of the population was female (70%), white (70%), married (60%), high-school educated or less (56.7%), earned less than $20,000 per annum (56.7%), and experiencing multiple chronic conditions (96.7%). The remainder of the demographic information can be found in Tables 1 and 2. This young population reported significant loneliness with low depressive symptoms. The SF-36 scores in Table 1 indicate self-reports of moderate quality of life. Prior to intervention, three participants refused to complete all parts of the surveys.

Prior to the intervention, there were no differences for gender, marital status, education, and income in regard to blood pressure, random glucose, and weight. Pre-intervention, the study sample measured an overall mean body weight of 218 pounds (lbs) ($M = 217.98$, $SD = 44.65$), with a calculated Body Mass Index (BMI) of nearly 37 ($M = 36.77$, $SD = 8.70$) which indicates obesity. A statistically significant difference was found for weight and BMI when comparing white (weight, $N = 22$, $M = 228.92$, $SD = 39.35$) (BMI, $N = 22$, $M = 38.59$, $SD = 8.83$) and non-white participants (weight, $N = 8$, $M = 187.88$ $SD = 46.91$) (BMI, $N = 8$, $M = 31.77$, $SD = 6.37$); [$t(28) = 2.4$, $P = 0.02$ (two-tailed)] with white participants having higher body weight. The magnitude of the differences in the means (weight mean difference = 41.06, 95% CI: 6.04 to76.02) (BMI mean difference = 6.82, 95% CI:0.64 to 13.00) was moderate for both (weight Cohen's d = 0.45) (BMI Cohen's d = 0.43). Both glucose and blood pressure were above current clinical standards for adequate control of chronic illness. The mean glucose of all participates was above the normal range at 201 mmol/liter (mmol/L) ($M = 201.93$, $SD = 88.29$). The pre-intervention systolic blood pressure was 134 mm of mercury (mmHg) ($M = 134.24$, $SD = 15.57$) and diastolic blood pressure was 88 ($M = 88.79$, $SD = 10.73$).

After the 12 week intervention, mean random glucose significantly decreased to 147 mmol/L ($M = 146.79$, $SD = 60.68$,

Table 1
Continuous demographics.

Variable	N	Mean	Std. Deviation	Minimum	Maximum
Age	30	52.00	10.031	29	64
# Unique Diagnosis	30	4.00	1.781	1	12
PHQ9 Pre-Score	28	7.21	6.414	0	26
UCLA Pre Score	27	53.88	5.91	40.00	67.00
SF36 Total	29	57.33	13.58	28.70	77.80

Table 2
Categorical demographics.

Demographic	N	%
Gender		
Male	9	30
Female	21	70
Ethnicity		
African American	2	6.7
Asian/Pacific Islander	1	3.3
Hispanic	3	10
Native American	1	3.3
White	21	70
Other	2	6.7
Marital Status		
Divorced	4	13.3
Married	18	60
Separated	3	10
Single	2	6.7
Widowed	3	10
Education		
Less than high school	7	23.3
High School/GED	10	33.3
Some College	5	16.7
2 year college degree	3	10
4 year college degree	3	10
Master's degree	2	6.7

$t(28) = 4.54$, $P = 0.000$). There were also statistically significant reductions in systolic blood pressure to 119 mmHg ($M = 118.93$, $SD = 12.57$, $t(28) = 6.29$, $P = 0.000$), diastolic blood pressure to 84 mmHg ($M = 83.62$, $SD = 8.07$, $t(28) = 4.32$, $P = 0.000$), and BMI to 35.05 ($M = 35.05$, $SD = 4.39$, $t(29) = 2.16$, $P = 0.04$). Mean weight did decrease to 207 lbs. but was not statistically significant, ($M = 207.43$, $SD = 43.90$, t $(29) = 2.02$, $P = 0.053$). After the intervention, there was no statistical difference between the BMI of white ($N = 22$, $M = 36.49$, $SD = 8.90$) and non-white participants ($N = 8$, $M = 31.07$, $SD = 6.13$); [t $(30) = 1.88$, $P = 0.07$ (two-tailed)]. Biophysical within group pre/post mean comparisons can be found in Table 3.

