



Using Telehealth to Disseminate Primary, Secondary, and Tertiary CVD Interventions to Rural Populations

Helene Vilme¹ · Naomi N. Duke² · Charles Muiruri^{1,3,4} · LaShawn Wordlaw⁵ · Asheley C. Skinner¹

© Springer Science+Business Media, LLC, part of Springer Nature 2019

Abstract

Purpose of Review This study aims to review the evidence on telehealth interventions in rural communities that use primary, secondary, or tertiary strategies for the prevention and management of cardiovascular disease (CVD).

Recent Findings Studies focused on the reduction of CVD risk factors and mitigation of disease progression among rural populations using telehealth are limited in number but appear to be increasing in the last 5 years. These studies suggest primary-, secondary-, and tertiary-level interventions can impact CVD risk and management. The current review found more studies addressing primary CVD intervention strategies, although the evidence for efficacy at all intervention levels is in the early stages.

Summary Leveraging prevention strategies via telehealth may be an effective vehicle to facilitate improved CVD outcomes among populations traditionally marginalized by geographic location.

Keywords Primary prevention of cardiovascular disease · Secondary prevention of cardiovascular disease · Tertiary prevention of cardiovascular disease · Rural health · Cardiovascular disease (CVD) · Health disparities

Introduction

Cardiovascular disease (CVD, including heart disease and stroke) is the leading cause of death in the USA, and rural populations are disproportionately burdened by CVD morbidity and mortality. According to the National Center for Health

Statistics [1], in 2015, the death rate from heart disease per 100,000 people in urban areas was 56.6, while in rural areas, it was 86.9. In rural communities, lack of access to care due to distance and transportation barriers, healthcare workforce shortages, hospital closures, and instability among remaining rural healthcare facilities directly impacts the ability of individuals to access timely and needed care [2, 3]. Access to healthcare is critical for disease prevention, appropriate diagnosis and treatment, and prevention of premature mortality [4].

Among rural communities, barriers to healthcare access may result in postponed and forgone care [3]. As such, lack of access to healthcare services may impose additional expenditure to individuals and the healthcare system as opportunities to mitigate disease incidence, prevalence, and severity are missed. Cardiovascular diseases cost the US healthcare system more than \$320 billion each year, and by 2030, the costs of CVDs are projected to increase to approximately \$818 billion [5]. As the prevalence of CVDs and the costs of healthcare delivery continue to rise, the need to deliver healthcare through modalities that minimize cost and the prevalence of CVDs has become a key priority.

Telehealth, which is defined as the use of telecommunications and information technologies to provide clinical care,

This article is part of the Topical Collection on *Telemedicine and Technology*

✉ Helene Vilme
Helene.Vilme@Duke.edu

¹ Department of Population Health Sciences, Duke University School of Medicine, 215 Morris St., Suite 210, Durham, NC 27701, USA

² Internal Medicine, Pediatrics, Adolescent Medicine, Division of Primary Care, Department of Pediatrics, Duke University, Durham, NC, USA

³ Kilimanjaro Christian Medical University College, Moshi, Tanzania

⁴ Department of Health Policy and Management, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

⁵ Department of Public Health Education, North Carolina Central University, Durham, NC, USA

education, and administrative services at a distance, is one of the proposed modalities recommended to overcome healthcare access barriers irrespective of geographic location [6]. As a result of reducing access barriers, the use of telehealth may result in a decrease in healthcare costs and an increase in efficiency of healthcare delivery [7••]. Research indicates that telehealth interventions have resulted in positive benefits including high-quality care, with high satisfaction rates reported by providers, patients, and caregivers [3].

The public health prevention framework provides an appropriate lens by which to evaluate the potential for telehealth to advance cardiovascular health in rural communities and reduce disparities in CVD burden. This framework has three mechanisms to prevent and reduce the impact of disease: primary, secondary, and tertiary prevention [8]. Primary prevention involves intervening before the onset of the disease. Secondary prevention focuses on screening of diseases in the earliest stages, before the onset of signs and symptoms and/or prevention of disease progression. Tertiary prevention focuses on rehabilitation following a significant illness through rapid initiation of treatment and close follow-up surveillance (see Fig. 1) [8].

Leveraging public health prevention strategies and using telehealth as the modality of intervention implementation allows clinicians to target patients where they are along the continuum of care. Therefore, the objective of this review is to summarize interventions that have been conducted using telehealth as the modality of implementation to bring primary, secondary, and tertiary CVD intervention strategies to rural communities. In addition, we discuss the overall barriers to implementing telehealth interventions in rural communities.

