



Promoting Culturally Tailored mHealth: A Scoping Review of Mobile Health Interventions in Latinx Communities

Carmen Gonzalez¹ · Jody Early² · Vanessa Gordon-Dseagu² · Teresa Mata³ · Carolina Nieto¹

Accepted: 29 April 2021 / Published online: 14 May 2021

© The Author(s), under exclusive licence to Springer Science+Business Media, LLC, part of Springer Nature 2021

Abstract

This scoping review of mHealth research focuses on intervention studies that utilize mobile technologies to promote behavior change and improve health outcomes in U.S. Latinx communities. 342 mHealth articles were reviewed using PRIMSA protocols; most did not include a majority Latinx study population or did not report on an intervention. The final sample resulted in 23 articles published between 2012 and 2020. Reviewed interventions focused on conditions such as: diabetes, depression, substance abuse, obesity, hypertension, maternal health, and farmworker safety. About one-third of mHealth interventions included mobile applications, the rest were limited to texting programs. Text message reminders can help improve medication adherence and care access, especially when coupled with support from community health workers. Bi-directional text message interventions with feedback loops and personalized treatment options can build user agency. Additionally, multi-modal applications that combine texting with self-guided interactive content show promise for culturally tailored mHealth.

Keywords MHealth · Latinx · Tailored · Interventions · Technology

Introduction

With the rise of digital connectivity and a trend toward individualized medicine, eHealth has been heralded as a path toward more equitable delivery of care and improved health outcomes. The COVID-19 pandemic has underscored the need for remote care, including telehealth and mobile health options. This need is particularly acute among communities most impacted by public health crises. The World Health Organization (WHO) defines eHealth as an approach to health that utilizes information and communication technologies (ICTs) [1]. Under the broad umbrella of eHealth, mobile health (mHealth) is defined as the use of wireless technologies, such as mobile phones and personal digital assistants, to provide health care services and information. Such services can include, but are not limited to, health

monitoring, disease recording/reporting, and the dissemination of information related to healthy behaviors. Emergent health communication research examines how the use of mHealth applications is associated with behavioral change related to fitness [2, 3], diabetes [4], depression [5], and sleep [6] among other health outcomes. In a systematic review of mHealth app research, Chib and Lin [7] found scant explanatory evidence of *how* mHealth effects are actually achieved, and a greater emphasis on accessibility rather than individual-level health outcomes. A rise in randomized control designs, however, does signal a growing interest in studying the effectiveness of mHealth interventions, particularly when considering the importance of evidence in policymaking.

In this scoping review, we focus on intervention designs that utilize mobile technologies to promote behavioral change and improve health outcomes within a specific demographic population. This emphasis is in response to calls for tailored digital health interventions broadly [7], and culturally tailored mHealth tools specifically [8]. We focus on Latinx populations in the United States for three important reasons. First, the U.S. Census estimates that approximately 18% of the U.S. population identify as Latinx, and it is projected that by 2050 one out of every three individuals in the U.S. will share this ethnic background [9, 10]. Second, the U.S. Latinx community has

✉ Carmen Gonzalez
cmgonzal@uw.edu

¹ Department of Communication, University of Washington, Communications Building 101, Seattle, WA 98195, USA

² School of Nursing and Health Studies, University of Washington Bothell, Bothell, USA

³ Fielding School of Public Health, University of California Los Angeles, Los Angeles, USA

historically been disproportionately affected by a number of health disparities and structural inequalities. Latinx individuals experience excess mortality from preventable causes such as diabetes, cervical cancer, and liver disease [11]. During the COVID-19 pandemic, Latinx individuals have been three times as likely to become infected, and nearly twice as likely to die from the virus as non-Hispanic White people. And third, Latinx consumers have been driving mobile adoption in the U.S. in recent years and are now going online at equivalent or higher rates than other ethnic groups after a long-standing digital divide [12, 13].

A 2020 Nielsen report study reports that 98% of the U.S. Latinx population now owns a smartphone, compared to 93% of the general population. Because the spectrum of digital inclusion includes access and use, the nature of this connectivity is important; 35% of U.S. Latinx U.S. adults (compared to 14% White and 24% Black adults) are smartphone dependent—that is they rely on smartphones as their primary means of online access at home [14]. Mobile-only households face unique information challenges that often impact their access to critical resources. According to the Centers for Disease Control, mobile-only households are more likely to experience significant barriers to health care [15]. These circumstances suggest that mobile-specific health interventions may be appropriate for addressing the health needs of Latinx populations, yet little is known about the effectiveness of such approaches.

The diverse health needs of the Latinx population, as well as the disparities they experience, require the design and implementation of health interventions which are equally diverse in nature [16]. One such approach is the development and utilization of mobile health (mHealth) tools and applications (apps) that allow for health care to be provided via technology that is familiar and accessible to patients [17]. Given the high rates of smartphone ownership, these tools are viewed as a method by which to provide culturally appropriate health information and care in ways which are convenient and sustainable. Latinx populations specifically report high rates of acceptability related to receiving health-related information via mHealth applications [18]. Despite this, few mHealth interventions have been developed that specifically address the health needs of Latinx communities [19, 20]. To better understand the mHealth potential in this area of need, we conducted a scoping review of published intervention studies that focused explicitly on Latinx patients and communities.

Methods

This review aims to provide a narrow focus on how mHealth interventions are being deployed within a specific research context. We relied on the National Institutes of Health's

definition of *intervention* as “a manipulation of the subject or subject's environment for the purpose of modifying one or more health-related biomedical or behavioral processes and/or endpoints.” Our focus on intervention research aims to fill a critical gap in identifying explanatory mechanisms for individual-level behavioral change. Our focus on a specific demographic responds to the need for culturally tailored mHealth tools and approaches. Based on these aims, a scoping review was identified as an appropriate method to: (1) identify what areas of health have been addressed by mHealth interventions with Latinx populations, (2) examine the effectiveness of these interventions at the individual level, and (3) understand how mobile tools are being designed and implemented for a specific demographic population faced with a host of health disparities. This research was deemed exempt from human subjects review by a university institutional review board.

Search Methods

A scoping review is defined as “a form of knowledge synthesis addressing an exploratory research question aimed at mapping key concepts, types of evidence, and gaps in the research related to a defined area or field by systematically searching, selecting, and synthesizing existing knowledge” [21]. Our methodology followed criteria established by the Joanna Briggs Institute [21, 22] and PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocols [23]. Initial searches were undertaken in Pubmed (<https://pubmed.ncbi.nlm.nih.gov/>), Web of Science (webof-knowledge.com) and PubMed Central (<https://www.ncbi.nlm.nih.gov/pmc/>). For race and ethnicity, the search terms “Hispanic”; “Latin”; “Spanish”; “Latino”; “Latinx” and “Spanish-speaking” were utilized. These were used in combination the following terms related to mHealth: “mHealth” “text messaging” “smart phone” “text-based” “web-based” “application/app.” The same search terms were then used to find papers available via Google Scholar (<https://scholar.google.com/>).

