Behavior Change Interventions Delivered by Mobile Telephone Short-Message Service

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Context: The expansion and adoption of new methods of communication provide new opportunities for delivering health behavior change interventions. This paper reviews the current research examining mobile telephone short-message service (SMS) for delivering health behavior change interventions via text messages. This service has wide population reach, can be individually tailored, and allows instant delivery with asynchronous receipt, suggesting potential as a delivery channel for health behavior interventions.

Evidence acquisition: An electronic database search was conducted for studies published between January 1990 and March 2008. Studies were included in the review if they (1) evaluated an intervention delivered primarily via SMS, (2) assessed change in health behavior using pre–post assessment, and (3) were published in English in a peer-reviewed scientific journal.

Evidence synthesis: Of 33 studies identified, 14 met the inclusion criteria. Four of the 14 studies reviewed targeted preventive health behaviors (e.g., smoking cessation), and ten focused on clinical care (e.g., diabetes self-management). Positive behavior change outcomes were observed in 13 of the 14 reviewed studies. Intervention initiation (researcher or participant), SMS dialogue initiation, tailoring of SMS content, and interactivity were found to be important features of SMS-delivered interventions. Methodologic issues with current SMS research were also identified.

Conclusions: This review suggests that SMS-delivered interventions have positive short-term behavioral outcomes. Further research is required to evaluate interventions for preventive health behaviors that incorporate features found to affect behavioral outcomes and participant acceptance. The quality of studies in this emerging field of research needs to improve to allow the full potential of this medium to be explored.
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Introduction

Recent reviews have focused on the effectiveness of health behavior change interventions delivered via telephone[1–4] and the Internet.[5–7] Researchers have suggested exploring other interactive delivery channels, such as mobile telephone short-message service (SMS),[8–12] but no systematic reviews have been reported to date. The aim of this paper is to review the preliminary evidence of health behavior change interventions delivered via SMS texting.

Mobile telephones and SMS are becoming integrated into virtually all aspects of society.[13–16] In the U.S. in 2007, approximately 7,000,000,000 SMS messages were sent every month.[17] In developed countries, use of SMS pervades all age groups,[9,15,18,19] cultures,[16] and socioeconomic backgrounds.[9,15] This service allows for instantaneous delivery of short messages (maximum 160 characters) directly to individuals at any time, place, or setting. These messages are asynchronous, meaning they can be accessed at a time that suits an individual. Customized SMS messages can be tailored to individuals, which is important given that personally tailored messages are more effective for health behavior change than untailored messages.[20–24] This medium also allows for seamless (and quantifiable) interaction between the participant and the interventionist, so that participant engagement with the intervention can be monitored and compared to exposure. Communication with SMS may also be more cost effective than other telephone or print-based interventions.[19,25]

The potential of SMS may be particularly significant among population groups most likely to use mobile telephones as their primary means of communication. The highest level of mobile telephone use is among adolescents, younger adults, socioeconomically disadvantaged populations, less educated young adults, and people who rent or frequently change addresses.[26–28]

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Further, a high level of mobile telephone use is associated with lower levels of self-rated health,[28] higher BMI,[29] and engaging in health-compromising behaviors.[30] Therefore, SMS presents a prime delivery channel for health behavior change interventions because it has high penetration in populations of lower sociodemographic position and populations with poorer health.

The application of SMS for behavioral intervention is new. However, there are established research agendas for using SMS to remind patients of scheduled medical appointments,[31–35] coordinate medical staff,[25] deliver medical test results,[36–38] and monitor patient side effects following treatment.[39] This review analyzes the application of SMS for delivering health behavior change interventions to establish what can be learned from research conducted to date and make recommendations for future research.

Evidence Acquisition

An electronic database search of MEDLINE, PubMed, ERIC, Web of Science, and PsycINFO was conducted for studies published between January 1990 and March 2008. The search terms included: *mobile telephone* or *cell phone*, *SMS* or *text message*, *health*, *health intervention*, and *behavior*. The search was limited to English. For inclusion in the review, studies had to evaluate an intervention delivered primarily via SMS to change a health behavior in any population group and have at least a pre–post design, but they were not required to have a control group. Because SMS research is in its early stages and because of the commercial nature of the medium, a number of studies have been published in so-called gray literature, such as magazines, newspapers, commercially funded reports, and editorial columns.[19,40,41] This review was limited to critically appraising studies published in peer-reviewed scientific journals.