Methods

The source material for this review includes articles identified from MEDLINE and PubMed databases using MESH terms such as: “telehealth,” “rural,” “primary prevention,” “secondary prevention,” “tertiary prevention,” “obesity,” “smoking,” “diet,” and “cardiac rehabilitation.” Studies were included if they were published in peer-reviewed journals in the English language, were conducted in the USA from 2010 to 2019, and focused on telehealth, along with primary, secondary, or tertiary prevention of CVD. A total of 241 articles were identified and screened for duplicates. Following removal of duplicates, 183 articles’ titles and abstracts were reviewed. Of

these, 96 (15 primary, 62 secondary, and 19 tertiary prevention) were given a full-text review. Studies were excluded if they did not focus on cardiovascular disease outcomes and rural populations designated by usage of the descriptor “rural.” Of the studies included, seven were primary prevention, four were secondary prevention, and two were tertiary prevention studies.

Results

Telehealth: Conduit of Primary Prevention Interventions for CVD Risk

Primary prevention focuses on preventing the onset of the disease [8]. Interventions within the primary prevention arena center on promoting lifestyle change activities to reduce occurrence of CVD risk factors such as diabetes, hypertension, excess weight, and elevated low-density lipoprotein cholesterol (LDL). Many people who live in rural areas have limited access to healthcare resources and providers; therefore, they may access medical care only when something has gone wrong [3, 9]. A total of seven studies used telehealth as a means of disseminating primary prevention interventions [10–16]. The largest sample size was 612 and the smallest sample was 101. Of the seven studies, only two studies were randomized controlled trials and the remainder were nonrandomized studies. Four studies used videoconferencing as the mechanism for intervention implementation, while the remainder used other technologies such as installation of telehealth kiosks in senior centers, health coaching via telephone, and text messaging. Three studies included a comparison group. The main primary outcomes reported were change in hemoglobin A1c, blood pressure, weight, and LDL cholesterol.

All three studies examining hemoglobin A1c reported a significant improvement. Shane-McWorther et al. [13] found that a total of 31% (14 of 45) of rural patients achieved a goal HbA1c of < 7% by the end of the study. Similarly, Litke and colleagues [15•] found that rural patients had a mean absolute HbA1c reduction of 1.61% (95% confidence interval (CI), 1.39–1.83%; $p < 0.0001$). In addition, Davis et al. [10] found a significant reduction in glycated hemoglobin in the intervention group from baseline to 6 and 12 months (9.4 ± 0.3 , 8.3 ± 0.3 , and 8.2 ± 0.4 , respectively) compared with usual care (8.8 ± 0.3 , 8.6 ± 0.3 , and 8.6 ± 0.3 , respectively).

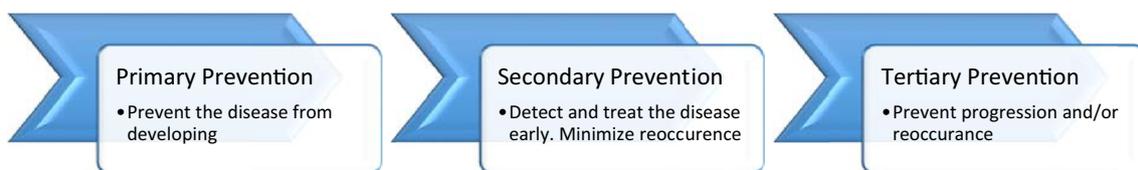


Fig. 1 Public health prevention model along the continuum of care

Four of the seven studies reported on blood pressure (BP), and the results were mixed. While Shane-McWorther et al. [13] and Litke et al. [15•] found a reduction in systolic blood pressure, Davis et al. [10] did not report a significant decline in systolic or diastolic BP. Resnick and colleagues [12] observed a change in systolic blood pressure, although inferential statistical analyses were not performed. Two of the studies reporting on BP outcomes also assessed LDL cholesterol. Shane-McWorther et al. [13] and Davis et al. [10] both reported a reduction in LDL cholesterol post-intervention. Finally, two studies [13, 16] assessed weight and found no significant difference pre and post-intervention (See Table 1). Overall, primary interventions targeting hemoglobin A1c had positive results, while the primary intervention study results were mixed for BP. On the other hand, reduction in LDL cholesterol levels was also observed. No significant changes were found in any of the studies that measured weight or body mass index as an outcome.

Telehealth: Conduit of Secondary Prevention for CVD Risk

Secondary prevention aims to detect CVD early and to prevent disease progression or recurrence. Secondary prevention includes measures to stop the progression of established, but essentially asymptomatic disease. The most significant benefit of secondary prevention interventions is that they tend to be far more affordable compared with major procedures such as bypass surgery and stent placement in tertiary prevention [23]. A critical first step in secondary prevention is the accurate identification of individuals at greatest risk of CVD [24]. Beyond risk stratification, secondary prevention of CVD includes the introduction of therapies to achieve target values for risk factors (blood pressure, cholesterol, blood sugar) to reduce the threat of further organ damage (heart, brain) [24]. Therapeutic interventions may occur in acute settings as a means to extend access to therapies previously only available in specialized centers.

