Title: Predicting attrition in a text-based nutrition education program: A survival analysis of Text2BHealthy

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Abstract

Background: Text-based programs have been shown to effectively address a wide variety of health issues. While little research examines SMS program characteristics that predict participant retention and attrition, features of text message programs, such as message content and the participants’ context, may have an impact. The impact of stop messages—messages with instructions for how to drop out of a text message program—may be particularly important to investigate.

Objective: The objectives of this study are to describe attrition from Text2BHealthy, a text-based nutrition and physical activity promotion program for parents of low-income elementary school children and to determine the impact of message content and number of stop messages received on attrition.

Methods: Using data from 972 parents enrolled in Text2BHealthy, we created Kaplan Meier curves to estimate differences in program duration for different message types. Covariates, including rurality and number of stop messages received, were included.

Results: Retention rates by school ranged from 74.1% to 95.0%, with an average retention rate of 85.7 percent. Program duration ranged from seven to 282 days, with a median program duration of 233 days and an average program duration of 211.7 days. The majority of participants who dropped out of the program did so after 90 days. Receiving a stop message increased the probability of attrition compared to receiving other message types. Furthermore, each additional stop message received increased the probability of attrition. The degree of rurality also had a significant effect on the probability of attrition, with metropolitan county participants more likely to drop out of the program than rural county participants. The interaction between message type and total number of stop messages received had a significant effect on attrition, with the effect of the number of stop messages received dependent on the message type.

Conclusions: This study demonstrates the potential of text message programs to retain participants over time. Further, this study suggests that the probability of attrition increases substantially when participants receive messages with instructions for dropping out of the program. Program planners should carefully consider the impact of stop messages and other program content and characteristics on program retention. Additional research is needed to identify participant, programmatic, and contextual predictors of program duration and to explicate the relationship between program duration and program efficacy.

Keywords: text messaging; retention; attrition; nutrition; food assistance; parents; survival analysis
Predicting attrition in a text-based nutrition education program: A survival analysis of Text2BHealthy

Introduction

Using text messages, also known as short message service (SMS), to deliver or supplement health interventions has increased in popularity in recent years. Text messages are an appealing mode of program delivery largely because they can be easily and inexpensively used to reach a broad audience [1]. In the United States, approximately 95% of adults own a cell phone [2], and 97% of smartphone users send and receive text messages [3]. Text messages may also be a useful tool for accessing underserved populations and addressing health disparities. Low-income and minority populations use cell phones at rates that equal or exceed those of their higher-income and white counterparts [2].

Text-based programs have been successfully used to address a wide variety of health issues, such as weight loss [4], smoking cessation [5], diabetes management [6], and sexual health [7]. Exposure to health-related text messages has also been effective in promoting participants’ adherence to a program and maintaining healthy behavior changes [8].

Given the effectiveness of text-based programs, it is important to understand when and why participants leave these programs to maximize program effectiveness. Many studies have shown that retention is generally high in text message programs [8–11] and attrition usually occurs early in the program [12]. There is some evidence that the number and type of messages received impacts attrition [13,14]. However, there are many unanswered questions about attrition. One particular area of exploration involves the impact of “stop messages.” Stop messages, which provide instructions for withdrawing from the program, may be a necessary feature of any voluntary program; however, it is unknown whether and how much such messages increase attrition.

Additionally, the context of participants who are enrolled in the program may also impact attrition. Participants in rural areas may be less likely to drop out of a text-based health promotion program as rural areas tend to have fewer health services and programs available [15].

Purpose

The purpose of the present study is to describe attrition from Text2BHealthy, a text message-based healthy eating and physical activity promotion program. Specifically, we sought to discern 1) how long participants remained in the program before dropping out, 2) whether particular types of messages, particularly stop messages, increased the likelihood that participants will drop out of the program, 3) whether the number of stop messages received increased the likelihood that participants will drop out of the program, and 4) whether contextual characteristics mitigated attrition.

Methods

Text2BHealthy Program
Text2BHealthy is a Maryland SNAP-Ed nutrition and physical activity promotion program delivered by text message to parents of elementary school children [16]. Parents received message content tailored to their children’s school and local community. Program participants received two to three messages per week. Messages provided information and actionable nudges about nutrition and physical activity, as well as a variety of other related content. Participants were able to remove themselves from the program at any time by texting “stop” to the program phone number or responding to a message with a message that included “stop.” Messages informing participants about how to leave the program were sent approximately every six weeks.

