A Health Belief Messaging Framework and a Randomized Controlled Trial of an SMS-based Intervention for Cancer Patient Outcomes

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Abstract

Cancer is on the rise, and the effectiveness of oral anticancer agent (OA) treatment depends heavily on adherence to the prescribed regimen. Adherence, however, is a significant problem with 42% of patients missing OA doses due to poor memory recall, lack of knowledge, incompatible beliefs, and depressive symptoms. Short Message Service (SMS) messaging may provide a feasible, low-cost approach to promote adherence and lead to improved patient outcomes when compared to other strategies that have had disappointing results. Through our Health Belief Messaging Framework, we propose that SMS message development may be informed by adherence antecedents, namely Perceived Benefits, Perceived Barriers, and Cues to Action. Through a 2-group, 80-patient, randomized controlled trial of a tailored, daily SMS intervention for 21 days, an improved adherence trend, and a statistically significant effect on the number of symptoms and physical function was observed; patient satisfaction with the SMS messaging was also reported.

1. Introduction

Cancer is on the rise, with more than 14.1 million new cases diagnosed each year, a rate that is expected to reach 24 million per year by 2035 [1,2]. More than 50 targeted oral anti-cancer agents (OAs) are available on the market, and within the next few years, 25% of cancer treatment is expected to be in pill form [3,4]. Cancer treatment effectiveness for patients taking OAs depends heavily on adherence to the regimen [4,5]. Adherence, however, is often challenging as it may involve taking medication twice a day, cycle on-and-off, or involve multiple medications. In addition to complex dosing [6,7], poor memory recall – a common issue among older cancer patients, who make up the majority of those diagnosed [8,9] – negatively affects adherence. Also, adherence has been found to be negatively affected by knowledge, beliefs, and depressive symptoms [10]. Studies suggest that medication adherence is a significant problem with 42% of patients missing OA doses [11] and 10% of OA patients not refilling their prescriptions [12]. Research suggests that adherence to OAs is a significant problem that may impact treatment success vis-à-vis improving a patient’s symptoms and physical function [11, 13-16].

Mobile health (mHealth) technology, such as Short Message Service (SMS) messaging on mobile phones to promote behavior change, may offer an effective platform to encapsulate and address the aforementioned barriers. SMS message development may be informed by the relevant antecedents to adherence, namely dosing recall, informational support (i.e. addressing insufficient knowledge and incorrect beliefs), and emotional support (i.e. supporting depressive symptoms), so as to lead to improved patient outcomes.
While lacking in novelty, mobile phones are the most commonly used form of technology worldwide [17-19]. In addition, SMS has significantly greater penetration than other digital communication technologies, such as mobile applications or tablets [20]. Furthermore, this technology’s reach and, by extension, feasibility among the primary population, i.e. cancer patients over the age of 50, who make up ~95% of the target users [21], far exceeds that of alternate technologies such as mobile apps, as SMS messaging is the primary non-voice mobile phone function used [22]. Early research findings speak to the potential of SMS in motivating behavioral change [23-27]. According to the Health Belief Model, attitudes and beliefs of individuals can explain health behavior. Important constructs of the model are perceived benefits and barriers about the health care regimen. Perceived benefits consist of the believed effectiveness of strategies designed to reduce the threat of illness; perceived barriers are the potential negative consequences that may result from taking particular health actions [28].

SMS could provide a realistic, low-cost approach to promote OA medication adherence and behavior change when compared to other strategies that have had disappointing results [29-31], and in turn improve a patient’s quality of life. A key success factor in achieving the desired patient outcomes is that patients believe that it is possible to obtain control over the disease [10]. The aim of the present study was to, therefore, determine whether an SMS-based messaging intervention that aims to inform, motivate, and remind cancer patients on an OA prescribed regimen would have an effect on both the number of symptoms and physical function over the course of the intervention.

Hence, this research is guided by the following four questions: what is the effect of an SMS-based OA regimen intervention on (i) patient adherence with a prescribed medication plan, (ii) the number of symptoms patients experience, (iii) the level of physical function patients achieve, and (iv) the post-treatment level of patient satisfaction with an SMS-based OA regimen intervention.