Eligible articles were independently reviewed; any disagreements in review outcomes were discussed until consensus was reached among the three authors. During the independent review process, the following information was extracted from the eligible articles and tabulated: study design, research setting, sample size, participant recruitment process, participant retention rate throughout trial, main outcome, measurement method of main outcome, validity and reliability of measure, duration of intervention, how SMS dialogue was initiated, level of SMS interactivity between participant and researcher, dose of SMS messages received by participant, additional intervention methods, impact evaluation of main outcome, and process evaluation of SMS intervention. This list of study characteristics was based on the requirements of the Quality of Reporting of Meta-Analyses (QUOROM) statement.[42]

Each study was rated on the level of SMS interactivity between researcher and participant. These ratings ranged from nil to high and were based on the number of weekly/monthly SMS messages each participant was prescribed to send to researchers. The interactivity ratings were nil (no opportunity for participants to use SMS with researchers); low (<monthly SMS interaction); moderate (<weekly but ≥monthly SMS interaction); or high (≥weekly SMS interaction). Intervention outcomes were assessed as having a positive or neutral impact on behavioral outcomes, and where there was an impact, the study design (between groups or within group) and significance of effects were also assessed. To be able to compare outcomes across studies, effect sizes were calculated for studies that had a control group and reported sufficient data. Effect sizes were calculated based on Cohen's formula[43] and were interpreted according to Cohen's guidelines of <0.2 for a small effect size, 0.5 for a medium effect size, and >0.8 for a large effect size.

Thirty-three studies[44–76] used SMS as a delivery channel for health behavior change interventions, and 14[63–76] met the inclusion criteria for this review (Table 1). Reasons for exclusion included lack of pre–post study design,[44–57] SMS being used as an adjunct but not as the main method of intervention delivery,[58–60] and publication in languages other than English.[61,62] Numerous studies reported the development of SMS programs to change health behaviors.[44,48,50–55] The large number of developmental studies published in the past year indicates that research into behavior change via SMS is increasing in volume. Of the14 studies reviewed, four used SMS for preventive health behavior change (e.g., smoking cessation)[63–66] and ten used SMS to support ongoing clinical care behavior change (e.g., diabetes self-management).[67–76]

Evidence Synthesis

Study Designs

Six[63,65,67,69,72,73] of the 14 studies were RCTs (Table 1). One study was a clustered randomized comparative trial[74]; one was a randomized crossover trial[70]; and the other six[64,66,68,71,75,76] were single group, pre–post design studies. Intervention length ranged from 6 weeks[64] to 1 year.[67,69] None of the 14 studies collected follow-up data beyond the end of the intervention period. Most studies used objective and validated measures to assess intervention outcomes. Three studies[63,64,76] used self-report measures, and two of these studies[64,76] reported the validity and reliability of the survey. Sample sizes varied greatly among studies, ranging from 10[71] to 1705.[63] Five[63,69,70,73,74] of the 14 studies reported conducting sample size calculations to determine statistical power. Four[64,65,69,76] of the 14 studies implemented theory-based interventions. Theories used included Social Cognitive Theory,[69] Behavioral Self-Regulation Theory,[64] Relapse Prevention,[76] and a combination of social psychological theories.[65]

Study Outcomes

Significant, positive behavioral changes were observed in eight studies,[63,65,66,68,70–72] and a further five studies[64,67,69,73,74] demonstrated positive behavioral trends but did not have sufficient statistical power to demonstrate significance (Table 1). One study[76] showed no positive changes in behavior. Most clinical care studies did not evaluate the behaviors that were targeted in the intervention (e.g., physical activity, nutrition) and

Table 1. Behavioral interventions using short-message service (SMS)

