

Interventions to Improve Management of Chronic Conditions Among Racial and Ethnic Minorities

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Abstract Digital and mhealth interventions can be effective in improving health outcomes among minority patients with diabetes, congestive heart failure, and chronic respiratory diseases. A number of electronic and digital approaches to individual and population-level interventions involving telephones, internet and web-based resources, and mobile platforms have been deployed to improve chronic disease outcomes. This paper summarizes the evidence supporting the efficacy of various behavioral and digital interventions targeting intermediate outcomes and hospitalizations with particular emphasis on studies examining the effects of these interventions on racial and ethnic minority population.

Keywords Racial disparities · Ambulatory care sensitive conditions · Digital interventions · mhealth

Introduction

Today, morbidity and mortality resulting from chronic diseases affect over 133 million Americans [1]. With about 17% Hispanics, 13% Blacks, and 5% Asians comprising the US population, health outcomes among these racial and ethnic

minorities are of critical importance to the American Healthcare System [2]. Racial disparities in the burden of disease and mortality caused by chronic conditions like diabetes, heart disease, and chronic respiratory conditions are well documented [3, 4]. Since 1988, non-Hispanic Blacks have experienced much higher age-adjusted prevalence of diabetes, hypertension, and obesity compared to the other racial/ethnic groups [5]. According to the Center for Disease Control and Prevention, non-Hispanic Blacks, Hispanics (particularly Mexican Americans and Puerto Ricans), and Asian Americans had higher risk of developing diabetes compared to non-Hispanic whites [6]. Non-Hispanic Blacks bear a higher cardiovascular disease burden in the USA, with a higher prevalence of hypertension and poor control compared to non-Hispanic Whites and Mexican Americans [7]. For chronic pulmonary conditions like chronic obstructive pulmonary disease (COPD), historically, Whites had a much higher prevalence and hospitalization risk. However, the prevalence among non-Hispanic Blacks is increasing [8]. Doshi et al. examined the existing evidence on racial disparities in preventable hospitalizations due to chronic ambulatory care sensitive conditions. Non-Hispanic Blacks suffer from a significantly higher burden of preventable hospitalizations due to chronic conditions like diabetes, congestive heart failure, and hypertension [9].

The primary objective of this narrative review is to present evidence regarding the different approaches to chronic disease management in general population and racial/ethnic minority population in the context of chronic ambulatory care sensitive conditions (ACSCs). Successful behavioral and digital health approaches involving interventions targeting patients were identified. In addition, we discuss the impact of digital interventions in improving health outcomes among racial/ethnic minority patients with chronic ACSCs. For this study, we have limited our focus to chronic ACSCs resulting in the highest

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rates of morbidity and mortality and where racial and ethnic disparities are already demonstrated [9].

For this study, we examined studies involving interventions targeting chronic ACSCs like diabetes, congestive heart failure, hypertension, asthma, and COPD among general population and specifically targeting racial and ethnic minority patient populations. Search terms including “digital health,” “ehealth,” “mhealth,” “diabetes,” “congestive heart failure,” “hypertension,” “asthma,” “COPD,” “minority,” “race,” “ethnicity,” “racial disparity,” “Black,” “African-American,” “Hispanic,” and “Asian” were used. We evaluated over 1500 abstracts from MEDLINE and Google Scholar and cited over 59 articles.