2. A Health Belief Messaging Framework

Prior research has explored the efficacy of SMS-based interventions in various healthcare related areas, including reminding patients of scheduled medical appointments [32-36], coordinating medical staff [37], delivering medical test results [38-41], and monitoring patient side effects following treatment [41]. However, the utilization of SMS in behavioral interventions has been under-investigated, and among this limited scholarly base, methodologic issues were also identified, such as a lack in the following areas: use of control groups in the research design, a priori sample size and power determinations, reporting of validity and reliability of survey data analysis, and use of theory in designing the interventions [42]. This study attempted to avoid replicating these methodologic issues, and our grounding and approach are presented next.

With respect to theory, this research is rooted in the Health Belief Model (HBM). HBM, a widely used theory in health behavior research, was developed by a group of U.S. Public Health service social psychologists, namely Hochbaum, Rosenstock, and Kegels, between 1950 and 1960 [43]. HBM aimed to explain and predict health-related behaviors, particularly to the update of health services (in the case of Hochbaum et al., use of a free tuberculosis health screening program). The model suggests that individual’s beliefs about health problems, the perceived benefits of action minus the perceived barriers to action, and self-efficacy explain the level of engagement in health-promoting behavior; however, a stimulus – or cue to action – must be provided to trigger the desired health-promoting behavior [43].

According to HBM, perceived benefits refers to an individual’s – subjective – belief, not objective facts, that an available action is effective in reducing the disease threat to which the individual feels subjected. At the same time, perceived barriers, such as perceptions regarding an action being unpleasant, expensive, painful, or upsetting, are likely to arouse conflicting motives of avoidance. Psychological barriers were later considered through the addition of self-efficacy to HBM by Rosenstock and others in 1988 [44]. Self-efficacy represents a personal judgment as to whether or not a person believes that they have the necessary background to achieve a desired outcome [45]. Specifically, coping efficacy embodies the belief and understanding that a person’s efforts to achieve individual goals were successful in a particular situation. Strategy itself is not enough [46]. Cancer patients must have the confidence and understanding that they have been given the knowledge and support needed to reach remission. However, depression associated with pain and treatment can contribute to low self-esteem, which decreases a cancer patient’s self-efficacy in coping with the pain [45]. Creating a cycle of emotional distress with the patient having the inability to emerge, poor mental health is associated with maladaptive coping strategies [46]. Thus, researchers and healthcare practitioners are faced with the challenge of identifying adaptive coping strategies and conceptual appropriateness that boost coping capacities and alleviate depressive symptoms [46].
The last factor in HBM, *cues to action*, refers to triggers to an appropriate health behavior when necessary. Such triggers may be internal (e.g., perception of bodily states) or external (e.g., receiving a reminder message by telephone from the oncologist).

A dimension of the abovementioned cues to action speaks to a subtle timing dimension (i.e., “when necessary”). HBM, however, does not explicitly incorporate this important factor, even though it has been well established that tailored health messages— which would include the time of message broadcast/dissemination and receipt—are more engaging and effective at changing behavior than untailored, bulk messages [47-50]. Hence, any health behavior messaging intervention needs to be informed by timing dimensions such as the specific time of exposure to a message in a day, as well as the level of repeated exposures (i.e. frequency) to such messages.

Lastly, any behavior intervention messaging plan would be well served to be informed by McLuhan’s work [51]. In his pioneering study, McLuhan proposed that the media, not the content that they carry, should be the focus of the study. In an era where electronic communication is fast displacing traditional forms (e.g., print), a number of options such as e-mail, SMS, and social media-based messaging are available to healthcare practitioners and patients alike. Selection of the medium, then, is an important consideration in itself, as the inherent features and affordances, from available real estate to synchronicity, are likely to influence the impact of the messaging content and overall plan.

Assembling the above considerations for a comprehensive, theoretically-informed, behavior intervention electronic messaging plan, three key factors emerge: where (i.e., which medium/a), what (i.e., what content), and when (i.e., how often and at what time(s)) should the intervention messaging be delivered. In accordance, we propose a Health Belief Messaging framework that can inform future electronic messaging behavior interventions (see Figure 1).

2.1. Proposed Hypotheses

Building off the Health Belief Messaging Framework, shown in Figure 1, and in line with the literature review provided in the previous section, the following three hypotheses are proposed and will be investigated in this study:

- **H1**: Patients receiving a tailored, SMS-based messaging intervention grounded in the Health Belief Messaging Framework in addition to usual care will have a significantly higher level of adherence than patients who receive usual care alone.