**Participants and Recruitment**
Participants for this study were 972 parents of children attending a selection of low-income elementary schools with youth SNAP-Ed programs in Maryland and participating in the Text2BHealthy program. Parents were recruited through school events and program promotional items sent home at the beginning of the school year. They were enrolled by either providing their phone number to program staff or enrolling themselves through a keyword texted to a short code. Data for this paper come from the September 2012 to June 2013 program year, which includes enrolled parents from 10 elementary schools in five Maryland counties and Baltimore City. Parents could enroll in and drop out of Text2BHealthy at any point during the program year.

**Variables and Measures**
The outcome of interest for this study was attrition from the Text2BHealthy program (i.e., survival time in days). Attrition data were recorded by the web platform that was used to send messages to participants. When participants sent a message to the program phone number indicating that they wanted to be removed from the program, the web platform would automatically and instantly remove them from the list of participants to receive messages and record the date and time that they left the program. Program enrollment date and dropout date were used to calculate program survival time in days.

Survival analyses were conducted to examine differences in participant attrition from the program. The primary predictor for survival time, in days, was message type. Message type was created by coding messages into five categories: nutrition; physical activity; stop messages describing how to drop out of the program; stop messages combined with content about nutrition or physical activity; and a variety of other content that included evaluation questions, goal-setting, and healthy event notifications, and other messages not explicitly addressing nutrition and physical activity actions (see Table 1).

<table>
<thead>
<tr>
<th>Message content type</th>
<th>Messages sent (n)</th>
<th>Message example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nutrition</td>
<td>587</td>
<td>Some students made mango salsa in nutrition class last week. All children have a copy of the recipe in their backpack today. Give it a try!</td>
</tr>
<tr>
<td>Physical Activity</td>
<td>170</td>
<td>It's going to be almost 50 degrees this afternoon! Enjoy some time outside with the kids after school. Take a walk with your family or play a game of catch!</td>
</tr>
<tr>
<td>Stop</td>
<td>55</td>
<td>Text2BHealthy is a free program from the</td>
</tr>
</tbody>
</table>
Nutrition with Stop\textsuperscript{a} & 14 & Broccoli is in season and $1.79 per pound at [local grocery store]. Steam or eat raw with low fat dip. Kids love broccoli! Msg & Data Rates May Apply. Reply STOP to quit. \\
Physical Activity with Stop\textsuperscript{a} & 16 & It's December & it's warm outside! Children love the extra time to play outside before dinner. Msg & Data Rates May Apply. To quit receiving messages, reply STOP. \\
Other\textsuperscript{b} & 130 & Take the family downtown this Saturday & Sunday for the Book Festival. Read, dance & hear from chefs & food experts. \\

\textsuperscript{a}Nutrition with stop and physical activity with stop were combined due to the small number of messages in each category. 
\textsuperscript{b}Other message types represent a broad variety of content that could not be classified into one of the five predominant message content types. Other messages include evaluation questions, goal-setting, event notifications, and other messages not explicitly addressing nutrition and physical activity actions.

Several covariates were included in the models including rurality and the number of stop messages received during the program year. Rurality was determined for each school using the United States Department of Agriculture’s (USDA) 2013 Rural-Urban Continuum Codes (the year the data were collected) for the county where the school was located. These codes range from 1-9 with 1-3 indicating metropolitan areas and 4-9 indicating non-metropolitan areas [17].

**Statistical Analysis**
All analyses were run in R Statistical Computing Package (v 3.2.1). Kaplan Meier curves were created to estimate differences in participant attrition for different message types. Using the survival package, Cox Proportional Hazards models were fit to estimate hazard ratios. A graphical inspection of the residuals was done to test the proportional hazards assumption.

**Results**

**Descriptive Statistics**
There were 972 participants during the 2012-2013 program year. Among the 10 participating schools, the average Free and Reduced Meals (FARM) rate, indicating the percent of students receiving free or reduced price meals, was 80.89 percent. According to the 2013 Rural-Urban Continuum Codes [17], seven out of ten of schools were located in metro counties with populations of one million or more, while one school was located in a metro county with a population of fewer than 250,000, and two schools were located in a nonmetro county with urban populations between 2,500 and 19,999. Retention rates by school ranged between 74.1 percent to 95.0 percent, with an average retention rate of 85.7 percent. Program duration ranged from seven
to 282 days, with a median program duration of 233 days and average program duration of 211.7 days (see Table 2). Fourteen percent (n=138) of participants dropped out of the program. Among those who dropped out, program duration ranged from seven to 247 days, with a median program duration of 102.5 days. The majority of participants who dropped out (84/138, 60.8%) did so after 90 days, while the other 39% (54/138) dropped out during the first 90 days. The program participants who dropped out of the program during this period represent 5.6% (54/972) of all program participants.