Diabetes

In one of the early meta-analysis of interventions for diabetes, Padgett et al. (1988) reviewed 93 studies, which used didactic education, enhanced education, diet instruction, exercise instruction, self-monitoring instruction, social learning, counseling, and relaxation training. Among these interventions, diet instruction (mean effect size 0.68; CI \pm 0.33) was found to be most effective in improving glycemic control and patient knowledge [10]. In a review evaluation studies for interventions for adult minority diabetic patients, Peek et al. identified 17 patient-targeted interventions (13 RCT, 1 controlled trial, 3 pre-post studies). They found that computer-based interventions were ineffective when applied without a human interaction component. In addition, culturally tailored interventions significantly reduced HbA1c (mean HbA1c reduction 69%; CI 0.37–1.0) [11]. Joo identified nine interventions published between 2005 and 2013 involving culturally tailored diabetes programs targeting older Asian (Bangladesh, China, Philippines, Korea) adults in the USA and examined their effect on improving intermediate health outcomes (HbA1c, lipids, weight, blood pressure), quality of life, and satisfaction. While three studies found positive changes in HbA1c, the fourth study did not see a significant change in HbA1c [12–15]. Dauvrin and Lorant identified 61 publications related to culturally competent interventions for type 2 diabetes and applied the equity model framework to examine the quality of research in this area. However, a majority of these studies failed to consider other factors such as health insurance coverage, socioeconomic determinants, and gender that impact health equity among minority patients [16]. Baig et al. reviewed 18 articles that involved digital quality improvement interventions focused on diabetes health disparities among Blacks and Hispanics between 2006 and 2009. A patient-centered approach was employed, in combination with culturally tailored interventions using peers and

social networks, for the digital interventions in six of these studies. They found cognitive-behavioral education and self-care management interventions adapting the current National Diabetes Prevention program were effective in improving glycemic control. Improvements in HbA1c were associated with interventions using personalized reports of laboratory values and goals [17].

More recently, the application of a long-term, multi-disciplinary, primary-secondary integrated care model applied to disadvantaged, multicultural population, reduced diabetes-related potentially preventable hospitalizations by 50% at 24 months [18]. In the early 1990s, Fedder et al. demonstrated that community health worker visits and phone calls had the potential to reduce hospitalization among African-American Medicare patients with diabetes by a third [19]. A prospective follow-up study on adult, African-American diabetes patients in 2001–2003 found that frequent contact (\geq 4 visits) with nurse care managers and community health worker was associated with a significant reduction in hospitalizations [20]. A nurse-led team intervention involving a detailed algorithm to provide appropriate care to diabetes patients reduced hospitalization rates by 51% in a predominantly African-American and Latino sample [21].

Electronic and mobile health interventions have used a number of different approaches to reduce hospitalizations among patients with diabetes. In one of the earliest telemedicine interventions, Smith et al. attempted to test the effectiveness of phone calls in reducing hospitalizations among diabetes patients. They found that while the intervention did improve compliance with scheduled physician visits, it did not reduce hospitalizations significantly [22]. Van den Berg et al. reviewed 18 studies using telemedicine interventions to improve diabetes outcomes among ambulatory elderly patients (\geq 60 years). The studies considered objective (medical outcomes, hospitalizations, mortality, healthcare utilization), patient reported (quality of life, acceptance, satisfaction, empowerment), and economic outcomes (costs, cost-effectiveness). Among the 16 studies that had hospitalizations as an outcome, 11 showed positive results, four were similar outcomes among intervention and control groups, and one had mixed results [23]. *Health Buddy*, a web-based patient interface technology, has been in use for monitoring diabetes and heart failure patients for over a decade. A recent pre-post study revealed that the use of the *Health Buddy* technology reduced the 1 year readmission rate among indigent border residents in California suffering from diabetes by 32% [24]. Cotter et al. reviewed the application of internet-based interventions to lifestyle modification among type II DM patients. They found nine studies, two of which demonstrated improvements in diet and/or physical activity and two demonstrating improvements in glycemic control. Almost all of these interventions focused on the individuals' use of the technology to create an online community while ignoring the ecology surrounding the

individual in real life. They concluded that there was need for more research involving high-risk and under-served populations in order to reduce health disparities [25].