Four secondary prevention studies were identified [17–20]. The sample sizes ranged from 20 to 7694. All studies focused on the evaluation and care of stroke patients. Anderson et al. [17] used the iPhone 4 to assess 20 patients who had an ischemic stroke. Patients were assessed simultaneously by a physician at the bedside and a physician remotely via FaceTime. Ten components of the National Institutes of Health Stroke Scale (NIHSS) showed perfect agreement between the bedside and remote assessments: level of consciousness, month and age, visual fields, right motor arm, left motor arm, right motor leg, left motor leg, sensation, language, and neglect. The average remote examination time was 8.45 min. Similarly Chapman et al. [19] assessed the technical feasibility and reliability of an iPad mobile telestroke option for ambulance transport as a means to perform prehospital neurologic

assessments in both rural and urban settings. Overall, correlation between bedside and mobile telestroke assessments was 0.96 (0.92–0.98).

Lazaridis et al. [18] and Al Kasab et al. [20] used web-based tools to provide telestroke care and consultation to rural communities. Among patients presenting with an ischemic stroke to hospitals in distant locations from a designated stroke center in South Carolina, Lazaridis and colleagues [18] demonstrated the safety and efficacy of telemedicine in increasing access to thrombolysis therapy. A total of 965 consults were performed. Among the 525 patients identified as candidates for tissue plasminogen activator (t-PA) therapy (NIHSS > 3, and no contraindication for thrombolytic therapy), 185 (35.7%) were treated with intravenous t-PA alone, 15 (2.9%) received a combination of intravenous and intra-arterial t-PA, and 11 (2.1%) were treated with intra-arterial t-PA alone. Of those who received intravenous t-PA, 119 (64.3%) were ultimately transferred to a stroke center. However, this study did not provide comparisons for outcomes. As a follow-up report on the progress of the South Carolina program, Al Kasab et al. [20] provide further evidence of the safety of the telestroke web-based tool in facilitating the provision of expert consultation to patients presenting with an acute ischemic stroke to rural facilities. In this study, a total of 7694 consults in rural hospitals were performed, and 3795 (49.2%) of these patients were diagnosed with an ischemic stroke. Out of the 3795 patients with ischemic stroke, 1324 (34.8%) received the intravenous thrombolytic, Alteplase. Over time, study findings revealed growth in the number of rural facilities served, reduction in the need for transfer of patients to a designated stroke center, and complication rates within an expected range [20].

Telehealth: Conduit of Tertiary Prevention Interventions for CVD

Tertiary prevention focuses on rehabilitation following a significant illness through rapid initiation of treatment and close follow-up surveillance [8]. Once an individual has had a severe event, tertiary prevention is necessary to halt further deterioration and to avert future catastrophic events. The objective of tertiary prevention is to restore function, delay complications, and reduce disability [8]. Individuals with known atherosclerotic cardiovascular disease and objective evidence of dysfunction are appropriate for tertiary prevention interventions. Tertiary prevention can include long-term case management for survivors of a CVD event, including a history of myocardial infarction and/or stroke. Patients who reside in rural areas may not have adequate transportation or immediate access to healthcare providers to continue specialized care.

Table 1 Summaries of the characteristics of the selected studies

Author	Sample size	Study design	Population	Intervention/program	Monitoring modality	Outcomes measured	Results
Primary prevention							
Shane-McWhorter et al. [13]	109	Nonrandomized prospective observational pre-post-intervention	Patients with uncontrolled diabetes and/or hypertension from 4 rural and 2 urban primary care clinics and 1 urban stroke center participated in a telemonitoring program	The program included telemonitoring of hemoglobin A1C (A1C), blood pressure, fasting lipids, weight, adherence	Authentidate Electronic House Call (Authentidate Holding Corp., Berkeley Heights, NJ) 2. Food and Drug Administration 510 (k)-cleared remote monitoring device.	Change in A1C and/or BP from baseline to discharge 2. LDL (for hyperlipidemia) and body mass index. 3. Changes in medication adherence, and patient knowledge of diabetes as well as HTN and exercise	Hemoglobin A1C(ok): Results from clinic sites were very similar because 32% (16 of 50 patients) of urban patients and 31.1% (14 of 45) of rural patients achieved a goal A1C of < 7% by the end of the study. Blood pressure: For urban patients, the percentages of patients at goal SBP for baseline and end point were 41.5% (22 of 53) and 64.2% (34 of 53), respectively. The percentages at goal DBP for baseline and end point were 58.5% (31 of 53) and 62.3% (33 of 53), respectively. For rural patients, the percentages of patients at goal SBP for baseline and end point were 55.8% (24 of 43) and 60.5% (26 of 43), respectively. The percentages of patients at goal DBP for baseline and end point were 51.2% (22 of 43) and 58.1% (25 of 43), respectively. LDL: In urban patients, 56.3% (18 of 32) were at goal LDL at baseline and 75% (24 of 32) were at goal at the end. For rural