Inclusion and Exclusion Criteria

The focus of the current scoping review was the use of mHealth tools within Latinx populations living in the U.S. We, therefore, did not limit inclusion by health outcome or the type of mHealth tool utilized within individual studies. Our key inclusion criteria were as follows: (1) intervention studies using some form of mobile health tool; (2) a U.S. study sample with a majority of participants identifying as Latinx; and (3) full-text articles published in peer-reviewed journals and written in English. No date restrictions were placed on the sample.

Exclusion criteria included: (1) studies that used mobile phones as research tools, for medical data collection, or as translation tools (e.g., video remote interpreting, Google Translate); (2) studies that included Latinx participants as a subset of a diverse study sample; and (3) systematic reviews and study protocols. Multiple publications from the same study were only included if the article reported a unique process or outcome.

Sample

Our initial set of keyword searches resulted in 318 articles. A follow-up search through Google Scholar resulted in 24 additional articles that met the criteria and/or were published after the initial search. The titles and abstracts of these 342 papers were reviewed by three of the authors. From this sample of 342, 195 articles were excluded due to not reporting on an intervention study using some form of mobile health tool, and 84 were excluded due to not including a U.S. study sample with a majority of participants identifying as Latinx. This then produced a sub sample of 63 articles that were fully reviewed for quality and inclusion. From this sub sample of 63, 23 articles were excluded due to presenting only a study design/protocol and not intervention outcomes, and 15 were excluded due to using mobile phones as research tools, for medical data collection, or as translation tools. This brought the sub sample to 25. When examining the articles further for uniqueness, two final articles were excluded for

duplication. Our final sample included 23 articles published between 2012 and 2020. The PRISMA flow chart below (Fig. 1) details the review process and the number of papers included/excluded at each stage.

Findings

The range of health issues addressed in the reviewed literature reflects significant health disparities that are disproportionately affecting U.S. Latinx populations (see Table 1 for annotated review). The time period for the review coincides with the emergence of mHealth in both academic research and the tech industry [24]. Interventions focused on managing public health concerns such as diabetes, depression, substance abuse, hypertension, maternal health, obesity, smoking, and farmworker safety. Diabetes ($n=6$) and depression ($n=4$) emerged as the most prevalent health concerns addressed through mHealth interventions in the reviewed sample. These results map on to current national disparities; Latinx individuals have a higher lifetime risk of diabetes compared to other ethnic groups [25] and are twice as likely as non-Hispanic White individuals to experience mental health disorders [26]. The following sections report on each of the reviewed mHealth intervention studies, focusing specifically on the design of each intervention, targeted individual-level health outcomes, and any significant challenges reported. Studies are grouped according to health outcome focus as appropriate.

Fig. 1 PRISMA flow diagram

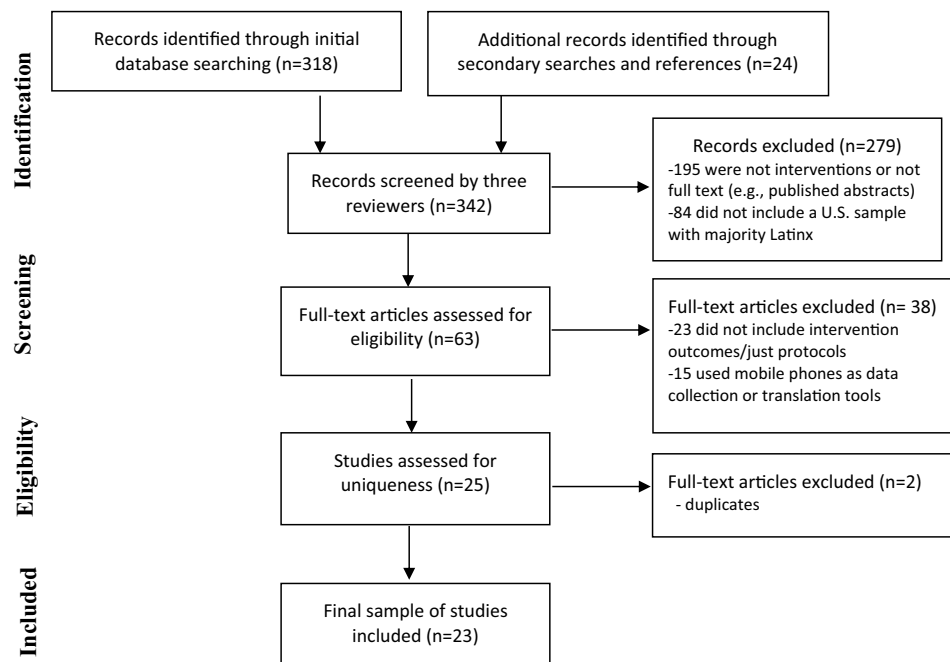


Table 1 Health focus, intervention design, and outcomes for each article in scoping review