Congestive Heart Failure

Between 1966 and 1999, there were 11 trials testing disease management programs for heart failure patients. While the effect varied by intervention, overall risk ratio of hospitalization due to heart failure was 0.87 (CI 0.79–0.96) in the intervention group. A substantial reduction in hospitalization rates (RR 0.77; CI 0.68–0.86) was observed for interventions involving specialized follow-up by multidisciplinary teams [26]. In Australia, exposure to general practitioner-led clinical management reduced readmissions among heart failure patients by 23%. The 1-year readmission rate for heart failure among exposed patients was 8.6% compared to 10.7% among unexposed patients [27]. Among older adults and elderly patients with history of heart failure, home-based telemanagement programs have shown great promise, with 1-year readmission rates among those exposed to the intervention almost half those of controls (19% readmitted vs. 32%; RR 0.49) [28]. Picture-based educational materials in combination with scheduled telephone follow-up showed reduction in hospitalizations among low literacy population (IRR = 0.39; CI 0.16, 0.91). Interventions like the iGetBetter system, which used transmission of self-monitored metrics through an iPad, improved patient engagement but no significant changes in planned (p value 0.23) and unplanned (p value 0.99) hospitalizations [29]. In their review, Delgado-Passler and McCaffrey demonstrated that advanced practice nurse-led telemanagement program reduced not only readmissions but also multiple admissions and healthcare costs among heart failure (HF) patients [30]. Manning took into consideration evidence regarding predictors of heart failure readmissions including race while developing a simple bedside screening tool for nurses. When used in combination with access to HF nurse educator for high-risk HF patients, there was marked reduction in 6-month hospitalization rates [31]. The Tele-HF randomized controlled trial found that daily monitoring by telephone reduced all-cause hospitalization rates among congestive heart failure (CHF) patients [32]. In their review evaluating evidence regarding mhealth interventions for CHF patients, Cajita et al. found that none of the nine studies showed conclusive evidence regarding its effectiveness in reducing heart failure-related hospitalizations [33].

Nahm et al. applied the transtheoretical model to examine the behavioral intention and readiness to use for a web-based learning module and telemonitoring and found that there was no significant difference between Black and White Medicare patients [34]. In a comparative effectiveness study for nurse telemonitoring (along with home monitoring device that

transfer physiological monitoring data to providers) vs nurse home visits in a predominantly Black population, it was found that the former significantly reduced HF readmissions at 3 months ($p \leq .001$) and 6 months ($p \leq .05$) [35]. Conversely, Copeland et al. found that nurse telemanagement interventions including education and coaching for behavior change showed no improvement in patient outcomes in a 22% Hispanic patient sample in a single site pre-post study conducted at the Veterans Health administration [36]. More recently, significant improvement in maintenance and management was observed in predominantly Black sample of HF patients using automated text messaging heart failure program delivering self-care reminders, patient education on diet, symptom recognition, and health care navigation [37].

Hypertension

Basic approaches to interventions for management of hypertension include diet modification and behavior change targeting salt consumption and weight reduction. With the availability of novel technologies in the early to mid-1990s, researchers started applying electronic and mobile-based interventions to improve outcomes among hypertensive patients. A number of studies targeted biologically vulnerable populations. In their “Five Plus Nuts and Beans” trial with African American patients, Miller et al. used a dietary intervention providing the treatment group with coach-directed dietary advice and assistance with weekly online ordering and purchasing of high-potassium foods (DASH-plus diet). The control group received information about the DASH diet. The DASH-plus group increased their consumption of fruits, vegetables, and estimated potassium intake. However, they found no significant difference in blood pressure in the two groups after 8 weeks [38]. The findings of this study point to the difficulties in remediating racial disparities in hypertension given the biological vulnerabilities of African-Americans.

Digital interventions such as internet-based counseling have been widely evaluated for their efficacy in reducing blood pressure. Lui et al. performed a systematic review identifying 13 trials and concluded that interventions that lasted 6 months or longer, used five or more behavior change techniques, or delivered health messages proactively were more likely to have the greatest impact on reducing blood pressure [39].

While a number of studies have utilized mobile-based interventions to monitor and reduce high blood pressure, very few mhealth studies have looked at hospitalizations as an outcome. In their systematic review of telemonitoring interventions, Verberk et al. concluded that telecare was a valuable tool for management of patients with high blood pressure [40]. Currently, there are two ongoing studies, which will utilize text messaging to control hypertension. The use of a text

messaging system, BPMED, to increase medication adherence among African-American patients was tested recently [41]. The StAR trial, a South African study, has medication adherence as the primary outcome and hospital admissions as the secondary outcome [42]. Findings of the hypertension intervention nurse telemedicine study revealed that combined behavioral and medication management improved the mean systolic blood pressure among African-American patients at 12 months by 6.6 mmHg (95% CI – 12.5, – 0.7; $p = 0.03$) and at 18 months by 9.7 mmHg (95% CI – 16.0, – 3.4; $p = 0.003$) [43].