- **H2**: Patients receiving a tailored, SMS-based messaging intervention grounded in the Health Belief Messaging Framework in addition to usual care will experience a significantly lower number of symptoms than patients who receive usual care alone.

- **H3**: Patients receiving a tailored, SMS-based messaging intervention grounded in the Health Belief Messaging Framework in addition to usual care will have a significantly higher level of physical function than patients who receive usual care alone.

In addition, the following proposition is put forth:

- **P1**: Patients will be satisfied with an SMS-based behavior intervention to support their OA regimen.

3. Methods

3.1. Research Design

A longitudinal 2-group randomized controlled trial (RCT) was conducted to test our hypotheses and proposition. The intervention group received SMS plus usual care, and the control group received usual care.

3.2. Participants

A U.S.-based, national specialty pharmacy and two community cancer centers in the Midwest were used in recruiting participants between July 2013 and January 2014. A convenience sample of 80 cancer patients enrolled in the study. Patients were screened for English proficiency, age (21 or older), prescription of OA, mobile phone ownership, and ability and willingness to write/send and read/receive SMS. Exclusion criteria included cognitive impairment that limited the ability to understand and answer questions were excluded. An initial sample of 264 patients were recruited and screened, of which 119 were deemed...
ineligible for this study based on the abovementioned criteria. Out of the 145 patients eligible for this study, 62 chose not to enroll, resulting in 83 consented patients. Of those, 3 patients did not enroll, yielding our final sample of 80 participants who were randomized in either the control or the experimental group.

Table 1 reports on the participant demographics, along with the test results indicating the non-significance in differences between the control and experimental groups.

### Table 1. Participant Demographics

<table>
<thead>
<tr>
<th></th>
<th>All n=80</th>
<th>Control Group n=40</th>
<th>SMS Group n=40</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>58.5 ±10.7</td>
<td>58.4 ±10.2</td>
<td>58.6 ±11.3</td>
<td>0.96</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>32 (40)</td>
<td>15 (37.5)</td>
<td>17 (42.5)</td>
<td>-</td>
</tr>
<tr>
<td>Female</td>
<td>48 (60)</td>
<td>25 (62.5)</td>
<td>23 (57.5)</td>
<td>-</td>
</tr>
<tr>
<td><strong>Race</strong>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>67 (83.8)</td>
<td>36 (90)</td>
<td>31 (77.5)</td>
<td>0.54</td>
</tr>
<tr>
<td>Black</td>
<td>9 (11.3)</td>
<td>3 (7.5)</td>
<td>6 (15)</td>
<td>0.32</td>
</tr>
<tr>
<td>Unknown</td>
<td>3 (3.8)</td>
<td>1 (2.5)</td>
<td>2 (5)</td>
<td>0.56</td>
</tr>
<tr>
<td>N/A</td>
<td>1 (1.3)</td>
<td>0 (0)</td>
<td>1 (2.5)</td>
<td>0.00</td>
</tr>
<tr>
<td><strong>Ethnicity</strong></td>
<td></td>
<td></td>
<td></td>
<td>0.56</td>
</tr>
<tr>
<td>Hispanic/Latino</td>
<td>6 (7.5)</td>
<td>1 (2.5)</td>
<td>5 (12.5)</td>
<td>-</td>
</tr>
<tr>
<td>Not Hispanic/Latino</td>
<td>73 (91.3)</td>
<td>39 (97.5)</td>
<td>34 (85)</td>
<td>-</td>
</tr>
<tr>
<td>N/A</td>
<td>1 (1.3)</td>
<td>0 (0)</td>
<td>1 (2.5)</td>
<td>-</td>
</tr>
<tr>
<td><strong>Education</strong>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High School or less</td>
<td>22 (27.5)</td>
<td>10 (25)</td>
<td>12 (30)</td>
<td>0.67</td>
</tr>
<tr>
<td>Some College/Bachelor’s</td>
<td>43 (53.8)</td>
<td>21 (52.5)</td>
<td>22 (55)</td>
<td>0.88</td>
</tr>
<tr>
<td>Graduate degree</td>
<td>15 (18.8)</td>
<td>9 (22.5)</td>
<td>6 (15)</td>
<td>0.44</td>
</tr>
<tr>
<td><strong>Employment</strong></td>
<td></td>
<td></td>
<td></td>
<td>0.89</td>
</tr>
<tr>
<td>Employed</td>
<td>19 (23.8)</td>
<td>10</td>
<td>9 (22.5)</td>
<td>-</td>
</tr>
<tr>
<td>Not Employed</td>
<td>61 (76.3)</td>
<td>30</td>
<td>31 (77.5)</td>
<td>-</td>
</tr>
</tbody>
</table>

Data are presented as mean ± SD, n (%).