Table 1 (continued)

Author	Sample size	Study design	Population	Intervention/program	Monitoring modality	Outcomes measured	Results
							<p>patients, 50% (14 of 28) were at goal LDL at baseline, and at the end, 57.1% (16 of 28) were at goal.</p> <p>Knowledge and medication adherence: There were statistically significant increases in both diabetes and HTN knowledge from baseline scores ($p < 0.001$ for both).</p> <p>Medication adherence for both diabetes and HTN improved but was not significant ($p = 0.09$ and $p = 0.054$, respectively).</p> <p>Weight: No effect on patients' weigh was observed. No distinction was made for rural and urban populations.</p>
Young et al. [14]	101	RCT	Participants were from 6 rural federally qualified health centers community clinics from Northern and Central California.	Usual care consisted of the services and care available at the rural clinic where the participant received healthcare. The intervention group attended a 2-h in-person session with a nurse coach where information was given about the MI counseling approach used during the intervention and an overview of typical health behavior goals they may choose to work on with their coach.	Participants were offered 2 modes to meet with their nurse coach: (1) by telephone or (2) face-to-face videoconference.	Self-efficacy, physical and mental health, and satisfaction with diabetes care	<p>Self-efficacy: A significantly higher self-efficacy scores in the intervention group compared with the control group based (4.03 versus 3.64, respectively, $p < 0.05$).</p> <p>Physical and mental health: A difference between the intervention group and the control group was observed but failed to reach statistical significance.</p> <p>Regarding satisfaction with diabetes care, the intervention group had a trend toward higher</p>

Table 1 (continued)

Author	Sample size	Study design	Population	Intervention/program	Monitoring modality	Outcomes measured	Results
Ciermins et al. [11]	206	Pre-post-intervention	Participants were from 5 rural and 1 urban clinic.	Received the Promoting Realistic Individual Self-Management (PRISM) Diabetes Program via telehealth or face-to-face	Telehealth systems used were Polycom HDX 7000 or Polycom HDX 8000 videoconference units.	Dilated eye exams, patient diabetes care satisfaction, self-reported blood glucose monitoring, monofilament foot test, self-management, diabetes knowledge, satisfaction, communication, self-efficacy, and self-reported symptoms	satisfaction with care received than the control group (15.32 versus 15.06). However, that difference was not significant ($p = 0.71$) Dilated eye exams, control of risk factors, patient satisfaction: Post-intervention, although statistically not significant, receipt of recommended dilated eye exams, control of 2 or more risk factors, and patient diabetes care satisfaction rates increased among telehealth and face-to-face patients.
Litke et al. [15•]	554	Retrospective quality-improvement evaluation of CPS-provided comprehensive medication management services within the V-IMPACT Hub specific to DM, HTN, HLD, and	Veterans in rural areas	Patients were categorized into DM and HTN groups. They all received a chronic disease management program which includes comprehensive medication management, tobacco cessation, and	Video telehealth and telephone encounters	The outcomes were the mean changes from baseline in glycosylated hemoglobin (HbA _{1c}) and blood pressure values and rates of guideline-indicated statin therapy and tobacco cessation.	Self-reported measures: There were no significant differences in increases between telehealth and face-to-face patients on any self-reported measures including self-management of diabetes, knowledge, satisfaction, communication, self-efficacy, and self-reported symptoms ($p = 0.08-0.97$). Hemoglobin A1C: Patients in the DM and HTN groups had a mean absolute HbA _{1c} reduction of 1.61% (95% confidence interval (CI), 1.39–1.83%; $p < 0.0001$). Blood pressure:

Table 1 (continued)