Asthma

Asthma has been one of the health conditions that is most amenable to improved management via telehealth interventions. In mid-1990's, Hoskins et al. demonstrated the effectiveness of self-management plans in reducing hospital admissions among asthma patients [44]. Griffith et al. found that a specialist nurse-led, liaison model-based intervention in East London reduced unscheduled care among White patients but had no impact on South Asian, Hispanic, and non-Hispanic Blacks [45]. This finding is in keeping with other studies showing that asthma education has lower impact on South Asians in the UK compared to Whites [46]. Subsequently, digital interventions for asthma self-care and management have been used to improve health service use, medication use, and self-management behaviors among patients. Apter made a case for the use of patient portals as resources for disease management education, communication with healthcare providers and improved access to healthcare thereby reducing racial disparities in asthma outcomes [47]. Fiks utilized an electronic health record-tethered patient portal on 60 families with asthmatic children and found marked reduction in emergency department use and hospitalizations [48]. However, five RCTs tested web-based interventions to reduce hospitalizations among adults and children but found no significant impact [49]. Lorig et al. used an internet-based self-management program including interactive self-management instructions and tools, four bulletin board discussion groups, and an instructional book (“Living a Healthy Life with Chronic Conditions”). This intervention, which was grounded in self-efficacy theory, was tested using a prospective, longitudinal, repeated measures design and reported no impact on 12-month hospitalization rates in the intervention group [50]. However, a small RCT using SMS messaging for peak expiratory flow rate monitoring was associated with significantly reduced hospitalization rates [51]. Two recent studies examining the use of smart phone applications to improve outcomes among asthma patients found no statistically significant effect on frequency of 6-month hospital admissions. However, one of these studies did observe a statistically significant reduction in emergency department use [52, 53]. A

small pilot study examining the effect of tailored mhealth intervention with a gaming approach with incentives for positive behaviors among African-American adolescents on inhaled corticosteroids showed a marked improvement in medication adherence at 8 weeks. However, when the researchers conducted a randomized controlled trial with a larger intervention, they found significant improvement in self-reported adherence ($p < 0.001$) but no improvement in objectively measured adherence ($p = 0.929$) at week 10 [54, 55].

Chronic Obstructive Pulmonary Disease

A meta-analysis of 26 randomized controlled trials involving multidisciplinary or multi-treatment integrated COPD management programs with duration of at least 3 months revealed that admissions were lower among intervention groups compared to control groups. The mean duration of hospital stays among the intervention groups was 3.78 days shorter than controls [56]. However, two large well-designed international studies have reported that telemonitoring of patients with COPD did not improve short-term hospitalization rates [57, 58]. Similarly, use of an electronic diary intervention with COPD patients in Philadelphia produced a small, non-statistically significant reduction in hospitalizations in the intervention group. However, the lack of significant differences could be because of the Hawthorne effect due to the rigorous symptom monitoring of symptoms among the control group. A systematic review of nine studies testing the effectiveness of home telemonitoring of COPD patients found that there was significant reduction in hospitalization rates [59]. Overall, evidence suggested that interventions with longer durations improved the long-term admission rates for COPD. Despite the marked racial disparities in healthcare utilization for COPD, there is scarcity of research focusing on mhealth interventions targeting racial and ethnic minorities.

Table 1 presents the summary of review papers that addressed the efficacy of digital health interventions to improve outcomes in chronic ACSCs.