Study	Behavior	Research design and participants	Intervention	Intervention effects
Preventive health behavior studies				
Rodgers (2005)[63]	Smoking cessation	Design: RCT Sample: 1705 smokers Setting: New Zealand public Recruitment: proactive Participant retention: 74% Main outcome measure: self-report—specific measure not reported	SMS initiation: researcher Format: daily, individually tailored SMS messages sent providing personalized smoking cessation advice, support, and distraction Supplementary materials: nil Duration: 26 weeks Interactivity: high[a]	Impact outcomes: more participants reported not smoking in the intervention group (28%) compared to the control group (13%) at 6 weeks ($p<0.0001$) and 12 weeks (29% vs 19%) ($p<0.0001$). At 26 weeks, there was no significant difference between groups ($p=0.4$). Process outcomes: high participant attrition rates in study evaluation (74% remained at 26 weeks) Calculated effect size: insufficient data reported Outcome overview: between group, significant, positive change in smoking cessation
Obermayer (2004)[64]	Smoking cessation	Design: pre–post pilot study Sample: 46 smokers Setting: colleges from the Washington DC area Recruitment: proactive Participant retention: 67% Main outcome measure: self-report—7-Day Smoking Reconstruction Form	SMS initiation: researcher Format: daily, individually tailored SMS sent to support smoking cessation; frequency of SMS tapered around nominated quit date Supplementary materials: interactive website with feedback and social support facility Duration: 6 weeks Interactivity: high	Impact outcomes: At 6 weeks point, 43% of participants had made at least one 24-hour attempt to quit, and 22% had quit based on a 7-day criterion. Process outcomes: moderately high use and acceptance of program. Satisfaction with program differed between quitters (M=4.3) and nonquitters (M=3.2) ($p<0.01$). Calculated effect size: NA Outcome overview: within group, positive change
Hurling (2007)[65]	Physical activity	Design: RCT Sample: 77 healthy adults Setting: Bedfordshire, United Kingdom Recruitment: proactive Participant retention:100% Main outcome measure: objective measure—accelerometer	SMS initiation: researcher Format: tailored SMS offering solutions for perceived barriers and schedule reminders for weekly physical activity Supplementary materials: email and interactive website with feedback facility; wrist accelerometers for self-monitoring Duration: 9 weeks Interactivity: moderate	Impact outcomes: At 9 weeks, the intervention group showed significantly more moderate-intensity physical activity than the control group ($p=0.02$). Average increase in the intervention group for moderate-intensity physical activity was 2 hours, 18 minutes per week (accelerometer data). Process outcomes: SMS-specific outcomes not reported. Website use was high (M=2.9 log-ons per week). Calculated effect size: 0.82 (moderate-intensity physical activity) Outcome overview: between group, significant, positive change in physical activity
Joo (2007)[66]	Anti-obesity behavior modification	Design: pre–post design Sample: 927 healthy adults Setting: Korean public health clinics Recruitment: active Participant retention: 47% Main outcome measure: objective measure—scales and stadiometer	SMS initiation: researcher Format: weekly, untailored behavior change SMS for nutrition and exercise Supplementary materials: initial consult with dietitian, weekly brochures mailed to participants, free access to dumbbells and pedometers Duration: 12 weeks Interactivity: moderate	Impact outcomes: At 12 weeks, there were mean reductions in weight (1.6 kg, $p<0.001$), waist circumference (4.3 cm, $p<0.001$) and BMI (0.6 kg/m^2, $p<0.001$) in those who completed the 12-week program. Process outcomes: 71% of participants who completed the 12-week program thought it was effective. More than half of originally recruited participants did not complete the program. Calculated effect size: NA Outcome overview: within group, significant, positive change in weight reduction
Clinical care studies				
Vahatalo (2004)[67]	Diabetes self-management	Design: nonparallel, non-RCT Sample: 200 patients with Type 1 diabetes Setting: Diabetes Outpatient Clinic of Turku Health Centre, Finland Recruitment: active Participant retention:100% Main outcome measure: objective measure—HbA1c	SMS initiation: participant Format: participants sent plasma glucose test results and received tailored feedback from doctors. Supplementary materials: nil Duration: 12 months Interactivity: high- moderate	Impact outcomes: Glycemic control (HbA1c) did not change in intervention patients. A subsample of seven high users (>20 SMS/week) showed a decrease in HbA1c resulting in a 0.75% difference ($p=0.09$). Insulin dose of intervention patients increased significantly ($p<0.05$). Process outcomes: low patient interaction with SMS program Calculated effect size: 0.09 (HbA1c) 0.59 (HbA1c—high users) Outcome overview: between group, positive change in glycemic control