*Due to small counts, comparisons of proportions for each category were carried out using Fisher’s exact tests.

Recruiters approached eligible patients (community cancer centers face-to-face and specialty pharmacy by phone or letter), presented the study, and obtained consent for those willing to participate. Trained interviewers at the authors’ university collected baseline, satisfaction, and exit data by phone using the web-based PROMIS Assessment Center Data Collection Platform [52]. Baseline interviews (week 1) were conducted; and once completed, patients were randomly assigned to the control or intervention group using a minimization algorithm that balanced the groups on age and recruitment location. Interviewers and recruiters were blinded to group assignment. Patients in both groups used an Automated Voice Responses (AVR) system to receive weekly assessments of symptom severity of 19 commonly experienced symptoms (i.e. nausea, pain, numbness and tingling, disturbed sleep, fatigue, anxiety, diarrhea, shortness of breath, lack of appetite, fever, pain in hands or feet, constipation, mouth sores, skin rash or sores, headache, swelling in hands or feet, cough, peeling, redness, weakness, joint or muscle pain). AVRs were introduced by Anastasia and Blevins [53] for symptom management, and are now commonly used to assess symptoms. Satisfaction surveys were conducted for the intervention group one week after completion of the intervention. Exit interviews were conducted at the end of the study. Patients were mailed (intervention group at baseline; control group at exit, so that they may also benefit from the resource upon completion of the study) a Medication and Symptom Management Toolkit, a bound notebook of evidence-based information that covers what is needed to manage common side effects from the cancer or cancer treatment. The Toolkit has been used as a tool to promote symptom management in several studies and is well accepted by patients [7, 54, 55].

### 3.4. Intervention Protocol: SMS Platform and Messages

A third party, Electronic Medical Office Logistics LLC (EMOL), handled the automated delivery of scheduled SMS messages to be sent, collection of SMS messages received by the participants, and storing of all log data. The research team created an SMS broadcast plan through the creation of a database that included the patient name, mobile phone number, OA drug brand name, regimen schedule, and delivery time for SMS; EMOL, then, handled the tailored and individualized (e.g. inclusion of drug name in sent message) SMS delivery. To ensure that SMS messages were not pushed on a day when patients were not on the OA, the research team confirmed each patient’s regimen schedule with both the recruiter and the
patient; and patients were asked to inform the study team of dose modifications (reductions, interruptions, or stoppage). Patients were instructed to password-protect their mobile phone to ensure privacy, but also to prevent erroneous replies to the intervention messages by parties other than the patients themselves.

Given the limited real estate afforded by the SMS platform, i.e. 160 characters, the research team engaged in a theoretically-informed design of SMS messages through the application of the Health Belief Messaging Framework (see Figure 1). This resulted in the development of a balanced messaging plan consisting of eight SMS messages that were used on a rotating basis; specifically, there were two (2) messages for each of the following categories: (i) Reminder + Cue to Action, (ii) Reminder + Cue to Action + Benefits, (iii) Reminder + Cue to Action + Barriers, and (iv) Reminder + Cue to Action + Benefits + Barriers. Through this balanced messaging plan, no single factor (e.g. Benefits) was favored in the intervention’s messaging plan, as there is no prior evidence to suggest otherwise.

In addition, one study welcome and one study end message were developed. The messages are provided in Appendix 7.1.

After randomization, those in the intervention group were sent a test SMS to ensure the correct mobile phone number had been entered in the database and that the participant could receive this message. The intervention SMS messages were delivered at the each individual patient’s time the OAs were prescribed to be taken for 21-days. In each SMS sent, patients were instructed to report by replying if the OA was taken.

In addition, an AVR symptom management assessment message was sent once a week.

### 3.5. Measures

Data were collected by recruiters on the enrollment form via patient self-report and medical record review. These data included OA type and regimen and concurrent intravenous chemotherapy treatment. Interviewers collected data via phone interviews at intake and exit.