Conclusions

Interventions to reduce preventable hospitalizations have shown great promise. The most promising have typically involved long-term interventions with multiple contacts over time involving human interaction and have been most effective for diabetes, congestive heart failure, and asthma [18, 20, 30]. Within this group of successful interventions, a number of electronic and mobile health approaches to individual and population-level interventions involving telephones, internet and web-based resources, and mobile platforms have been deployed in controlled studies to improve chronic disease

Table 1 Highlighting systematic reviews of interventions for chronic ambulatory care sensitive conditions

Authors	Inclusion	Time frame	Studies	Findings
Padgett D, Mumford E, Hynes M, Carter R	Controlled studies of educational and psychosocial interventions in the treatment of DM.	1985–2006	93 studies with 7451 patients	Moderate significant improvement for all studies (effect size (ES) 0.51 ± 0.11). Diet instruction (ES 0.68 ± 0.58) and social learning (ES 0.57 ± 0.42) most effective.
Peek ME, Cargill A, Huang ES	Evaluation studies of interventions for adult minority patients living with type 2 DM.	2005–2013	43 studies	Culturally tailored patient-targeted interventions resulted in 0.69% reduction in HbA1c while others showed up to 0.10% improvement. Positive outcomes—peer support and one-on-one interactions more often reported. Negative to negligible outcomes—computer-based patient education, online self-management coaching, peer support, and computer-based education modules. Culturally tailored diabetes programs improve HbA1c and psychobehavioral outcomes.
Joo JY	Studies tailoring community-based diabetes intervention to Asian immigrant cultures.	2005–2011	9 studies	Bilingual educational programs and healthcare providers were associated with high patient satisfaction. There is need for more robust study designs which involve longitudinal follow-up and sub-classify Asian immigrants.
Dauvrin M, Lorant V	Culturally competent (CC) interventions aim to reduce health inequalities for ethnic minorities.	2005–2011	61 studies	33 studies had low congruence score. Only 10 studies compared ethnic minority to majority groups. About 30 studies did not include socioeconomic covariates.
Baig AA, Wilkes AE, Davis AM, Peek ME, Huang ES, Bell DS, Chin MH	QI interventions focused on African-American and Hispanic diabetic patients.	QI review 2006–2009 Health IT review 2000–2009	QI-18 articles Health IT—10 articles	Adaptation of current Diabetes prevention programs with emphasis on cognitive-behavioral education and self-care management were successful. Among Health IT studies, computer-generated personalized HbA1c goals showed statistically significant improvement in HbA1c; Computer kiosks for diabetes education for low health literacy population was ineffective.
van den Berg N, Schumann M, Kraft K, Hoffmann W	Controlled studies in an ambulant setting that analyzed telemedicine interventions involving patients aged ≥ 60 years.	2007–2012	18 studies addressed diabetes	Majority of studies showed positive results. Most of them involved a combination of measuring vital metrics in combination with interaction with healthcare provider. Behavioral endpoints were more likely to be improved compared to medical outcomes.
Cotter AP, Durant N, Agne AA, Cherrington AL	Studies involving internet interventions, targeted adults with type 2 DM, focused on lifestyle modification, had an evaluation component with behavioral outcomes.	Published before January 2013	9 studies	Most studies targeted activity (8/9), dietary habits (6/9) and glucose monitoring (5/9). Peer support/online community included in 6 out of 9 studies. Glasgow (2003) found addition of tailored self-management and peer support through online community did not improve outcomes. Carter et al. did not evaluate the social networking component separately but found improvement in HbA1c, BMI, and patient behaviors. Lorig et al. included bulletin boards in their 3-arm RCT and found improvement in HbA1c and PAM. In 2010, Glasgow et al. found that internet-based personalized goal setting with moderated forum was effective in improving eating habits, fat intake and physical activity. Additional follow-up calls had not impact on outcomes. Liebreich et al. demonstrated that online log book in combination with message boards improved physical activity.
McAlister FA, Lawson FM, Teo KK, Armstrong PW	Randomized clinical trials of disease management programs in patients with heart failure.	1966–1999	11 trials	Hospitalizations were reduced by the programs (RR 0.87; 95%CI 0.79–0.96). However, the effect of interventions varied. Multidisciplinary specialized team follow ups were more effective than telephone contacts targeting coordination of primary care services utilization.