Article	Health focus	Intervention design/mHealth utilized in study	Outcomes
Aguilera et al. (2017)	Depression	Controlled trial Text message adjunct with mood monitoring and treatment-related text messages, clinician dashboard with patient data	Patients assigned to the mHealth adjunct stayed in therapy longer and attended more therapy sessions. No differences found in depressive symptom severity between control group and intervention group
Arora et al. (2012)	Diabetes	Feasibility trial Automated daily text messages with diabetes-management content (educational, motivational, medication reminders, healthy living challenges, trivia, phone links)	Enrolled patients reported increase in nutrition, exercise, and foot checks. Efficacy scores improved, and medication adherence improved dramatically
Arora et al. (2015)	ER follow up	Controlled trial Automated text messages with appointment reminders (personalized with date, time, and clinic location)	Intervention improved attendance at scheduled follow-up appointments. Intervention most effective among English-speaking patients with specialty care appointments
Bruehlman-Senechal et al. (2017)	Depression	Uncontrolled trial Automated daily mood-monitoring text messages with prompting patients to respond with a number corresponding to their mood	Self-reported mood via text predicted group therapy attendance. Positive mood corresponded with greater likelihood of attendance
Burner et al. (2013)	Diabetes	Qualitative assessment of feasibility trial Automated daily text messages with diabetes-management content (educational, motivational, medication reminders, healthy living challenges, trivia, phone links)	Gender impacts patient perceptions of the program, challenges, and diabetes management strategies. Gender differences found in dietary self-efficacy, health information source preferences, and desired content of educational materials
Burner et al. (2014)	Diabetes	Qualitative assessment of controlled trial Automated daily text messages with diabetes-management content (educational, motivational, medication reminders, healthy living challenges, trivia, phone links)	Intervention acted as a behavioral trigger. Messages that cued specific behaviors (e.g. taking medication and exercising) were most effective. Increased personalization could augment cues
Burner et al. (2018)	Diabetes	Controlled feasibility trial Automated daily text messages with diabetes-management content supplemented by messaging to family and friends of patients. Corresponding text messages sent to patients and supporters synchronously to promote conversation	Intervention improved HbA1c, self-monitoring of glucose, and physical activity. Patients reported improved motivation, behaviors, and relationships. Supporters reported making healthier decisions for themselves
Cartujano-Barrera et al. (2019)	Smoking	Pilot study Automated text messages with cessation support motivation tailored to personalized 12-week quit timeline and keyword-triggered messages responding to participant texts. Counselors responded to non-automated text queries within 24 h	Self-reported cessation outcome (7-day point prevalence abstinence) among one third of retained participants. Engagement varied, and minimal participant text messages used keywords

Table 1 (continued)

Article	Health focus	Intervention design/mHealth utilized in study	Outcomes
Chandler et al. (2019)	Hypertension	Case-control efficacy trial Culturally tailored mobile app that interfaced with a Bluetooth blood pressure monitor and electronic medication tray. App recorded daily BP readings and provided user with audio and visual reports. Reports determined reminder and feedback messages. Motivational text messages supplemented tailored feedback, based on participant response to branch logic questionnaire. Medication trays sent reminders via lights, chimes, and automated texts or phone call. Control group received text message links with lifestyle tips	Significantly lower blood pressure readings for the intervention group compared to control group. Significant increases in medication adherence over time in intervention group
Chernick et al. (2017)	Family Planning	Pilot controlled trial Automated text messages with education and action components (family planning clinics, STIs, birth control options)	Contraception initiation was limited. While the intervention group reported acceptance, contraception initiation resulted higher in the control arm
Dahne et al. (2019)	Depression	Pilot controlled trial Behavioral activation mobile app with self-help messaging (user-identified life values generate suggested activities which are scheduled and tracked in a daily calendar along with mood fluctuations)	App users reported significantly lower depressive systems over time. Acceptance, use, and weekly retention was strong among intervention group
Evans et al. (2012)	Maternal Health	Pilot controlled trial Automated text messages with tips related to prenatal care. Designed to build knowledge and skills to prevent health risks by avoiding specific behaviors (e.g., smoking, drinking)	Exposure to mobile messaging was associated with improvement in targeted belief of preparedness for motherhood (one of the main belief outcomes) and attitudes toward alcohol
Fortmann et al. (2017)	Diabetes	Controlled trial Automated daily text messages with glycemic control content (motivational, educational, call-to-action). Users had the option to text message in their blood-glucose numbers; study coordinators would follow up as needed	Intervention achieved a significantly greater reduction in HbA1c levels. Frequency of texting in blood glucose values predicted final HbA1c numbers
Fukuoka et al. (2018)	Diabetes	Uncontrolled pilot study Daily use of wearable activity tracker and mobile app . Fitbit tracked steps, participants logged their caloric intake and weight on the Fitbit app, and interacted on a private Facebook group	Participants lost weight; significant reductions in blood pressure. Use of the mobile app weight diary associated with weight loss

Table 1 (continued)

Article	Health focus	Intervention design/mHealth utilized in study	Outcomes
Muroff et al. (2019)	Substance Abuse	Single group pre-post study Culturally-tailored mobile app with digital voice services, text messaging, web access, GPS, voice recognition, and video capabilities. Within-app resources included social support (e.g., discussion groups), tools (e.g., relaxation exercises), and information services (e.g., substance effects). Participants received automated daily medication reminders and surveys; case managers followed up as needed	Low baseline substance abuse and mental health symptoms sustained during 6-month intervention. Discontinued use of the app within first 4 months associated with higher rates of substance abuse and anxiety/depression symptoms
Olson et al. (2016)	Speech Delay	Uncontrolled pilot study Weekly text messages with optional survey questions to respond via text. Messages included information on activities and local resources that promote child language development	Participants reported being more aware of language-promoting activities and community resources for child development. Library visits increased significantly; parent-child reading increased slightly
Palacios et al. (2018)	Obesity	Controlled pilot trial Mobile app which provided personalized healthy grocery list and sample menus (customized based on household budget, individual dietary needs, local supermarket discounts). Users instructed to open app before grocery shopping and select budget and timeframe; app generated unique shopping list	Intervention group reported significant improvements in household purchasing and intake of healthy foods. No significant differences between groups
Pratap et al. (2018)	Depression	Controlled trial Self-guided mobile apps (a video game inspired cognitive intervention, an internet-based problem-solving therapy treatment, and an information control that provided daily health tips for depression). Participants randomized into one of three apps	Participants reported improvement in depression and disability measures over time. Outcomes did not vary by treatment app. Barriers in long-term engagement
Silverman-Lloyd et al. (2020)	Pediatric Primary Care	Cohort study Interactive text messages supplied over the span of a year. Text messages included appointment reminders and information about referrals and medications and health monitoring	Latino parents with low English proficiency (LEP) successfully engaged with interactive Spanish-language texts from the provider, and parent acceptability was high. This study demonstrates feasibility for interventions tailored to Latino families and those with emerging language skills
Sloand et al. (2019)	Influenza vaccine among children	Quality improvement trial Text messages were sent to caregivers to encourage uptake of the flu vaccine among children six months and older with asthma	Latino parents/caregivers who received text messages in Spanish were more likely to have their vaccinated than parents or caregivers received text messages
Snipes et al. (2016)	Farmworker Safety	Uncontrolled feasibility study Mobile app with daily surveys to assess work conditions and individually tailored messages with motivational cues to encourage use of personal protective equipment (PPE)	Evaluation demonstrated strong feasibility; individualized messages perceived as helpful when they communicated health risks

Table 1 (continued)