Demographic data regarding age, gender, race, ethnicity, education, and employment were collected via self-report. Cognition was assessed using the Cimprich Attentional Function Inventory for cognition assessment for cancer patients, which is scored from not at all well to extremely well [56]. Depression was assessed using the 8-question PROMIS 8a short-form; and physical function was assessed using the 6a short-form; with an alpha coefficient above .85 [57]. Additional data were obtained from AVR and SMS. OA adherence was measured by patient report of whether they took OA pills as directed in the past 7-days during weekly AVR and exit interview; and patients in the intervention group returned SMS if the OAs were taken. The number of symptoms experienced and physical function were assessed during the intake interview, weekly AVR contacts (for symptoms only), and exit interview. Satisfaction with SMS was measured using a tool previously developed by the research team and administered in several previous studies; with satisfaction deemed high for scores exceeding 80% [7,55]. The satisfaction survey was administered by an interviewer over the phone.

### 4. Analysis

SAS 9.4 was used for the data analysis. Descriptive statistics were computed for variables of interest (e.g. those in Table 1), to include frequency distributions, measures of central tendency, skewness, and variability. Preliminary analysis was conducted to check the intake equivalence of groups created by the randomization. Outcome measures at intake and covariates were compared between groups using chi-square, Fisher’s exact or t-tests.

To answer Research Question 1 (i.e. what is the effect of SMS on adherence, and given the very small sample size that would preclude meaningful tests of significance week by week) descriptive statistics were used to speak to the overall adherence trend. To answer Research Questions 2 and 3 (i.e. the efficacy of SMS on symptom severity and physical function respectively) general linear modeling was used. The covariates included study group and outcome value at baseline. Due to the exploratory nature of the study, in addition to statistical significance, effect sizes were estimated to gauge clinical significance and inform planning of a larger study. Effect sizes were computed as Cohen’s d, the difference between group means expressed in standard deviation units. We computed the adjusted effect sizes from the linear models as differences between least square (LS) means divided by the adjusted standard deviation (square root of the mean square error) [58,59]. To answer Research Question 4 (i.e. what is the post-treatment level of patient satisfaction with the SMS messaging) frequency distributions were used.

### 5. Results

In regards to Research Question 1 (i.e. the effect of SMS messaging on adherence with a prescribed medication plan) the intervention group had an average level of adherence of 95.29% compared to the control group’s level of adherence of 92.68%; significance
cannot be reported given the limited sample sizes involved, but an overall higher level of adherence in the experimental group relative to the control group was observed. A summary of weekly self-reported OA adherence levels for each group, along with study averages, is presented in Table 2 below.

Table 2. Summary of Weekly and Study Averages of self-reported OA adherence

<table>
<thead>
<tr>
<th></th>
<th>Control Group N (%)</th>
<th>SMS Group N (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Week 1</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adherent</td>
<td>27 (93)</td>
<td>31 (97)</td>
</tr>
<tr>
<td>Non-adherent</td>
<td>2 (7)</td>
<td>1 (3)</td>
</tr>
<tr>
<td>Dose change</td>
<td>11 (N/A)</td>
<td>8 (N/A)</td>
</tr>
<tr>
<td><strong>Week 2</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adherent</td>
<td>25 (89)</td>
<td>26 (93)</td>
</tr>
<tr>
<td>Non-adherent</td>
<td>3 (11)</td>
<td>2 (7)</td>
</tr>
<tr>
<td>Dose change</td>
<td>12 (N/A)</td>
<td>12 (N/A)</td>
</tr>
<tr>
<td><strong>Week 3</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adherent</td>
<td>24 (96)</td>
<td>24 (96)</td>
</tr>
<tr>
<td>Non-adherent</td>
<td>1 (4)</td>
<td>1 (4)</td>
</tr>
<tr>
<td>Dose change</td>
<td>15 (N/A)</td>
<td>15 (N/A)</td>
</tr>
<tr>
<td><strong>Study Averages</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adherent</td>
<td>76/82 (92.68)</td>
<td>81/85 (95.29)</td>
</tr>
<tr>
<td>Non-adherent</td>
<td>6/82 (7.32)</td>
<td>4/85 (4.71)</td>
</tr>
<tr>
<td>Dose Change</td>
<td>38</td>
<td>35</td>
</tr>
</tbody>
</table>

Data presented as “LS mean (Standard Error)”

* Denotes small effect
** Denotes medium effect

With respect to Research Question 2 (i.e. what is the efficacy of SMS messaging on mitigating experienced symptoms, of the 19 commonly experienced symptoms from side effects assessed) the intervention group had a total number of 3.86 (SE 0.05) while the control group had 5.26 (SE 0.46); a significant post intervention difference with a moderate effect size (ES 0.50).