Pre-intervention, there was a medium positive correlation between age and systolic blood pressure ($r = 0.37$, $n = 29$, $P = 0.04$) with higher age associated with higher systolic blood pressure. Conversely, pre-intervention, there was a medium negative correlation between age and diastolic blood pressure ($r = -0.44$, $n = 29$, $P = 0.02$) with higher age associated with lower diastolic blood pressure. Age was not significantly correlated with any other pre/post biophysical measurement. Number of people living in the home was not significantly correlated with any pre/post biophysical measurement. There was a medium negative correlation between number of chronic illness and diastolic blood pressure pre-intervention ($r = -0.43$, $n = 29$, $P = 0.01$) and post-intervention ($r = -0.37$, $n = 29$, $P = 0.04$) with lower numbers of illnesses associated with higher diastolic blood pressure. Number of chronic illness was not significantly correlated with any other pre/post biophysical measurement.

There was a medium positive correlation between number of self-monitor results transmitted and pre-intervention weight ($r = 0.37$, $n = 30$, $P = 0.04$) with higher numbers of self-monitor results transmitted by those with a higher body weight. Number of self-monitoring results obtained was not significantly correlated with any other pre/post biophysical measurement. Number of interactions with the intervention web-site was not significantly correlated with any pre/post biophysical measurement. There was a medium positive correlation between total SF-36 score and pre-intervention diastolic blood pressure ($r = 0.46$, $n = 28$, $P = 0.02$) with higher pre-intervention diastolic blood pressure being associated with higher total SF-36 scores. Total UCLA loneliness scores and PHQ-9 scores were not significantly correlated with any pre/post biophysical measurement.

5. Discussion

The findings from this study begin to demonstrate that patients with low socioeconomic status are willing and able to improve their health status through the use of technology. Individuals receiving care at this rural clinic are in poor health having more than 4 chronic conditions and suffer from significant health disparity related to social, economic, and environmental disadvantage. Prior to this intervention, it was not known if use of technology would be feasible, acceptable or efficacious in rural, underserved populations living with multiple chronic conditions. The barriers to providing care with technology are often discussed when considering using technology in rural practices. These barriers include lack of patient willingness, ability, and access to internet [20–22]. However, the findings of this study begin to dispute these as barriers in this population.

The demographic characteristics of this population are similar to our previous studies [17,23] except that the initial trial for mI SMART included a sample of more ethnically diverse individuals. Ethnic diversity in the sample did expose a difference in the body weight of participants prior to beginning the intervention. The findings related to body weight and BMI are consistent with other research in the area of rurality and obesity. Using national NHANES data, researchers discovered that higher rates of obesity are found in rural compared to urban participants for all ethnic groups. Rural residence was strongly correlated to obesity and remained significant after controlling for age, education, income, race/ethnicity, marital status, as well as diet and physical activity, indicating that rural residence is associated with higher obesity prevalence [24]. After the intervention in this study, there was no significant difference in weight between Ethnic groups, suggesting that those that needed to lose more weight benefited the most from the intervention. Though the small sample size of this study was small and did not allow for comparisons of various ethnic backgrounds, it is clear that obesity continues to be an issue in rural populations and needs to be considered in future iterations of this platform.

Many combinations of technologies, functions, and specific chronic conditions have been studied [25]. Prior review of interventions using technology suggested that the most successful intervention would be supported by theoretical models and include; a combination of multiple technology interventions, live technical support, enhancements for usability, face-to care communications, affordability, and back-up interventions for technical issues that cannot be resolved in real time [9]. This is the first trial of mI SMART, a technology designed to combine all of the above in order to provide a potential method to improve outcomes in a difficult to reach population. The structure of mI SMART facilitates a change in the care delivery system to improve self-management ability and patient/NP communication while decreasing burden for both patients and NPs. In addition, the significant changes in biophysical outcomes may have also been influenced by the willingness of the Nurse Practitioners in the clinic to implement mI

Table 3
Biophysical within group pre/post mean comparisons.