Article	Health focus	Intervention design/mHealth utilized in study	Outcomes
Tebb et al. (2019)	Family Planning	Controlled trial Mobile app that provides patient-centered contraceptive information in conjunction with a clinical encounter. Culturally and linguistically tailored for adolescent girls. App provides tailored health information based on user input	App was successfully integrated into clinical workflows of school-based health centers. Youth engagement in app development and implementation was essential
Vaughan et al. (2020)	Diabetes	Randomized clinical trial Clinical care supplemented by Community Health Workers (CHWs) who engaged patients via telehealth and text messages . CHWs contacted patients weekly to assess glucose control, medication adherence, and address concerns	Latino participants with diabetes showed lower HbA1c after 12 weeks of participating in a telehealth and text-message intervention in Spanish with community health workers than those in the control group. Tailored mHealth combined with CHW support is a promising strategy to assist with diabetes self-management

Diabetes Management and Prevention

Three of the six reviewed articles focusing on diabetes resulted from a multi-year, mixed-method intervention promoting disease management and social support among lower-income Latinx patients [27–29]. Measured health outcomes included improved medication adherence, physical activity, self-efficacy, glucose monitoring, and biomarkers such as hemoglobin levels. During a 2012 feasibility trial, Arora et al. [27] recruited 23 resource-poor bilingual patients with diabetes, a majority of whom identified as Latino, from the emergency department of a public safety-net hospital. The mHealth intervention consisted of unidirectional automated daily text messages with health promotion messaging. Educational and motivational messages focusing on content areas such as blood glucose control, blood pressure, cholesterol, and health eating were adapted from a national diabetes education program and tailored to knowledge deficits in the population. Messaging included medication reminders, healthy living challenges, and phone links encouraging participants to engage in specific behavior. At the end of the 3-week trial, participants reported improved health behaviors such as eating fruits and vegetables, exercising, and conducting regular foot checks. Medication adherence improved dramatically, while self-efficacy increased modestly. The brief intervention period, however, limited the measure of changes in hemoglobin levels. Results of the pilot intervention suggest that poor-resourced patients with diabetes who use emergency departments for care may benefit from diabetes-specific mHealth programs.

Qualitative assessments of the feasibility trial revealed that messages which cued specific diabetes management behaviors were the most effective [29] and that gender can impact diabetes management strategies [28]. In the subsequent controlled trial, the text messaging intervention was expanded to include friends and family members of the patients [30]. Corresponding diabetes-management messages were sent to patients and their supporters synchronously to encourage conversation and social support. This intervention design resulted in more robust health outcomes, including improved glycated hemoglobin (HbA1c) levels and increased self-monitoring of glucose. Patients reported improved motivation, behaviors, and relationships. Their supporters also reported making healthier decisions for themselves as a result of their participation in the intervention.

In another diabetes-focused intervention, Fortmann et al. [31] assessed the utility of motivational, educational, and call-to-action daily text messages over a six-month period in controlling HbA1c levels among a Latinx population diagnosed with type-2 diabetes. They found those who received the text message intervention achieved a statistically significant reduction in HbA1c compared with those who received

usual care. At the same time, they found no differences in other clinical markers between the intervention and usual care group; while those in the intervention arm of the study reported both satisfaction and acceptability with the text messages they received.

The effectiveness of tailored text messages was also examined in a 2020 randomized clinical trial by Vaughan et al. [32]. The researchers combined the use of tailored text messages with live Spanish telehealth sessions with community health workers (CHWs) to determine if HbA1c levels among a sample of 89 Latino adults would improve after a 12-week intervention compared to those in the control group. Among those who participated in the intervention, there was statistically significant improvement in HbA1c and blood pressure compared to the control group. However, other health measures, such as BMI, did not show any improvement. Tailored mHealth combined with CHW support is a promising strategy to assist with diabetes self-management.

Fukuoka et al. [20] developed an in-person weight loss program in conjunction with a commercially available Fit-bit mobile health app and enrolled 54 Latinx individuals at risk of incident Type-2 diabetes. They found a statistically significant mean percentage loss of total body weight, reductions in hip/weight circumference, and blood pressure. The key weakness of the study appears to be the lack of a control group, with the researchers calling for the intervention to be further evaluated within a randomized controlled trial.

Depression and Mental Health Care

Four of the reviewed studies explored the role that mHealth might play within the provision of mental health services, particularly those related to cognitive behavioral therapy. These interventions ranged in design and interactivity, albeit with similar goals of increasing access to behavioral health among Latinx communities. Pratap et al. [33] conducted a controlled trial with a cohort of Latinx patients experiencing mild to moderate depression. Using three self-guided mobile apps translated into Spanish, this intervention aimed to test the potential of fully remote behavioral health treatments. A total of 348 active app users were assigned to three different apps over a 12-week period: (1) iPST (based on evidence-based therapeutic principles informed by problem-solving therapy techniques); (2) Project Evolution (cognitive training informed by cognitive neuroscience) and (3) health tips (control group). Clinical outcomes of interest were depressive symptom severity and functional impairment; while depressive symptoms improved overall, outcomes did not vary significantly by treatment app. The researchers note long-term engagement challenges, particularly for participants from lower-income households.

Aguilera et al. [34] assessed the utility of combining a text message-based service with a traditional program of cognitive behavioral therapy (CBT) provided to a cohort of low-income, Spanish speaking Latinos. They compared a control group who received CBT alone ($n = 40$) with an intervention group who received CBT and the text message intervention ($n = 45$). The text-based intervention provided the participants with five types of information provided in Spanish (mood rating, messages supporting live therapy, medication reminders, psychotherapy appointment reminders and study opt-out reminders). The first three message types were provided daily, while the last two were provided on a weekly and monthly basis, respectively. The study found no difference in appointment attendance between the control and intervention groups nor in improvements in indicators of depressive symptoms. Those who received text messages did stay in the study for longer compared with the CBT-only group—13.5 weeks compared with three weeks, respectively. Reporting on a mood monitoring adjunct in this same study, Bruhlmann-Senecal et al. [35], assess the predictive capacity of daily mood-monitoring text messages in relation to attendance at a CBT program. Automated daily text messages prompted patients to respond via text with a number corresponding to their mood (on a scale of 1–9). Results indicated that mood, the day prior to each CBT session, was a good predictor of attendance. The authors posit that the usefulness of text-messaging lies in its potential to support traditional modes of health care provision.

In a more interactive and tailored intervention, an 8-week controlled pilot study by Dahne et al. [36] assessed the feasibility of the *¡Aptivate!* (Get Fit!) tailored mHealth app when compared with a translated Spanish language app (*iCouch* CBT) and CBT alone. The tailored app included self-help messaging based on user-identified life values. After users report their values and daily moods, the app suggests activities that are scheduled and tracked in a daily calendar. Approximately half of those in the *¡Aptivate!* intervention arm continued to use the app until the end of the study period and reported significantly lower depressive symptoms over time when compared with the CBT-only control group; outcomes were the same for those in the *¡Aptivate!* and *iCouch* study arms. The small sample size, and short study period, call for further analysis of the impact of the interactive app on clinical outcomes.