With respect to Research Question 3 (i.e. what is the efficacy of SMS messaging on improving physical function) the latter was found to be better in the intervention group (47.6 [SE1.2] to 44.9 [SE 1.1]; ES 0.40) with a moderate effect size. Results for the efficacy of the SMS messaging intervention on these two dependent variables is reported in Table 3 below.

Table 3. Post-intervention tests for effects significance

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Control Group</th>
<th>SMS Group</th>
<th>p-value</th>
<th>Effect Size</th>
</tr>
</thead>
<tbody>
<tr>
<td># of symptoms experienced</td>
<td>5.26 (0.45)</td>
<td>3.86 (0.50)</td>
<td>0.04</td>
<td>0.50**</td>
</tr>
<tr>
<td>PROMIS physical</td>
<td>44.87 (1.09)</td>
<td>47.56 (1.21)</td>
<td>0.11</td>
<td>0.40*</td>
</tr>
</tbody>
</table>

With respect to Research Question 4 (i.e. patient satisfaction with the SMS messaging intervention) the following results were obtained: 86% (n=30) read the SMS all of the time, 11% did so most of the time (n=4), and 3% did so some of the time (n=1). The majority of patients indicated they were either highly satisfied (40%; n=14) or very much satisfied (46%; n=16), with the remaining reporting they were either somewhat satisfied (11%; n=4) or not at all satisfied (3%, n=1) with the intervention. Ninety-four percent (n=34) found the SMS messaging intervention mostly helpful, while 3% (n=1) felt the SMS was a burden, and 3% (n=1) found it to be both a burden and helpful. Of the 36 patients in this sample, 97% (n=35) of patients were likely to recommend SMS for symptom management to family or friends; and 86% (n=31) were likely to recommend to SMS to their oncologist (see Figure 2).

Figure 2. Intention to recommend SMS messaging for symptom management

In addition, 80% (n=28) reported the SMS helped them take their OA on time, while only 3% (n=1) reported it did not help, and the remaining 17% (n=6) reported neither. Lastly, 86% (n=32) would recommend SMS as a way to help patients remember to take OAs, while 14% (n=5) would not.

6. Discussion

With cancer being on the rise and the effectiveness of OA treatment being heavily dependent on regimen adherence, investigating and informing efficient and effective methods for improving adherence is one of the most pressing issues in behavioral intervention research. In order to address this urgent issue, this study proposed a Health Belief Messaging framework to inform the implementation of a mobile phone-
enabled, SMS message development around three sets of adherence antecedents, namely Perceived Benefits, Perceived Barriers, and Cues to Action. Furthermore, and through a 2-group, 80-patient, randomized controlled trial of a tailored\textsuperscript{4}, daily SMS intervention for 21 days, this study empirically validated the Health Belief Messaging Framework and revealed a statistically significant effect on patient outcomes, including the reduction in the number of symptoms and the improvement in physical function patients experienced. In addition, a trend of improved adherence and overall patient satisfaction were also observed.

Based on these findings, this paper offers two important contributions to behavioral intervention research in the context of health. First, although previous SMS-based research has shown the potential of SMS for behavioral intervention, the majority of studies suffered from various methodological issues [42], most of which were addressed in this study. Hence, this multitrait-multimethod clinical trial—with high reliability and validity—increases our confidence in the effectiveness of SMS for health interventions.

Second, the Health Belief Messaging Framework proposed in this paper, offers a reliable and useful guide to health researchers and practitioners in designing effective SMS messages for supporting prescribed regimen adherence.

6.1. Challenges and Future Research

Despite the contributions of the Health Belief Messaging Framework developed and tested in this study, there are four limitations that can inform future research on behavioral intervention, in general, and SMS interventions, in particular. First, although the effects on adherence were not statistically significant—potentially as a result of the relative small sample size—the overall positive trend for adherence during the 21-days of SMS messaging illustrates, at least, a short-term effect of SMS interventions on health behaviors. Although previous studies have revealed similar short-lasting results associated with SMS interventions, this study—through repeated (i.e., weekly) and multi-method results—offers more reliable insights into this temporal nature (i.e. duration of effect) of technology-based interventions. Hence, future research should further extend the duration of the technology-based interventions so as to empirically validate the potential necessity of persistent rather than short-term interventions.