Biophysical Measure		N	Mean	Std. Deviation	Std. Error Mean	t	df	Cohen's d	P
Blood Glucose	Pre	29	201.93	88.29	16.39	4.54	28	0.84	*0.000
millimoles/liter (mmol/L)	Post	29	146.79	60.67	11.26				
Systolic Blood Pressure	Pre	29	134.24	15.57	2.89	6.29	28	1.16	*0.000
millimeters of mercury (mmHg)	Post	29	118.93	12.56	2.33				
Diastolic Blood Pressure	Pre	29	88.79	10.72	1.99	4.31	28	0.80	*0.000
millimeters of mercury (mmHg)	Post	29	83.62	8.06	1.49				
Body Weight	Pre	30	217.97	44.64	8.15	2.08	29	0.36	0.053
pounds (lbs)	Post	30	207.43	43.89	8.01				

SMART as a novel technology-based intervention in order to benefit their patients.

The loneliness identified in this population is concerning to the study team given the recent national emphasis on loneliness [26] as a known contributor to multiple chronic conditions and poor health outcomes including worsening hypertension, heart disease, stroke, functional decline and mortality [27–30]. Knowing that patients in this population are experiencing the biopsychosocial stressor of loneliness leads to the consideration that interventions for this population should include strategies to identify and improve both behavioral and physical health outcomes. Further complicating the issue is the current knowledge regarding the cyclical nature of loneliness and chronic illnesses, with studies indicating that the isolation and decreased functional ability of chronic illnesses could also lead to worsening loneliness. Future technology based interventions could be adapted to include interventions that target loneliness such as LISTEN, an intervention developed by an NP that was designed to target loneliness as a unique psychological construct [31,32].

The main limitations of this study are the small sample size and lack of a comparison group. Moreover, the due to the convenience sample, participants were not assessed for being native to a rural population, were all between the ages of 29–74, and community dwelling. Hence, findings should not be generalized to other rural populations and clinics. All of these limitations will be addressed in a larger future randomized trial of the intervention.

Future steps will be multifaceted and will comprehensively evaluate the potential uses of mI SMART as a modality to improve delivery of healthcare by NPs at the system level in rural locations. Prior to larger trials, updates to the current technology intervention are needed based on feedback from both patients and NPs. Integration of data into existing systems and healthcare records is necessary to decrease complexity for NPs. Accessing multiple platforms takes time and introduces safety concerns that should outweigh potential concerns of data ownership. Reimbursement for technology interventions should be perceived as a long-term investment into population health instead of fee-for-service returns. Cost of providing this type of intervention to both the system and patient needs to be evaluated compared to the current standard of practice. The workflow process of mI SMART worked well in this specific clinic. However, assessments of workflow in each new area of implementation will need to be completed and implementation plans created for each new site. In addition, it is clear from the results of this study that future iterations need to specifically address obesity and loneliness as these clinical issues impact the outcomes of multiple chronic conditions.

6. Conclusion

The findings of this study provide additional information about the relationship between providing Advanced Practice Nursing care through the use of technology and individual patient outcomes. The baseline characteristics of individuals living in rural areas willing to use technology to receive care are similar to the general population of this rural state. This study used a pre/post design to identify mI SMART as a potential intervention for improving patient outcomes associated with multiple chronic conditions in individuals living with health disparities in rural and underserved areas. Participants of the first mI SMART trial improved their glucose levels, blood pressure, and weight in a short 12 week time frame. These findings support that improving rural patient outcomes of multiple chronic conditions with technology interventions by NPs is possible. Previous studies of individual interventions using mHealth interventions have focused on one single chronic illness or acute issues. However, this technique leaves rural practices overburdened with providing segmented care or dealing with emergent issues only. The change in focus to preventative, health maintenance, and routine chronic illness care specific to individualized patient needs may improve outcomes leading to decreased burden and complexity for both patients and practices. As previously reported, the intervention was also shown to be feasible and acceptable to patients. The next step is a larger randomized controlled trial. The focus of future work will include cost analysis, workflow disruptions and improvements, a focus on population health in addition to individual improvements, and longitudinal follow-up to determine if initial health improvements are maintained.

Conflicts of interest

The authors declare no conflicts of interest.

Funding

The time and research funding for Dr. Mallow to complete this work is supported by the Robert Wood Johnson Foundation Nurse Faculty Scholars Program Grant ID 72119.