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Table 1. Behavioral interventions using short-message service (SMS) *(continued)*

Study	Behavior	Research design and participants	Intervention	Intervention effects
Kwon (2004)[68]	Diabetes self-management	Design: pre–post design Sample: 185 diabetic patients Setting: St. Mary's Hospital, Korea Recruitment: proactive Participant retention: 72% Main outcome measure: objective measure— HbA1c	SMS initiation: participant Format: participants sent blood glucose level, medication, number of meals, and exercise to doctor. Doctor sent individualized management SMS. Supplementary materials: interactive website with feedback facility. Consultations with dietitians were available to all participants. Duration: 3 months Interactivity: moderate	Impact outcomes: Mean HbA1c improved from 7.5 (±1.5) to 7.0 (±1.1) after the intervention (p=0.003). Lipid profiles also improved after the intervention. Process outcomes: participant compliance with SMS program was 72%. Satisfaction with SMS program was good. Calculated effect size: NA Outcome overview: within group, significant, positive change in HbA1c levels
Franklin (2006)[69]	Diabetes self-management	Design: RCT (three groups—control, CIT + SweetTalk, IIT + SweetTalk) Sample: 92 pediatric patients with Type 1 diabetes Setting: Scottish pediatric clinic Recruitment: proactive Participant retention: 98% Main outcome measure: objective measure— HbA1c	SMS initiation: researcher Format: SweetTalk program sent daily SMS providing personalized goal-specific prompts tailored to age, gender, and insulin regimen Supplementary materials: adapted insulin therapy for IIT group; goal-setting consult for CIT and IIT groups Duration: 12 months Interactivity: high	Impact outcomes: At 12 months, HbA1c did not change in the control or CIT groups, but did change in the IIT group (9.2±2.2%, CI=–1.9, 0.5, p<0.001). SweetTalk was associated with improvements in diabetes self-efficacy (p<0.003) and self-reported adherence to insulin regimen (p<0.042). Process outcomes: 72% felt SweetTalk helped manage their diabetes; 90% wanted to continue receiving SMS. Calculated effect size: 0.12 (HbA1c—CIT) 0.56 (HbA1c—IIT) Outcome overview: between group, positive change in HbA1c levels
Rami (2006)[70]	Diabetes self-management	Design: randomized crossover trial Sample: 36 adolescents with Type 1 diabetes Setting: diabetes clinic, Vienna, Austria Recruitment: proactive Participant retention:100% Main outcome measure: objective measure— HbA1c	SMS initiation: participant Format: participants sent daily blood glucose level, insulin doses and carbohydrate intake to monitoring center via a GPRS. Monitoring center sent 1 SMS per week with individualized or generic advice depending on need for treatment changes. Supplementary materials: paper diary of symptoms Duration: 3 months Interactivity: high	Impact outcomes: At 3 months, HbA1c significantly improved during the intervention phase for both groups (p<0.05). Process outcomes: There were technical problems with GPRS access for some participants. Most participants rated the program as useful and reported it took less than 1 minute to send their daily data via SMS. Calculated effect size: insufficient data reported Outcome overview: between group, significant, positive change in HbA1c levels
Kollman (2007)[71]	Diabetes self-management	Design: pre–post pilot study Sample: 10 patients with Type 1 diabetes Setting: diabetes clinic, Vienna, Austria Recruitment: proactive Participant retention:100% Main outcome measure: objective measure— HbA1c	SMS initiation: participant Format: participants sent daily blood glucose level, insulin doses, nutrition and physical activity data to monitoring center. Monitoring center generated individualized management SMS. Supplementary materials: interactive website with feedback facility Duration: 3 months Interactivity: high	Impact outcomes: At 3 months, there was a significant improvement in metabolic control (from 7.9% to 7.5%, p=0.02) and a nonsignificant improvement in average blood glucose level. Process outcomes: average of 14 parameters transmitted per day per participant Calculated effect size: NA Outcome overview: within group, significant, positive change in metabolic control
Kim (2007)[72]	Diabetes self-management	Design: RCT Sample: 60 patients with Type 2 diabetes Setting: endocrinology department of hospital, South Korea Recruitment: proactive Participant retention: 85% Main outcome measure: objective measure— HbA1c	SMS initiation: researcher Format: participants sent data about blood glucose level and insulin doses via a website. Staff sent weekly SMS messages with individualized management strategies. Supplementary materials: interactive website with feedback facility Duration: 12 weeks Interactivity: moderate	Impact outcomes: At 12 weeks, there was a significant difference in mean HbA1c decrease between the intervention group (1.15% decrease) and control group (0.07% decrease) (p=0.005). Process outcomes: not reported Calculated effect size: 0.75 (HbA1c) Outcome overview: between group, significant, positive change in HbA1c levels