Author	Sample size	Study design	Population	Intervention/program	Monitoring modality	Outcomes measured	Results
Gore et al. [16]	612	Quasi-experimental design	Individuals living in rural areas of southeastern and western Colorado	management of diabetes mellitus (DM), hypertension (HTN), and hyperlipidemia (HLD). Colorado Healthy Heart Solutions (CHHS) program provides cardiovascular disease (CVD) risk factor screening and education to the medically underserved using SMS text messages	Patient Relationship Management (PRM) system. The PRM system was designed to automatically send unidirectional text messages to participants according to an established schedule.	The primary outcome was program engagement, defined as the number of completed interactions with the program during the entire follow-up period. Secondary outcomes were program retention, defined as any interaction during the last 2 months of the study; change in self-reported healthy behaviors (physical activity, weight loss, smoking cessation, fat intake); and change in CVD risk factors.	A mean systolic blood pressure reduction of 26.00 mmHg (95% CI, 22.99–28.50 mmHg; $p < 0.001$), respectively. HDL: In the HLD group, 93% of patients were discharged on a lipid-lowering medication. Tobacco cessation was achieved in 42% of targeted patients. There were trends for differences between groups across multiple outcomes, but most did not reach statistical significance, except for a greater decrease in self-reported fat intake in the intervention vs. control groups (26.3 vs. 10.6%, $p = 0.001$). In addition, a subset of surveyed participants who viewed the SMS messages as motivating showed greater program retention ($p = 0.03$).
Davis et al. [10]	165	RCT	African American adults with diabetes living in rural communities	Intervention: Diabetes TeleCare was a 12-month DSME intervention with 13 sessions, 3 individuals, and 10 groups. Usual care consisted of one 20-min diabetes education session, using ADA materials, conducted individually at the time of	Interactive videoconferencing, telephone (both cellular and land lines), fax line, and a telehealth-enabled retinal camera	Glycated hemoglobin outcomes, albumin-to-creatinine ratio (mg/g), LDL cholesterol, blood pressure	Glycated hemoglobin (GHb): A significant reduction in glycated hemoglobin (GHb) in the Diabetes TeleCare group from baseline to 6 and 12 months (9.4 ± 0.3 , 8.3 ± 0.3 , and 8.2 ± 0.4 , respectively) compared with usual care (8.8 ± 0.3 , 8.6 ± 0.3 , and 8.6 ± 0.3 , respectively).

Table 1 (continued)

Author	Sample size	Study design	Population	Intervention/program	Monitoring modality	Outcomes measured	Results
				randomization by the LPN.			<p>Albumin-to-creatinine ratio (mg/g): There was no statistical difference between the intervention and usual care group</p> <p>LDL cholesterol was reduced at 12 months in the Diabetes TeleCare group compared with usual care.</p> <p>Blood pressure: There was no statistical difference between the intervention and usual care group.</p> <p>BMI: There was no statistical difference between the intervention and usual care group.</p>
Resnick et al. [12]	112	Quasi-experimental	Senior citizens with diagnosed hypertension	Intervention: 2 centers used telehealth kiosks to assist participants to monitor their blood pressure. Control: usual care	Kiosk	Blood pressure	<p>Blood pressure: Mean baseline systolic BPs were 131 and 138 mmHg in the intervention and control groups, respectively. At 10 months, mean systolic BP was 126 and 132 mmHg in the intervention and control groups, respectively.</p>
Secondary prevention							
Anderson et al. [17]	20	Blinded prospective clinical study	Ischemic stroke patients	Each patient was examined simultaneously by a physician at bedside and a separate physician remotely via FaceTime	FaceTime technology on iPhone 4	Average remote examination time National Institute of Health Stroke Scale scores	<p>The average remote examination time was 8.45 min.</p> <p>10 components of the National Institute of Health Stroke Scale scores showed perfect agreement between the</p>

Table 1 (continued)

Author	Sample size	Study design	Population	Intervention/program	Monitoring modality	Outcomes measured	Results
Lazaridis et al. [18]	525	Retrospective cross-sectional	Patients with a National Institutes of Health Stroke Score > 3	A Web-based telestroke tool (remote evaluation of acute ischemic stroke at Medical University of South Carolina (REACH-MUSC)), was implemented to provide acute stroke care 24 h/day, 7 days/week to 12 community hospitals in South Carolina.	The REACH-MUSC system hardware and software	Intravenous (IV) thrombolysis with recombinant tissue plasminogen activator (t-PA)	bedside and remote rates: level of consciousness, month and age, visual fields, right motor arm, left motor arm, right motor leg, left motor leg, sensation, language, and neglect. Of the 525 patients, 185 (35.7%) were treated with t-PA alone, 15 (2.9%) received IV, and 11 (2.1%) were treated with intra-arterial therapy alone. Of those who received intravenous t-PA, 119 (64.3%) were transferred to the hub
Chapman et al. [19]	2 centers	Experimental simulation	Mobile telestroke system	Assessed the technical feasibility and reliability of a low cost, tablet-based mobile telestroke option for ambulance transport to perform prehospital neurologic assessments in both rural and urban settings.	Apple iPad with retina display, LTE CradlePoint modem with Verizon 4G Mini SIM, externally mounted cellular antennae, and Cisco Jabber (Movi) videoconferencing application	Correlation of the NIHSS score between the bedside and remote examiners	The mean difference between bedside (face-to-face) and remote (video) NIHSS scores was 0.25 (1.00 to -0.50). Overall, correlation of the NIHSS between bedside and mobile telestroke assessments was 0.96 (0.92-0.98).
Kasab et al. [20]	7694	Retrospective cross-sectional	Acute ischemic stroke (AIS) patients	At the Medical University of South Carolina (MUSC), a Web-based telestroke program that allows patients presenting with AIS at a rural hospital to receive expert stroke consultation within minutes was implemented	Web-based/Internet	Total of consults, number of patients transferred to MUSC, number of mechanical thrombectomies performed on transferred patients, rate of symptomatic intracerebral hemorrhages (sICHs), and discharge location.	A total of 7694 consults were performed during the study period. Of them, 3795 (49.2%) patients were diagnosed with ischemic stroke; of those, 1324 (34.8%) received IV alteplase. A total of 1282 patients were transferred to MUSC for further care. From November 2014 to April 2016, 56 patients received mechanical