Table 1 (continued)

Authors	Inclusion	Time frame	Studies	Findings
Cajita MI, Gleason KT, Han HR	RCT/quasiexperimental design, mHealth intervention, included adult HF patients, published in English.	Published before June 2015.	10 articles/9 studies; 1777 participants	3 studies investigated impact on hospitalizations and none of them found any improvement. Hagglund et al. (intervention: mobile device, weighing scale, implantable defibrillator) and Scheer et al. (intervention: mobile device, BP device, weighing scale) found reduced length of stay.
Liu S, Dunford SD, Leung YW, Brooks D, Thomas SG, Eysenbach G, Nolan RP	Human trials that investigated the effect of Internet-based lifestyle interventions on SBP and DBP.	Published before June 2012	13 studies	Internet-based lifestyle interventions significantly reduced both SBP and DBP. Studies with duration 6–12 months had a higher reduction in SBP. The effect size was highest for SBP and DBP for studies involving ≥ 5 behavior change techniques. Expert-driven approach was more effective in reducing DBP.
Verberk WJ, Kessels AG, Thien T	RCT, ambulatory hypertensive patients. Data were transmitted to healthcare providers by telephone, modem, Internet, or mail; BP target, published in English language.	Published before 2011	9 studies	Telecare resulted in significant reduction in SBP. BP target achievement was also higher among telecare patients though it was not significant. Telecare had a positive impact on patient's motivation to improved lifestyle and adherence to treatment.
Kruis AL, Smidt N, Assendelft WJ, Gussekloo J, Boland MR, Ruitten-van Mülken M, Chavannes NH	RCT testing integrated disease management programs for COPD patients.	Published before April 2012	26 trials	There was clinically significant improvement in the disease-specific QoL. Hospitalizations (20/100 in intervention group vs 27/100 in control group) and length of stay (mean difference – 3.78 days) were significantly lower in the intervention group.
Cruz J, Brooks D, Marques A	Studies testing home telemonitoring to reduce healthcare utilization and improve outcomes of patients with COPD.	June 2012–July 2013	9 studies	Home telemonitoring significantly improved HRQoL and reduced number of exacerbations. It was associated with significantly lower hospitalization rates (RR 0.72; 95% CI 0.53–0.98). However, the impact was not significant on ED visits and length of stay. The intervention also.

outcomes. Electronic monitoring of health metrics was found to be an effective approach for reducing hospitalizations related to COPD and asthma, while telemonitoring was effective in reducing hospitalizations for CHF patients and improving overall control among hypertensive patients [32, 40]. For asthma, SMS monitoring of a specific disease metric (PEFR) was associated with decreased hospitalization [51]. While smart phone applications were ineffective in reducing hospitalizations, one application was associated with decreased utilization of emergency care [52, 53]. Home telemonitoring was a particularly effective intervention for COPD patients [59].

Although this research demonstrates that behavioral and digital interventions may be useful for improving health outcomes, it is not clear whether they can meaningfully reduce race and ethnic disparities in hospitalization among those with chronic diseases. Very few interventions have specifically targeted chronic ACSC hospitalizations in racial minorities, and the evidence for their effectiveness is at this point promising but inconclusive. In addition, intervention studies focusing on minority populations often use the same approach as studies targeting general population. While Manning et al. successfully identified race as a risk factor for diabetes, their study outcomes did not measure the impact of their educational interventions on racial disparities [31]. However, culturally tailored interventions have been associated with improved outcomes among Blacks and Asians [12, 16]. Furthermore, our review of this literature suggests that most telehealth and mhealth interventions mainly target basic theoretical factors implicated in preventable hospitalizations, such as socioeconomic status and health behavior, and do not address the complex sets of exposures and psychological stress resulting from minority status that are likely implicated race and ethnic disparities in these outcomes. Given this gap in approach to interventions, mhealth interventions addressing race and ethnic disparities would be well served by adopting a more comprehensive and multifactorial approach targeting the causes of racial disparities to reducing preventable hospitalizations among minority population with chronic diseases.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Ethical Approval This article does not contain any studies with human participants performed by any of the authors.

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