Author contributions

Dr. Jenifer Mallow conceived the study, designed the trial and obtained research funding. Brian Mallow Was the programmer responsible for developing the technology, supervised the technical conduct of the trail. Dr. Laurie Theeke provided statistical advice, study design insight and supervised fidelity to intervention and data collection. Elliott Theeke undertook recruitment, patient technical support and managed the data, including quality control. All authors participated in drafting the manuscript contributed substantially to its revision. All authors take responsibility for the paper as a whole.

References

[1] Centers for Disease Contro and Prevention. Death and mortality. National Center for Health Staistics; 2013. p. 2 (14) 60648–60656, https://doi.org/10.1016/S0140-6736.

[2] World Health Organization. Global health observatory (gho) data: top 10 causes of death. 2017 [Retrieved].
[3] Ward BW, Schiller JS, Goodman RA. Peer reviewed: multiple chronic conditions among US adults: a 2012 update. Prev Chronic Dis 2014;11. https://doi.org/10.5888/pcd11.130389.
[4] Bauer UE, Briss PA, Goodman RA, Bowman BA. Prevention of chronic disease in the 21st century: elimination of the leading preventable causes of premature death and disability in the USA. Lancet 2014;384:45–52. https://doi.org/10.1016/S0140-6736(14)60648-6.
[5] Grembowski D, Schaefer J, Johnson KE, Fischer H, Moore SL, Tai-Seale M, Ricciardi R, Fraser JR, Miller D, LeRoy L. A conceptual model of the role of complexity in the care of patients with multiple chronic conditions. Med care 2014;52:S7–14. https://doi.org/10.1097/MLR.0000000000000045.
[6] LeRoy L, Bayliss E, Domino M, Miller BF, Rust G, Gerteis J, Miller T. The agency for healthcare research and quality multiple chronic conditions research network: overview of research contributions and future priorities. Med care 2014;52:S15–22. https://doi.org/10.1097/MLR.0000000000000095.
[7] Magnan EM, Palta M, Mahoney JE, Pandhi N, Bolt DM, Fink J, Greenlee RT, Smith MA. The relationship of individual comorbid chronic conditions to diabetes care quality. BMJ Open Diab Res Care 2015;3. e000080, https://doi.org/10.1136/bmjdrc-2015-000080.
[8] Tinetti ME, Basu J. Research on multiple chronic conditions: where we are and where we need to go. Med care 2014;52:S3–6. https://doi.org/10.1097/MLR.0000000000000093.
[9] Mallow JA, Theeke LA, Barnes ER, Whetsel T, Mallow BK. Using mHealth tools to improve rural diabetes care guided by the chronic care model. Online J Rural Nurs Health Care: Off J Rural Nurse Org 2014;14(43). https://doi.org/10.14574/ojrnhc.v14i1.276.
[10] Khairat S, Wijesinghe N, Wolfson J, Scott R, Simkus R. Building a multicenter telehealth network to advance chronic disease management. Integ Inform Technol Manag Qual Care 2014;202:299.
[11] Corry M, Clarke M, While AE, Lalor J. Developing complex interventions for nursing: a critical review of key guidelines. J Clin Nurs 2013;22:2366–86. https://doi.org/10.1111/jocn.12173.
[12] Mallow JA, Theeke LA, Walls R, Theeke E, Mallow BK. Part A: the development of mI SMART, a Nurse-led technology intervention for multiple chronic conditions. Open J Nurs 2016;6(303). https://doi.org/10.14574/ojrnhc.v14i1.276.
[13] Mallow JA, Theeke LA, Walls R, Theeke E, Mallow BK. Part B: the feasibility and acceptability of mI SMART, a nurse-led technology intervention for multiple chronic conditions. Open J Nurs 2016;6(323). https://doi.org/10.4236/ojn.2016.64031.
[14] Mitchell PH, Ferketich S, Jennings BM. Quality health outcomes model. Image - J Nurs Scholarsh 1998;30:43–6. https://doi.org/10.1111/j.1547-5069.1998.tb01234.x.
[15] Mitchell PH, Heinrich J, Moritz P, Hinshaw AS. Outcome measures and care delivery systems: introduction and purposes of conference. Med care 1997;35:NS1–5. https://doi.org/10.1097/00005650-199711001-00001.