Family Planning, Maternal and Sexual Health

Four of the reviewed studies used mHealth approaches to target behavioral change among Latina women specifically. A pilot randomized control trial by Chernick et al. [37] explored the efficacy and feasibility of a text-based mHealth program to increase contraception use among a sample of 100 young women (aged 14–19) attending emergency care.

Half of the participants received text-based information for a 3-month period, while the control group received traditional discharge information. Automated text messages included education and action components (e.g., information on family planning clinics, sexually transmitted diseases, and birth control options). The results of the study were somewhat limited by the high rate of text delivery failure; no differences were found in contraception initiation between the intervention and control groups.

In a more tailored approach, Tebb et al. [38] developed an evidence-based, Spanish -language app called *Salud iTu* to provide sexual health information to Latina adolescents. The app included interactive, tailored information to assist an individual to make decisions about contraceptive use. This information was culturally and linguistically tailored to the intervention group and was administered in conjunction with a clinical encounter within school-based health centers. While changes in contraceptive use were not measured, the app was successfully integrated into clinical workflows of school-based health centers. The results of the study suggest that, for mHealth applications to be successfully rolled out via health care providers, they need to be developed in ways which include the target audience right from the start, while also involving health care providers and other stakeholders as appropriate. Participatory design sessions with target users and providers facilitated the meaningful tailoring of the app. However, a number of challenges were reported, including those related to technology (including limited internet access in some locations), maintaining patient confidentiality, how best to disseminate information about new mHealth programs, high staff turnover and services continuity, and the length of time patients required to complete the app's information requirements.

Focusing on prenatal care and maternal health, a randomized control trial by Evans et al. [39] assigned 123 pregnant Latina women to either the control group (traditional health care) or the intervention arm (traditional health care + Text4baby text messages). The messages received by the expectant mothers sought to improve clinical outcomes via information dissemination to encourage healthy behaviors. These messages included tips designed to build knowledge and reduce health risks by avoiding specific behaviors (e.g., smoking, drinking). The study found that the app had a statistically significant impact upon how prepared for motherhood the women felt and their attitudes towards alcohol and harm to their unborn child. However, no significant attitudinal differences were found, between baseline and follow-up, in several areas including the consumption of fruit, vegetables and vitamins, the importance of visiting a health care provider and abstaining from tobacco consumption.

In a similar intervention, Williams et al. [40] used automated text messages to promote optimal weight in first-time pregnant Latina mothers living in a U.S.-Mexico

border community. Text messages supplemented in-person group sessions that focused on nutrition, physical activity, and breastfeeding. A promotora (or community health worker) would provide updates and feedback via text. One significant challenge was that the SMS system was not supported by many participants' pay-as-you-go mobile phone plans. A private Facebook group implemented to facilitate communication between participants and with the promotora resulted in higher feasibility than text messaging. Ultimately, participants reported success in breastfeeding and postpartum weight loss.

Obesity and Hypertension

Two of the reviewed non-diabetes intervention studies addressed weight-related risk factors through interactive mobile apps. The MyNutriCart app provides users with healthy shopping lists and aims to improve diet and reduce overweight and obesity. Shopping lists and sample menus are customized according to household budget, dietary needs, and locals supermarket discounts. Users are instructed to open the app before grocery shopping and select their budget and timeframe. In a controlled pilot trial with Latino users, Palacios et al. [41] found no significant differences between the control ($n = 24$) and app-intervention ($n = 27$) groups in relation to body weight; although those involved in both arms of the study did improve behavior related to food choices—such as increased purchasing of vegetables and reductions in consumption of snacks. The authors suggested the use of such apps may be a cost-saving approach compared with traditional diet and healthy behavior programs.

In a more innovative and culturally-tailored intervention, Chandler et al. [42] undertook a nine-month efficacy trial to explore the utility of a smartphone app (Smartphone Med Adherence Stops Hypertension—SMASH) compared with enhanced standard care. The mobile app interfaced with a Bluetooth-enabled blood pressure monitor and medication tray. The app records daily blood pressure readings and provides the user with audio and visual reports which determine reminder and feedback messages. Motivational text messages supplement the tailored feedback, based on participant responses to in-app branch logic questionnaires. Bluetooth-enabled medication trays send reminders via lights, chimes, and automated texts or phone calls. Among the 54 Hispanic participants with uncontrolled hypertension and poor medication adherence, 26 were assigned to the SMASH arm. Systolic blood pressure readings and medication adherence significantly improved in the intervention group over time; more intervention arm participants attained the Joint National Committee cutoffs for systolic blood pressure compared with those who received standard care.

Farmworker Safety

Snipes et al. [43, 44] published two studies exploring the potential for mHealth interventions to increase the use of personal protective equipment (PPE) among Mexican immigrant and Mexican American farmworkers. The ¡Protéjase! (Protect Yourself!) program began with daily individualized text messages with motivational risk-reduction recommendations to encourage PPE use. Messages were tailored culturally, linguistically, and were responsive to PPE use reported at baseline. The text-only component of the intervention resulted in participants wearing more PPE at follow-up compared with baseline [43]. Following the pilot study, a mobile app was developed to administer daily surveys to the workers assessing working conditions. This allowed for even further tailoring of motivational messaging based on dynamic daily conditions. A total of 55 farmworkers participated in the ¡Protéjase! mHealth program; 75% of participants completed the program with few noting difficulties in understanding the messages disseminated [44]. Individualized messages were perceived as helpful when they communicated health risks. Feasibility and satisfaction with the program were also found to be high and participants appeared to see the usefulness of the platform in encouraging uptake of PPE.

Smoking and Substance Abuse

Two of the reviewed studies focused on mHealth interventions to reduce substance abuse in the Latinx community. Cartujano-Barrera et al. [19] found that the use of a text messaging program among a small cohort ($n=20$) of Latino smokers had high engagement and could produce increased cessation rates—approximately 30% of the study sample abstained from smoking for seven days. Automated text messages with cessation support motivation were tailored to participants' personalized 12-week quit timelines. Users had the option of replying with keyword-triggered text messages, although few participants used this feature. Counselors were on-call to respond to non-automated text queries within 24 h.