Table 1 (continued)

Author	Sample size	Study design	Population	Intervention/program	Monitoring modality	Outcomes measured	Results
Tertiary prevention Barnason et al. [21]	43	RCT	Adults who had undergone either coronary artery bypass surgery (CABS) or percutaneous coronary intervention (PCI) and participated in a rural CR programs	Intervention: weight management intervention (WMI) plus cardiac rehabilitation (CR) Control: Cardiac rehabilitation only	Viterion telehealth device	The primary outcome was weight loss. Secondary outcomes included physical activity, patient self-efficacy, and use of weight management behaviors.	The WMI group had significantly more weight loss averaged across the 4 and 6 months of 13.8 lb (± 2.8) compared with the control group (mean = 7.8 lb (± 2.2)). There were no significant differences in physical activity (activity counts or daily minutes in moderate or more intense activity). The WMI group had significantly higher levels of patient activation. They also had significantly higher total scores on the Diet and Exercise Self-Management survey, and subscales that included self-efficacy for specific eating habits and managing diet behavior.
Wolf et al. [22••]	99	RCT	Hemiparetic participants with limited access to upper extremity rehabilitation	Control group: Home Exercise Program Only Exercises include preparatory activities to improve range of motion, strength, and coordination of the impaired upper extremity	The Hand Mentor Pro: robotic device, Internet, telephone, and e-mail.	The primary outcome is the change in UE function using the Action Research Arm Test. Secondary outcomes include changes in: UE function (Wolf Motor Function Test), UE	The findings indicate that a robotic telerehabilitation program can be successful in producing significant improvements in motor outcomes for subacute stroke survivors,

Table 1 (continued)

Author	Sample size	Study design	Population	Intervention/program	Monitoring modality	Outcomes measured	Results
				<p>(UE), in addition to functional, task-based activities. Participants were asked to complete 2 h of these and 1 h of functional activities, which incorporated the movements learned during these exercises, each day, 5 days/week for 8 weeks.</p> <p>Intervention group: Participants in the treatment group are prescribed an identical dose of therapeutic intervention as the control group; however, 2 h are using the robotic device while the third hour of therapy is spent performing exercises and functional tasks similar to the control group. The Hand Mentor Pro robotic device uses a pneumatic artificial muscle to facilitate movement about the wrist and fingers while providing visual biofeedback about the quality and quantity of wrist movements.</p>		<p>impairment (UE portion of the Fugl-Meyer Test), self-reported quality of life (Stroke Impact Scale), and affect (Centers for Epidemiologic Studies Depression Scale).</p>	<p>especially in the home environment. The results also demonstrate that HEP + robotic telerehabilitation can be equally effective as an individualized HEP.</p>

Thus, using tele-tertiary prevention strategies may reduce access barriers.

Two studies [21, 22••] utilized telehealth as a means of implementing tertiary prevention intervention for patients with a history of a CVD-related event. The largest sample size was 99 and the smallest sample was 43. Both studies were randomized control trials. Mode of intervention implementation included telephone, Internet, telehealth device, and a robotic device. Wolf and colleagues [22••] demonstrated the efficacy of two tele-monitored home exercise programs for hemi-paretic patients less than 6 months post-stroke. In one group, patients received a tele-monitored home exercise program; in the second group, the home exercise program included the use of a robotic-assisted therapy. Both groups experienced improvement in all upper extremity outcomes, with no significant difference in change of motor function over time. Next steps for the work include the determination of dose-response metrics for optimization of motor outcomes [22••]. Barnason and colleagues [21] assessed weight-related outcomes (weight loss, weight management behaviors) for overweight and obese patients participating in cardiac rehab (groups divided into cardiac rehab alone vs. cardiac rehab + telehealth weight management intervention). The researchers observed significantly greater weight loss among participants in the telehealth weight management intervention at 4 and 6 months: 13.8 lb (± 2.8) compared with the control group [mean = 7.8 lb (± 2.2)] [21]. Participants in the telehealth intervention also had higher scores on a weight management behavior survey.