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Table 1. *(continued)*

Study	Behavior	Research design and participants	Intervention	Intervention effects
Ostojic (2005)[73]	Asthma self-management	Design: RCT Sample: 16 asthma patients Setting: Croatian asthma clinic Recruitment: active Participant retention:100% Main outcome measure: objective measure— PEF	SMS Initiation: participant Format: Participants sent daily PEF measures to doctor and received reply of tips and education. Supplementary materials: consultation with medical staff, paper diary to record asthma symptoms, PEF Duration: 16 weeks Interactivity: moderate	Impact outcomes: At 16 weeks, no difference in PEF between groups at any time of the day (morning, afternoon, or evening). PEF variability was significantly reduced in intervention group (16.12%) compared to the control group (27.24%) (p= 0.049). Control group had significantly higher scores for coughs (p<0.05) and night symptoms (p<0.05) than intervention group. Process outcomes: Participant compliance with SMS transmission of PEF was 99%. Calculated effect size: 1.38 (PEF variability) Outcome overview: between group, positive change in PEF
Marquez (2004)[74]	Hypertension medication compliance	Design: randomized cluster comparative trial Sample: 104 patients with uncontrolled HTN Setting: 26 primary healthcare centers in Spain Recruitment: active Participant retention: 64% Main outcome measure: objective measure—count tablets and BP	SMS initiation: researcher Format: 2 SMS messages/week sent to participants about "good health," nutrition, medication reminders, and advice Supplementary materials: printed information about HTN Duration: 6 months Interactivity: nil	Impact outcomes: At 6 months, there were no significant differences in medication compliance between intervention (89.5%) and control groups (78.9%). There were no significant differences in blood pressure between groups at 6 months, but positive trend in intervention group. Process outcomes: none reported Calculated effect size: 0.50 (medication compliance) 0.09 (systolic BP); 0.22 (diastolic BP) Outcome overview: between group, positive change for BP control
Logan (2007)[75]	Hypertension self-management in diabetic patients	Design: Pre–post pilot study Sample: 33 patients with Type 2 diabetes and uncontrolled ambulatory BP Setting: 25 family physicians in Toronto and U.S. Recruitment: proactive Participant retention: 94% Main outcome measure: objective measure—BP	SMS initiation: participant Format: participants reported 2 consecutive BP readings twice daily for 2 days per week to local physician. Tailored recommendations were sent to patients. Supplementary materials: nil Duration: 4 months Interactivity: high	Impact outcomes: Both ambulatory BP (p<0.001) and 2-week average home BP (0=0.005) showed significant improvement following pilot study. Process outcomes: Number of BP reports was higher than requested of the patients but did drop over the 4 months (11.6 per week to 10.5 per week). Calculated effect size: NA Outcome overview: within group, significant, positive change in BP
Robinson (2006)[76]	Bulimia nervosa outpatient care	Design: pre–post design Sample: 21 patients diagnosed with bulimia nervosa Setting: London outpatient clinic Recruitment: proactive Participant retention: 43% Main outcome measure: self-report—Short Evaluation of Eating Disorders	SMS initiation: participant Format: Participants sent weekly updates of bulimic symptoms and received a tailored SMS offering support. Supplementary materials: nil Duration: 6 months Interactivity: low	Impact outcomes: no significant symptom change between pre- and post-intervention Process outcomes: Program use was low and attrition rates were high. Calculated effect size: NA Outcome overview: within group, no change

[a]High interactivity: ≥weekly SMS interaction; moderate interactivity: <weekly but ≥monthly SMS interaction; low interactivity: <monthly SMS interaction

BP, blood pressure; CIT, conventional insulin therapy; GPRS, General Packet Radio Service; HTN, hypertension; IIT, intensive insulin therapy; NA, not applicable for study design; PEF, peak expiratory flow

instead evaluated the health outcomes of the intervention (e.g., blood glucose levels, peak expiratory flow).