In a similar approach, Muroff et al. [45] designed a culturally tailored mobile app for Latinx Spanish-speakers with substance use disorders. The app included digital voice services, text messaging, web access, GPS, voice recognition, and video capabilities. Within-app resources included discussion groups, relaxation tools, and information services. Participants received automated daily medication reminders and surveys with follow up from case managers as needed. The use of the Addiction-Comprehensive Health Enhancement Support System (A-CHESS), once translated and adapted for Spanish speakers (into CASA-CHESS) enabled lower rates of relapse among the program participants compared with those who completed a residential program of

cessation only or who dropped out of CASA-CHESS within the first four months.

General Care and Access

Four of the reviewed studies implemented mHealth interventions to improve healthcare access among Latinx patients and families. Arora et al. [46] implemented text message appointment reminders to improve attendance at post-emergency department visits. The appointment reminders were personalized with date, time, and clinic location. The intervention improved attendance at scheduled follow-up appointments and was most effective among English-speaking patients with specialty care appointments. Similarly, Olson et al. [47] used weekly text messages to share language development resources with parents of children experiencing speech delays. Messages included information on educational activities and local resources, with the option to respond to survey questions via text. Participants reported being more aware of community resources for child development, with library visits increasing significantly and parent-child reading increasing slightly.

Silverman-Lloyd et al. [48] sought to assess the effectiveness and acceptability of an interactive text messaging service, provided in Spanish, in relation to enabling families to access pediatric primary care services, medications and referrals. Among those included in the study ($n=79$), the researchers found high rates of engagement with the text messages, with appointment reminders viewed especially favorably. Similarly, Sloand et al. [49] undertook a two-year study to improve the quality of a text message program that sought to increase uptake of the influenza vaccine among children with asthma in a low-resource, majority Latinx, population. Between year 1 and 2, the study improved both the content and timing of the text messages, as well as providing the messages in the family's preferred language. Latinx parents/caregivers who received text messages in Spanish were more likely to have their vaccinated than children from English-speaking, non-Latinx families whose parents or caregivers received text messages.

Discussion

This scoping review focused on intervention designs and individual-level health outcomes in mHealth programs targeting Latinx communities. In response to calls for tailored mHealth solutions, this review contributes to broader discussions of how mobile tools can be leveraged to improve population health, and why cultural tailoring is critical. Our focus on the U.S. Latinx population as the fastest growing demographic group with increasing access to mobile technology suggests promising paths forward. We found that mHealth

interventions tailored to Latinx patients in the U.S. focus on a range of health outcomes, many of which are disproportionately impacting Latinx communities. Interventions limited to text message reminders and information sharing can be successful in improving medication adherence and care access [30, 34, 47]. Bi-directional text message interventions with feedback loops and personalized treatment options can build agency and capacity among users to change health behaviors [19, 31, 40]. And multi-modal smartphone apps that combine texting functions with self-guided interactive content show promise for culturally-tailored mHealth interventions that promote long-term engagement [38, 42, 44, 45]. Overall, slightly over one-third (7 out of 23) of the reviewed studies implemented mHealth interventions that included mobile apps—all of these studies were published in 2018 and 2019. As mobile technologies become more accessible for researchers and underserved communities alike, we should expect an emergence of mHealth interventions that leverage innovation in creative ways. It is important, however, that such projects build from the successes and failures of past studies to responsibly promote tailored mHealth interventions.

Two projects that creatively engaged digital tools to promote self-management and behavior change among Latinx participants are worth highlighting. Fukuoka et al. [20] combined the use of a commercially available tracking app with a Fitbit device to promote weight loss. Chandler et al. [42] used a mobile application linked to a Bluetooth-enabled blood pressure monitor and electronic medicine tray to enable the self-management of hypertension. Both interventions resulted in significantly improved individual-level health outcomes for critical risk factors (i.e., obesity and hypertension). While these successes are promising, they also signal the importance of digital literacy in mHealth interventions. Only a few of the reviewed studies described the process of teaching participants how to use various tools to ensure consistent engagement during the intervention. More transparency and reflexivity among researchers on how mHealth interventions are implemented would further contribute to an explanatory understanding of mHealth effects.

Finally, many of the reviewed articles suggested that participatory and user-centered design approaches with Latinx communities would help inform sustainable mHealth interventions and provide strategies to improve long-term engagement with mHealth tools. Co-design efforts with intended users could help address many of the challenges of culturally-tailored mHealth interventions, including: (1) costs of developing and maintaining mHealth programs, (2) limited access to latest devices and functionalities, (3) limited digital literacy, (4) concerns of scale and cultural sensitivity, and (5) small sample sizes. The results of our scoping review support prior research in finding that community-based and participatory health

interventions are often more successful because of community investment and ownership (Authors 2019) [50]. Tailored mHealth interventions that are designed in partnership with intended users can yield tools and programs that are more responsive to collective needs, reinforce digital literacy skills and capacity, and thus become more sustainable over time. Interventions that leverage digital tools and meaningfully engage community health workers are particularly promising.

Conclusion

This scoping review underscores that there is a growing number of mHealth resources being developed, and made available, for diverse populations. This is, perhaps, due to an acknowledgment of the health disparities experienced by Latinx populations in the U.S.; many of the authors of the included studies highlighted the need for novel approaches to healthcare that are culturally-tailored and personalized. By focusing on interventions targeting Latinx populations, we were able to identify target health areas and individual-level health outcomes. mHealth interventions ranged from unidirectional text message programs to more complex multi-modal mobile apps and functions. Changes in health behavior included medication adherence, self-management and tracking, change in daily habits, and increased knowledge of health resources.

While a rise in intervention designs signals a growing interest in studying the effectiveness of mHealth programs, there is limited understanding of the explanatory mechanisms that support cultural tailoring. Meanwhile, the ongoing COVID-19 pandemic, which is disproportionately impacting communities of color, has heightened the need for tailored mHealth modalities. There are currently 62.3 million individuals living in the U.S. who identify as Hispanic or Latinx, and 98% of them own a smartphone—during the COVID-19 pandemic they reported spending an average of over 30 h per week on their smartphone, two more hours per week than the general population [51]. This area of focus is thus ripe for investigation and warrants further research on the effectiveness of mHealth interventions. Our goal with this review is to map evidence of the potential for mHealth to support the health needs of Latinx communities so that future interventions can build on existing efforts. Ultimately, designing technologies *with* and not just *for* diverse communities and underserved groups will help to cultivate more than just tech, and provide tools and strategies that are best suited to address the priorities, capacity, and needs of those most impacted by structural inequities.

Declarations

Conflict of interest There are no conflict of interest to disclose.