Overall, tertiary interventions focused on rehabilitation demonstrated positive outcomes. Although weight was not improved among primary prevention studies included in this review, patients participating in a tertiary intervention (cardiac rehab + telehealth weight management program) showed significant weight loss compared with usual care. Change in CVD risk factors such as BP, cholesterol, and HbA1c were not reported for the tertiary prevention studies reviewed.

Overall Barriers to Implementing Telehealth Programs in Rural Communities

Although telehealth interventions can continuously monitor patients with CVD and favorably affect CVD risk and treatment, some barriers exist. From the studies reviewed, the barriers identified most often for primary prevention interventions were improper and noncontinuous use of the devices provided to patients. Barriers listed for secondary prevention were Wi-Fi connectivity and limitations in the capacity of healthcare providers to effectively operate electronic devices. For tertiary prevention interventions, challenges were similar to what may be encountered across patient populations, including patient attrition and comprehension, and ease of use of electronic devices.

Conclusion

In order for rural residents to have sufficient access to necessary and appropriate healthcare, services must be available and obtainable in a timely manner. The use of telehealth in the CVD-related outcome studies reviewed here was generally noted to have a favorable impact on rural populations. We found fewer articles focused on secondary and tertiary prevention interventions targeting rural populations; however, given the early stage of the current research across all intervention levels, more research is needed in general. Evidence for intervention efficacy could be strengthened by the inclusion of more studies with a longitudinal design and standardization of clinical outcome measurement. The premise of telehealth also portends the potential for healthcare cost savings. As such, we recommend the inclusion of economic analyses to determine the value of interventions as a means to further inform population-level healthcare delivery decisions.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflicts of interest relevant to this manuscript.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

References

Papers of particular interest, published recently, have been highlighted as:

- Of importance
 - Of major importance
1. National Center for Health Statistics. Cardiovascular disease Mortality rural-urban differences. Hyattsville: Centers for Disease Control and Prevention. <https://www.ruralhealthinfo.org/charts/50>. Accessed 16 June 2019
 2. MacQueen IT, Maggard-Gibbons M, Capra G, Raaen L, Ulloa JG, Shekelle PG, et al. Recruiting rural healthcare providers today: a systematic review of training program success and determinants of geographic choices. *J Gen Intern Med*. 2018;33(2):191–9. <https://doi.org/10.1007/s11606-017-4210-z>.
 3. Rural Health Information Hub. Healthcare access in rural communities. <https://www.ruralhealthinfo.org/topics/healthcare-access>. Accessed 16 June 2019.
 4. Office of Disease Prevention and Health Promotion (ODPHP). Healthy people 2020 leading health indicators, 2019. <https://www.healthypeople.gov/2020/leading-health-indicators/2020-lhi-topics/Access-to-Health-Services>. Accessed 24 August 2019.
 5. Giedrimiene D, King R. Abstract 207: burden of cardiovascular disease (CVD) on economic cost. Comparison of outcomes in US and Europe. *Circ Cardiovasc Qual Outcomes*. 2017;10(suppl_3): A207-A. https://doi.org/10.1161/circoutcomes.10.suppl_3.207.