[16] Wagner EH. Chronic disease management: what will it take to improve care for chronic illness? Effect Clin Pract: ECP 1997;1:2–4.
[17] Mallow JA, Theeke LA, Barnes ER, Whetsel T, Mallow BK. Free care is not enough: barriers to attending free clinic visits in a sample of uninsured individuals with diabetes. Open J Nurs 2014;4(912). https://doi.org/10.4236/ojn.2014.413097.
[18] Lancaster GA, Dodd S, Williamson PR. Design and analysis of pilot studies: recommendations for good practice. J Eval Clin Pract 2004;10:307–12. https://doi.org/10.1111/j.2002.384.doc.x.
[19] McHorney CA, Ware Jr JE, Lu JR, Sherbourne CD. The MOS 36-item Short-Form Health Survey (SF-36): III. tests of data quality, scaling assumptions, and reliability across diverse patient groups. Med care 1994:40–66. https://doi.org/10.1097/00005650-199401000-00004.
[20] Davis MM, Freeman M, Kaye J, Vuckovic N, Buckley DI. A systematic review of clinician and staff views on the acceptability of incorporating remote monitoring technology into primary care. Telemed e-Health 2014;20:428–38. https://doi.org/10.1089/tmj.2013.0166.
[21] Rutledge CM, Haney T, Bordelon M, Renaud M, Fowler C. Telehealth: preparing advanced practice nurses to address healthcare needs in rural and underserved populations. Int J Nurs Educ Scholarsh 2014;11:1–9. https://doi.org/10.1515/ijnes-2013-0061.
[22] Chang F, Paramsothy T, Roche M, Gupta NS. Patient, staff, and clinician perspectives on implementing electronic communications in an interdisciplinary rural family health practice. Prim Health Care Res Dev 2017;18:149–60. https://doi.org/10.1017/S1463423616000414.
[23] Mallow J, Theeke L, Whetsel T, Barnes E. Dose of diabetes group medical visits and biophysical outcomes of care in uninsured appalachian adults. West J Nurs Res 2014;37(8):1033–61.
[24] Befort CA, Nazir N, Perri MG. Prevalence of obesity among adults from rural and urban areas of the United States: findings from NHANES (2005-2008). J Rural Health 2012;28:392–7. https://doi.org/10.1111/j.1748-0361.2012.00411.x.
[25] Totten AM, Womack DM, Eden KB, McDonagh MS, Griffin JC, Grusing S, Hersh WR. Telehealth: mapping the evidence for patient outcomes from systematic reviews. 2016.
[26] United States Senate Special Committee on Aging. Senate aging committee examines the mental and physical effects of social isolation and loneliness. 2017. https://www.aging.senate.gov/press-releases/senate-aging-committee-examines-the-mental-and-physical-effects-of-social-isolation-and-loneliness.
[27] Thurston RC, Kubzansky LD. Women, loneliness, and incident coronary heart disease. Psychosom Med 2009;71(836). https://doi.org/10.1097/PSY.0b013e3181b40efc.
[28] Theeke L, Horstman P, Mallow J, Lucke-Wold N, Culp S, Domico J, Barr T. Quality of life and loneliness in stroke survivors living in appalachia. J Neurosci Nurs: J Am Assoc Neurosci Nurses 2014;46. E3.
[29] Perissinotto CM, Cenzer IS, Covinsky KE. Loneliness in older persons: a predictor of functional decline and death. Arch Intern Med 2012;172:1078–84. https://doi.org/10.1001/archinternmed.2012.1993.
[30] Luo Y, Hawkley LC, Waite LJ, Cacioppo JT. Loneliness, health, and mortality in old age: a national longitudinal study. Soc Sci Med 2012;74:907–14. https://doi.org/10.1016/j.socscimed.2011.11.028.
[31] Cacioppo S, Grippo AJ, London S, Goossens L, Cacioppo JT. Loneliness: clinical import and interventions. Perspect Psychol Sci 2015;10:238–49. https://doi.org/10.1177/1745691615570616.
[32] Theeke LA, Mallow JA, Moore J, McBurney A, Rellick S, VanGilder R. Effectiveness of LISTEN on loneliness, neuroimmunological stress response, psychosocial functioning, quality of life, and physical health measures of chronic illness. Internat J Nur Sci 2016;3:242–51. https://doi.org/10.1016/j.ijnss.2016.08.004.