References

- World Health Organization. Frequently asked questions on Global Task Force on digital health for TB and its work. In: World Health Organization Tuberculosis (TB). World Health Organization. 2017. <https://www.who.int/tb/areas-of-work/digital-health/faq/en/>. Accessed 16 Feb 2020.
- Molina MD, Sundar SS. Can mobile apps motivate fitness tracking? A study of technological affordances and workout behaviors. *Health Commun.* 2020;35(1):65–74.
- Wei J, Vinnikova A, Lu L, Xu J. Understanding and predicting the adoption of fitness mobile apps: evidence from China. *Health Commun.* 2020;2020:1–12.
- Kim H, Tietz C, Posther K, Michaelides A, Toro-Ramos T. Enabling self-management of a chronic condition through patient-centered coaching: a case of an mhealth diabetes prevention program for older adults. *Health Commun.* 2019;35:1–9.
- Scherr S, Goering M. Is a self-monitoring app for depression a good place for additional mental health information? Ecological momentary assessment of mental help information seeking among smartphone users. *Health Commun.* 2019;35:1–9.
- Robbins R, Krebs P, Rapoport DM, Jean-Louis G, Duncan DT. Examining use of mobile phones for sleep tracking among a national sample in the USA. *Health Commun.* 2019;34(5):545–51.
- Chib A, Lin SH. Theoretical advancements in mHealth: a systematic review of mobile apps. *J Health Commun.* 2018;23(10–11):909–55.
- World Health Organization. mHealth: New Horizons for Health through Mobile Technologies, Vol 3. Geneva: World Health Organization; 2011.
- Passel JS, Cohn D. US population projections: 2005–2050. In: Pew Hispanic Center Reports. Pew Research Center. 2008. <https://www.pewresearch.org/wp-content/uploads/sites/5/reports/85.pdf>. Accessed 16 Feb 2019.
- U.S. Census Bureau QuickFacts. United States. 2020. <https://www.census.gov/quickfacts/fact/table/US/RH1725218>. Accessed 10 Dec 2020.
- Vega WA, Rodriguez MA, Gruskin E. Health disparities in the Latino population. *Epidemiol Rev.* 2009;31(1):99–112.
- Brenner J, Smith A. 72% of online adults are social networking site users. In: Pew Research Center Internet and Technology. Pew Research Center. 2013. <https://www.pewresearch.org/internet/2013/08/05/72-of-online-adults-are-social-networking-site-users/>. Accessed 6 Oct 2020.
- Lopez MH, Gonzalez-Barrera A, Patten E. Closing the digital divide: Latinos and technology adoption. In: Pew Hispanic Trends. Pew Research Center. 2013. <http://www.pewhispanic.org/2013/03/07/closing-the-digital-divide-latinos-and-technology-adoption/>. Accessed 25 Sept 2020.
- Pew Research Center. Internet/broadband fact sheet. In: Pew Research Center Internet and Technology. Pew Research Center. 2018. <http://www.pewinternet.org/fact-sheet/internet-broadband/>. Accessed 15 Aug 2020.
- Blumberg SJ. Wireless Substitution: Early Release of Estimates from the National Health Interview Survey, July–December 2017. United States: National Center for Health Statistics; 2018.
- Dominguez K, Penman-Aguilar A, Chang MH, Moonesinghe R, Castellanos T, Rodriguez-Lainz A, Schieber R. Vital signs: leading causes of death, prevalence of diseases and risk factors, and use of health services among Hispanics in the United States—2009–2013. *MMWR Morbid Mortal Wly Rep.* 2015;64(17):469.
- Arora S, Ford K, Terp S, Abramson T, Ruiz R, Camilon M, Coyne CJ, Lam CN, Mechine M, Burner E. Describing the evolution of mobile technology usage for Latino patients and comparing findings to national mHealth estimates. *J Am Med Inform Assoc.* 2016;23(5):979–83.
- Leite L, Buresh M, Rios N, Conley A, Flys T, Page KR. Cell phone utilization among foreign-born Latinos: a promising tool for dissemination of health and HIV information. *J Immigr Minor Health.* 2014;16(4):661–9.
- Cartujano-Barrera F, Arana-Chicas E, Ramírez-Mantilla M, Perales J, Cox LS, Ellerbeck EF, Catley D, Cupertino AP. “Every day I think about your messages”: assessing text messaging engagement among Latino smokers in a mobile cessation program. *Patient Prefer Adher.* 2019;13:1213.
- Fukuoka Y, Vittinghoff E, Hooper J. A weight loss intervention using a commercial mobile application in Latino Americans—Adelgaza Trial. *Transl Behav Med.* 2018;8(5):714–23.
- Colquhoun HL, Levac D, O’Brien KK, Straus S, Tricco AC, Perrier L, Moher D. Scoping reviews: time for clarity in definition, methods, and reporting. *J Clin Epidemiol.* 2014;67:1291–4.
- Peters MD, Godfrey CM, Khalil H, McInerney P, Parker D, Soares CB. Guidance for conducting systematic scoping reviews. *Int J Evid-Based Healthc.* 2015;13:141–6.
- Tricco AC, Lillie E, Zarin W, O’Brien KK, Colquhoun H, Levac D, Straus SE. PRISMA Extension for Scoping Reviews (PRISMA-ScR): checklist and explanation. *Ann Intern Med.* 2018;169:467–73.
- Steinhubl SR, Muse ED, Topol EJ. The emerging field of mobile health. *Sci Transl Med.* 2015;7(283):283rv3.
- Qi Q, Stilp AM, Sofer T, Moon JY, Hidalgo B, Szpiro AA, Wang T, Ng MCY, Guo X, MEDIA Consortium, Chen YI, Taylor K, Aviles-Santa L, Papanicolaou G, Pankow J, Schneiderman N, Laurie C, Rotter J, Kaplan R. Genetics of Type 2 Diabetes in US Hispanic/Latino Individuals: Results From the Hispanic Community Health Study/Study of Latinos (HCHS/SOL). *Diabetes.* 2017;66(5):1419–25.
- Limon FJ, Lamson AL, Hodgson J, Bowler M, Saeed S. Screening for depression in Latino immigrants: a systematic review of depression screening instruments translated into Spanish. *J Immigr Minor Health.* 2016;18(4):787–98.
- Arora S, Peters AL, Agy C, Menchine M. A mobile health intervention for inner city patients with poorly controlled diabetes: proof-of-concept of the TexT-MED program. *Diabetes Technol Ther.* 2012;14(6):492–6.
- Burner E, Menchine M, Taylor E, Arora S. Gender differences in diabetes self-management: a mixed-methods analysis of a mobile health intervention for inner-city Latino patients. *J Diabetes Sci Technol.* 2013;7(1):111–8.
- Burner ER, Menchine MD, Kubicek K, Robles M, Arora S. Perceptions of successful cues to action and opportunities to augment behavioral triggers in diabetes self-management: qualitative analysis of a mobile intervention for low-income Latinos with diabetes. *J Med Internet Res.* 2014;16(1):e25.
- Burner E, Lam CN, DeRoss R, Kagawa-Singer M, Menchine M, Arora S. Using mobile health to improve social support for low-income Latino patients with diabetes: a mixed-methods analysis of the feasibility trial of TexT-MED+ FANS. *Diabetes Technol Ther.* 2018;20(1):39–48.
- Fortmann AL, Gallo LC, Garcia MI, Taleb M, Euyoque JA, Clark T, Skidmore J, Ruiz M, Dharkar-Surber S, Schultz J, Philis-Tsimikas A. Dulce Digital: an mHealth SMS-based