Of the eight studies[63,65,67,69,70,72–74] with a control group, six[65,67,69,72–74] reported sufficient data to enable effect sizes to be calculated. The range of effect sizes was 0.09[67] to 1.38[73] (Table 1). Based on Cohen's guidelines,[43] four of the six calculated effect sizes were classified as medium[72,74] or large effects.[65,73] The calculated effect sizes for the other two studies were classified as small (0.09[67] and 0.12[69]). However, both of these studies reported stronger findings for a subgroup of participants who either were more actively engaged in the SMS intervention[67] or received a more intensive complimentary treatment.[69] When effect sizes were calculated for these subgroups, both had effect sizes classified as medium (0.59[67] and 0.56[69]).

Process outcomes were poorly evaluated in most studies. Participant retention ranged from 43% to 100% (Table 1). There was great variability in participant compliance and acceptance of SMS programs across studies. One study reported that participants wanted to continue the SMS program after the trial had been completed.[69]

Specific SMS Characteristics

Mode of intervention initiation varied among studies. Twelve programs[65–76] were initiated by a face-to-face meeting with a health professional; the others used SMS to initiate the program and gain participant consent,[63] or an interactive website.[64] There were also differences in the initiation of SMS dialogue. In seven studies,[63–66,69,72,74] the researchers initiated the SMS dialogue and participants were able to respond (researcher-initiated technique). In the other seven studies,[67,68,70,71,73,75,76] participants initiated the SMS dialogue and then the researchers responded (participant-initiated technique). There were no clear differences in intervention outcomes based on SMS dialogue initiation. However, all the preventive health behavior studies used researcher-initiated techniques, and most of the tertiary-level interventions used participant-initiated techniques.

The frequency of SMS transmission reflected the expected frequency of the targeted behavior (e.g., smoking [5/day], physical activity [5/week]) for all but three studies.[66,72,74] Most of the interventions provided personally tailored SMS, except two studies[66,74] that used bulk, untailored SMS. Tailoring variables included participant's name or nickname, nominated support person's name, age, gender, behavioral history, behavioral preferences, behavioral goals, behavioral barriers, previous SMS responses, and medical status. The two studies[66,74] that used untailored SMS were in the top three for highest participant attrition.

Some studies supplemented SMS-delivered components with other intervention strategies or materials, such as interactive websites,[64,65,68,71,72] a paper diary to record symptoms,[70,73] consultation sessions with health professionals,[66,68,69,73] or printed materials.[66,74] Evaluation and reporting of the uptake and behavioral outcomes of these separate intervention strategies were poor.

Most studies allowed moderate to high SMS interaction between participants and researchers. One study[74] had no SMS interaction with participants. However, it is difficult to compare interaction levels across studies because some interventions offered other channels of interaction (e.g., websites or clinical visits).

Discussion

This review draws together the preliminary evidence of delivering health behavior change interventions via SMS. Most studies conducted to date have focused on clinical care interventions, using SMS as a reminder to increase adherence to treatment programs among sick individuals. Fewer studies have focused on promoting preventive health behaviors to healthy individuals through SMS. Of the 14 SMS reviewed interventions, 13 demonstrated positive behavior changes, although some studies were too statistically underpowered to show significant results.

It is important at this early stage of research to acknowledge the limited number of high-quality SMS intervention studies. The broad range of study designs used and the varying use of specific SMS characteristics in interventions limit the conclusions that can be drawn from this review but at the same time highlight the importance of improving the quality and rigor of future research in this area.

Future studies should use adequate sample sizes to provide sufficient statistical power for detecting hypothesized effects and should explicitly report the calculations performed to estimate power. Although it is recognized that some of the reviewed studies were pilot tests or feasibility studies, positive effects need to be rigorously evaluated in larger follow-up trials that test the efficacy of the intervention in more-representative samples. Assessment of the maintenance of behavioral effects after the intervention period is another important focus for future research. Future studies should also report on process measures associated with intervention delivery, such as number of sent SMS messages, number of SMS replies, how participants treated received SMS messages, and how stored SMS messages are treated. In some reviewed studies, it was also difficult to determine the relative impact of the SMS strategy because it was evaluated as an adjunct rather than as a comprehensive strategy. Future research should explore SMS as a primary means of intervention and report on appropriate process outcomes.