6. White LA, Krousel-Wood MA, Mather F. Technology meets healthcare: distance learning and telehealth. *Ochsner J*. 2001;3(1): 22–9.
7. American Hospital Association. Rural report, 2019. <https://www.aha.org/system/files/2019-02/rural-report-2019.pdf>. Accessed 24 August 2019. **This report highlight the chalenges facing rural communities and the roadmap to encure local access to high-quality, affordable care.**
8. Centers for Disease Control and Prevention. Picture of America Prevention. https://www.cdc.gov/pictureofamerica/pdfs/picture_of_america_prevention.pdf. Accessed 8 July 2019.
9. Spleen AM, Lengerich EJ, Camacho FT, Vanderpool RC. Health care avoidance among rural populations: results from a nationally representative survey. *J Rural Health: Official Journal of the American Rural Health Association and the National Rural Health Care Association*. 2014;30(1):79–88. <https://doi.org/10.1111/jrh.12032>.
10. Davis RM, Hitch AD, Salaam MM, Herman WH, Zimmer-Galler IE, Mayer-Davis EJ. TeleHealth improves diabetes self-management in an underserved community: diabetes TeleCare. *Diabetes Care*. 2010;33(8):1712–7. <https://doi.org/10.2337/dc09-1919>.
11. Ciemins E, Coon P, Peck R, Holloway B, Min SJ. Using telehealth to provide diabetes care to patients in rural Montana: findings from the promoting realistic individual self-management program. *Telemed J E Health*. 2011;17(8):596–602. <https://doi.org/10.1089/tmj.2011.0028>.
12. Resnick HE, Ilagan PR, Kaylor MB, Mehling D, Alwan M. TEAhM-technologies for enhancing access to health management: a pilot study of community-based telehealth. *Telemed J E Health*. 2012;18(3):166–74. <https://doi.org/10.1089/tmj.2011.0122>.
13. Shane-McWhorter L, Lenert L, Petersen M, Woolsey S, McAdam-Marx C, Coursey JM, et al. The Utah remote monitoring project: improving health care one patient at a time. *Diabetes Technol Ther*. 2014;16(10):653–60. <https://doi.org/10.1089/dia.2014.0045>.
14. Young H, Miyamoto S, Ward D, Dharmar M, Tang-Feldman Y, Berglund L. Sustained effects of a nurse coaching intervention via telehealth to improve health behavior change in diabetes. *Telemed J E Health*. 2014;20(9):828–34. <https://doi.org/10.1089/tmj.2013.0326>.
15. Litke J, Spoutz L, Ahlstrom D, Perdew C, Llamas W, Erickson K. Impact of the clinical pharmacy specialist in telehealth primary care. *Am J Health Syst Pharm*. 2018;75(13):982–6. <https://doi.org/10.2146/ajhp170633> **This research study focused on leveraging clinical pharmacy specialist to provide primare comprehensive medication management services soley via telehealth. Since there are shortages of physicians in rural communities, leveraging other healthcare providers to help improve disease management is an important contribution to the literature on telehealth.**
16. Gore MO, Krantz MJ, Albright K, Beaty B, Coronel-Mockler S, Bull S, et al. A controlled trial of mobile short message service among participants in a rural cardiovascular disease prevention program. *Prev Med Rep*. 2019;13:126–31. <https://doi.org/10.1016/j.pmedr.2018.11.021>.
17. Anderson ER, Smith B, Ido M, Frankel M. Remote assessment of stroke using the iPhone 4. *J Stroke Cerebrovasc Dis*. 2013;22(4): 340–4. <https://doi.org/10.1016/j.jstrokecerebrovasdis.2011.09.013>.
18. Lazaridis C, DeSantis SM, Jauch EC, Adams RJ. Telestroke in South Carolina. *J Stroke Cerebrovasc Dis*. 2013;22(7):946–50. <https://doi.org/10.1016/j.jstrokecerebrovasdis.2011.11.008>.
19. Chapman Smith SN, Govindarajan P, Padrick MM, Lippman JM, McMurry TL, Resler BL, et al. A low-cost, tablet-based option for prehospital neurologic assessment: the iTREAT study. *Neurology*. 2016;87(1):19–26. <https://doi.org/10.1212/wnl.0000000000002799>.
20. Al Kasab S, Adams RJ, Debenham E, Jones DJ, Holmstedt CA. Medical University of South Carolina Telestroke: a telemedicine facilitated network for stroke treatment in South Carolina—a Progress report. *Telemed J E Health*. 2017;23(8):674–7. <https://doi.org/10.1089/tmj.2016.0229>.
21. Barnason S, Zimmerman L, Schulz P, Pullen C, Schuelke S. Weight management telehealth intervention for overweight and obese rural cardiac rehabilitation participants: a randomised trial. *J Clin Nurs*. 2019;28(9–10):1808–18. <https://doi.org/10.1111/jocn.14784>.
22. Wolf SL, Sahu K, Bay RC, Buchanan S, Reiss A, Linder S, et al. The HAAPI (Home Arm Assistance Progression Initiative) trial: a novel robotics delivery approach in stroke rehabilitation. *Neurorehabil Neural Repair*. 2015;29(10):958–68. <https://doi.org/10.1177/1545968315575612> **Access to care is a barrier for patients in rural communities. This study is the first to systematically assess the efficacy and feasibility of a robotic telerehabilitation intervention to improve post-stroke patients with limited access to rehabilitation services upper-extemity function capabilities. This is an important contribution to science.**
23. Karunathilake SP, Ganegoda GU. Secondary prevention of cardiovascular diseases and application of technology for early diagnosis. *Biomed Res Int*. 2018;2018:5767864. <https://doi.org/10.1155/2018/5767864>.
24. Hobbs FD. Cardiovascular disease: different strategies for primary and secondary prevention? *Heart*. 2004;90(10):1217–23. <https://doi.org/10.1136/hrt.2003.027680>.

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.