- intervention improves glycemic control in Hispanics with type 2 diabetes. *Diabetes Care*. 2017;40(10):1349–55.
32. Vaughan EM, Hyman DJ, Naik AD, Samson SL, Razjouyan J, Foreyt JP. A telehealth-supported, integrated care with CHWs, and medication-access (TIME) Program for Diabetes Improves HbA1c: a randomized clinical trial. *J Gen Intern Med JGIM*. 2020. <https://doi.org/10.1007/s11606-020-06017-4>.
 33. Pratap A, Renn BN, Volponi J, Mooney SD, Gazzaley A, Areal PA, Anguera JA. Using mobile apps to assess and treat depression in Hispanic and Latino populations: fully remote randomized clinical trial. *J Med Internet Res*. 2018;20(8):e10130.
 34. Aguilera A, Bruehlman-Senecal E, Demasi O, Avila P. Automated text messaging as an adjunct to cognitive behavioral therapy for depression: a clinical trial. *J Med Internet Res*. 2017;19(5):e148.
 35. Bruehlman-Senecal E, Aguilera A, Schueller SM. Mobile phone-based mood ratings prospectively predict psychotherapy attendance. *Behav Ther*. 2017;48(5):614–23.
 36. Dahne J, Collado A, Lejuez CW, Risco CM, Diaz VA, Coles L, Kustanowitz J. Pilot randomized controlled trial of a Spanish-language Behavioral Activation mobile app (¡ Aptivate!) for the treatment of depressive symptoms among united states Latinx adults with limited English proficiency. *J Affect Disord*. 2019;250:210–7.
 37. Chernick LS, Stockwell MS, Wu M, Castaño PM, Schnall R, Westhoff CL, Santelli J, Dayan PS. Texting to increase contraceptive initiation among adolescents in the emergency department. *J Adolesc Health*. 2017;61(6):786–90.
 38. Tebb KP, Trieu SL, Rico R, Renteria R, Rodriguez F, Puffer M. A mobile health contraception decision support intervention for Latina adolescents: implementation evaluation for use in school-based health centers. *JMIR mHealth uHealth*. 2019;7(3):e11163.
 39. Evans WD, Wallace JL, Snider J. Pilot evaluation of the text4baby mobile health program. *BMC Public Health*. 2012;12(1):1031.
 40. Williams CB, LaCoursiere DY, Talavera GA, Gahagan S. A feasibility study to promote optimal weight in first time pregnant mothers and their babies: lessons learned in a US-Mexico Border Community. *Matern Child Health J*. 2019;23:1–7.
 41. Palacios C, Torres M, López D, Trak-Fellermeier MA, Coccia C, Pérez CM. Effectiveness of the nutritional app “mynutricart” on food choices related to purchase and dietary behavior: a pilot randomized controlled trial. *Nutrients*. 2018;10(12):1967.
 42. Chandler J, Sox L, Kellam K, Feder L, Nemeth L, Treiber F. Impact of a culturally tailored mhealth medication regimen self-management program upon blood pressure among hypertensive hispanic adults. *Int J Environ Res Public Health*. 2019;16(7):1226.
 43. Snipes SA, Smyth JM, Murphy D, Miranda PY, Ishino FAM. Provision increases reported PPE use for Mexican Immigrant farmworkers: an mHealth pilot study. *J Occup Environ Med*. 2015;57(12):1343–6.
 44. Snipes SA, Montiel-Ishino FA, Smyth JM, Murphy DJ, Miranda PY, Davis LA. User perceptions of ¡Protéjase!: an intervention designed to increase protective equipment use among Mexican immigrant and Mexican American farmworkers. *JMIR mHealth uHealth*. 2016;4(2):e28.
 45. Muroff J, Robinson W, Chassler D, López LM, Lundgren L, Guauque C, Dargon-Hart, Stewart E, Dejesus D, Johnson K, Peromashko K, Gustafson DH. An outcome study of the CASA-CHES smartphone relapse prevention tool for Latinx Spanish-speakers with substance use disorders. *Subst Use Misuse*. 2019;1–12.
 46. Arora S, Burner E, Terp S, Nok Lam C, Nercisian A, Bhatt V, Menchine M. Improving attendance at post-emergency department follow-up via automated text message appointment reminders: a randomized controlled trial. *Acad Emerg Med*. 2015;22(1):31–7.
 47. Olson KB, Wilkinson CL, Wilkinson MJ, Harris J, Whittle A. Texts for talking: evaluation of a mobile health program addressing speech and language delay. *Clin Pediatr*. 2016;55(11):1044–9.
 48. Silverman-Lloyd LG, Cortez JD, Godage SK, Araujo DV, Rivera T, Polk S, et al. Immigrant Latino parents demonstrated high interactivity with pediatric primary care text messaging intervention. *mHealth*. 2020;6:45–45. <https://doi.org/10.21037/mhealth.2020.01.06>.
 49. Sloan E, VanGraafeiland B, Holm A, MacQueen A, Polk S. Text message quality improvement project for influenza vaccine in a low-resource largely Latino pediatric population. *J Healthc Qual*. 2019;41(6):362–8. <https://doi.org/10.1097/JHQ.0000000000000190>.
 50. Wallerstein N, Duran B, Oetzel JG, Minkler M, editors. Community-based participatory research for health: advancing social and health equity. San Francisco: John Wiley & Sons; 2017.
 51. Nielsen Company. Cultural Connectivity Transformed: How Latinos are Connecting while Social Distancing. In: *The Hispanic Diverse Intelligence Series 2020*. The Nielsen Company. 2020. <https://www.nielsen.com/wp-content/uploads/sites/3/2020/08/nielsen-2020-hispanic-dis-report.pdf>. Accessed 10 Dec 2020.

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