A strength of the current research is the use of objective and validated measures. This is important to ensure that the behavioral outcomes of SMS-delivered

interventions are accurately assessed, and this should be maintained in future research. A major evaluation problem in the current literature is the lack of assessment of intervention effects on targeted behaviors. Most clinical care studies failed to measure the behaviors targeted in the intervention, even though these outcomes are more proximal to intervention exposure than health outcomes. This has serious consequences as it prevents assessment of the intervention effects on the targeted behaviors that are hypothesized to cause subsequent health benefits.

Future studies should explicitly describe the theoretical constructs being targeted in interventions. This will assist further testing and development of behavior change theory as it applies to this new medium. The lack of theory-based interventions in this review may reflect the current focus of SMS interventions on clinical care rather than on preventive health behavior change.

Another area for future research is the variations in the use of specific SMS characteristics across interventions. Characteristics of SMS of interest in the current literature include mode of intervention initiation, initiation of SMS dialogue, tailoring of SMS content, and the opportunity for SMS interaction between participants and researchers. Because this research field is in the early stages of development and because of the study designs used, it is difficult to determine the impacts that these specific SMS characteristics may have on behavioral outcomes. However, it is important to acknowledge that these issues are specific to SMS interventions, and if this field of research is to progress, the importance of these SMS characteristics needs to be explored further.

Intervention initiation methods differed between clinical care interventions and preventive health behavior interventions. Clinical care interventions involve patients already engaged in the health system because of illness or disease and thus focus on better managing their treatment. As such, clinical care interventions are often initiated face-to-face because patients are consulting with health professionals. In contrast, preventive health behavior interventions require delivery channels that can reach mass populations of healthy individuals who may not be engaged with health professionals. Two of the preventive health behavior studies in this review demonstrated methods of intervention initiation that could be feasible for population-wide dissemination—a registration website[64] and registration SMS.[63] In both cases, these initiation methods provided sufficient communication to allow for informed participant consent, personal information for tailoring SMS, and instructions for how to use the program.

Initiation of the SMS dialogue also differed between clinical care and preventive health behavior interventions. All the preventive health behavior interventions in this review used researcher-initiated SMS dialogue, whereas the majority of the clinical care interventions used participant-initiated techniques. Participants in preventive health behavior interventions may not be motivated to initiate dialogue because they are healthy, unlike participants in need of clinical care intervention who are accustomed to regularly reporting to health professionals about their health status. Initiation methods may play an important role in participants' perceptions of personal invasion and behavioral control, which may affect behavioral outcomes. Therefore, the SMS initiation method may be an important intervention element to explore further in terms of relative behavior change outcomes.

It is well established that tailored health messages are more engaging and effective at changing behavior than untailored, bulk messages.[21–24] All but two studies in this review used tailored SMS. The two studies[66,74] using untailored SMS targeted a wide range of behavioral changes (e.g., physical activity, nutrition, medication compliance, smoking, alcohol consumption) and were among the studies with the highest participant attrition. This finding may support the notion that untailored health messages are less engaging for participants. Because participant engagement and retention are critical factors in successful behavior change research, it is important to further investigate the impact of tailoring content in SMS research.

Interactivity and responsiveness to participants' needs, a potential feature of SMS-delivered interventions, may improve the outcomes of behavior change interventions.[11] One reviewed study[74] did not allow interaction with participants, and that study had poor participant retention, which may have been associated with poor participant engagement. Interactivity of interventions was poorly reported and was often difficult to quantify because of the potential influence of other forms of interaction with participants (e.g., websites). The effect of interactivity of SMS-delivered interventions needs to be explored further to determine the optimal level of interaction for successful behavior change.

Although first-generation studies have demonstrated the potential of delivering health behavior change interventions via SMS, there is still much to be learned about optimizing and enhancing this intervention channel. Research on the effects of specific SMS characteristics is now required to better understand the potential of this new medium. Consideration of the methodologic issues highlighted in this review is needed to improve the quality of research in this field. These issues need to be considered promptly to allow scientific knowledge to develop at a pace in keeping with the rapid advancement of SMS technologic capabilities and reach.

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