Second, although our messaging was informed by the three sets of adherence antecedents that underpin the Health Belief Model, this study developed a balanced messaging plan where an equal number of messages were developed for each set of antecedents. Future research could build upon and extend the Health Belief Messaging Framework proposed in this paper in two ways. On the one hand, by drawing on additional theoretical models beyond the Health Belief Model, additional antecedents may be identified for which appropriate messages can be developed. On the other hand, empirical research should explore the behavioral outcomes associated with each set of antecedents—Perceived Benefits, Perceived Barriers, and Cues to Action—in order to develop a weighted messaging plan. For instance, if Perceived Barriers are found to be the most significant antecedent to adherence, a messaging plan could increase the number of messages aimed at overcoming perceived barriers while reducing the frequency of messages based on the remaining two antecedents.

Third, and related, although this study presents one of the first attempts at tailoring SMS messages by adjusting the timing of the cue to action and brand name of the OA medication for each individual patient, additional tailoring approaches need to be investigated and may prove more effective. Additional tailoring opportunities may include personalizing messages based on a-priori self-efficacy measures reported by the patient; frequency and types of messages received based on personal needs; or even selection of the channel (e.g., SMS, email, or social media) through which messages are received. Furthermore, rather than sending messages out based on a pre-determined schedule tailored to the patient’s adherence regimen, future research could also explore possibilities for patient’s to initiate (additional) interaction and its effect on adherence, reported symptoms, physical function, and satisfaction.

Fourth, while the Health Belief Messaging Framework is an important step forward in effectively supporting chronically ill patients, more works remains in exploring the impact that context of use may have on the effectiveness of related technology interventions. Doing so would warrant considering, proposing, and testing how contextual characteristics, including user/patient demographics and psychographics, disease specifics such as type and stage of cancer, and environmental specifics – both socioeconomic and physical, such as collocation of others, may affect the design of messages framed around perceived benefits, perceived barriers, and offering cues to action.

7. Footnotes
Tailoring of the SMS message delivery was accomplished according to the prescribed medication regimen, i.e. either once or twice per day.

8. Acknowledgement

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9. Appendices

9.1 SMS Intervention Messages

The following messages were used at the time OA was to be taken by the patients in the intervention group only, and rotated over the 21-days. All messages included a "Reminder" and a "Cue to Action":

SMS #0start – (Welcome) "Welcome to the study. For 21 days, you will receive text message reminders to take your cancer pills and use the toolkit. Reply "OK" after reading this message."

SMS #1 – (Cue to Action only) "Please take your xxx* now. Reply "Taken" when you've taken it."

SMS #2 – (Cue to Action + Benefits) "A reminder to take your xxx* now. Taking your pill on time is critical in managing your cancer. Reply "Taken" when you've taken it."

SMS #3 – (Cue to Action + Barriers) "This is a reminder that it's time to take your XXX*. Find the routine that makes it easiest for you. Reply "Taken" when you've taken it."

SMS #4 – (Cue to Action + Benefits + Barriers) "It's time to take your xxx*. Remember, taking your pill is easy and important in managing your cancer. Reply "Taken" when you've taken it."

SMS #5 – (Cue to Action only) "Please take your xxx* now. Reply "Taken" when you've taken it."

SMS #6 – (Cue to Action + Benefits) "A reminder to take your xxx* now. Doing so is an important step in managing your cancer. Reply "Taken" when you've taken it."

SMS #7 – (Cue to Action + Barriers) "It's time to take your xxx*. You've done great all week in taking it on time, so keep at it! Reply "Taken" when you've taken it."

SMS #8 – (Cue to Action + Benefits + Barriers) "Remember to use the Symptom Management Toolkit as needed. It is easy to use and can help you manage your symptoms at home."

SMS #0end – (End of Study) "Our study is over. Remember: it is both easy and important to take your cancer pills as prescribed. If you have questions call your clinician. Thank you."

*xxx is the brand name of the OA medication to be taken by patient

10. References


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