<table>
<thead>
<tr>
<th>School</th>
<th>Participants (N)</th>
<th>FARM Rate¹ (%)</th>
<th>RUCC²</th>
<th>Retention Rate (%)</th>
<th>Duration (M±SD) (days)</th>
<th>Duration (Mdn) (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>65</td>
<td>96.77</td>
<td>1</td>
<td>86.2</td>
<td>202.31 ± 71.6</td>
<td>234</td>
</tr>
<tr>
<td>2</td>
<td>46</td>
<td>63.24</td>
<td>6</td>
<td>84.8</td>
<td>223.93 ± 52.2</td>
<td>241</td>
</tr>
<tr>
<td>3S</td>
<td>99</td>
<td>77.43</td>
<td>1</td>
<td>82.8</td>
<td>198.42 ± 64.2</td>
<td>219</td>
</tr>
<tr>
<td>3E</td>
<td>55</td>
<td>77.43</td>
<td>1</td>
<td>80.0</td>
<td>198.91 ± 69.1</td>
<td>219</td>
</tr>
<tr>
<td>4</td>
<td>119</td>
<td>91.21</td>
<td>1</td>
<td>84.9</td>
<td>215.45 ± 47.7</td>
<td>233</td>
</tr>
<tr>
<td>5</td>
<td>139</td>
<td>77.69</td>
<td>3</td>
<td>86.3</td>
<td>213.12 ± 60.2</td>
<td>243</td>
</tr>
<tr>
<td>6</td>
<td>95</td>
<td>98.82</td>
<td>1</td>
<td>96.8</td>
<td>229.38 ± 34.5</td>
<td>240</td>
</tr>
<tr>
<td>7</td>
<td>68</td>
<td>75.05</td>
<td>1</td>
<td>85.3</td>
<td>183.25 ± 71.6</td>
<td>226</td>
</tr>
<tr>
<td>8</td>
<td>139</td>
<td>92.38</td>
<td>1</td>
<td>95.0</td>
<td>230.14 ± 33.3</td>
<td>240</td>
</tr>
<tr>
<td>9</td>
<td>66</td>
<td>73.37</td>
<td>1</td>
<td>75.8</td>
<td>195.03 ± 75.5</td>
<td>221</td>
</tr>
<tr>
<td>10</td>
<td>81</td>
<td>62.98</td>
<td>6</td>
<td>74.1</td>
<td>213.89 ± 61.4</td>
<td>227</td>
</tr>
<tr>
<td>Total</td>
<td>972</td>
<td>80.89</td>
<td></td>
<td>85.7</td>
<td>211.66 ± 58.8</td>
<td>233</td>
</tr>
</tbody>
</table>

Note: 3S = Spanish language messages sent to participants at school 3. 3E = English language messages sent to participants at school 3. These two groups were kept separate because 3 participants from school 3 elected to receive both English and Spanish messages.

¹Students are eligible for free school meals if household annual income falls below 130% of the federal poverty guidelines. Students are eligible for reduced price meals if household annual income falls between 130% and 185% of the federal poverty guidelines.

²RUCC 1 = Fringe counties of metro areas of one million population or more (metro county); RUCC 3 = Counties in metro areas of fewer than 250,000 population (metro county); RUCC 6 = Urban population of 2,500 to 19,999, adjacent to a metro area (non-metro county)

**Survival Analysis**

Kaplan-Meier survival curves indicate differences in program attrition by message type (see Figure 1). A log-rank test was used to examine differences in attrition among message types ($X^2 = 916, 3$ df, $p < 0.001$). Among those who did drop out of the program, participants were more likely to drop out after having received a stop message, followed by a stop message paired with nutrition or physical activity content and then by physical activity content alone. Participants were least likely to drop out after receiving a nutrition message. Based on these findings, Cox Proportional Hazards models were fit to estimate the effect of several covariates on program attrition.

Model 1 examines the predictive effect of message type on program attrition (see Table 3). As seen in Figure 1, stop messages are associated with a high probability of program attrition (HR = 51.5, 95% CI: 32.46, 81.7). The addition of covariates to the model attenuates this relationship, however the magnitude of the effect of stop messages remains substantial in comparison to
nutrition messages. In Model 2, which examines message type and the total number of stop messages received, the hazard ratio decreases substantially to 10.36. Additionally, Model 2 shows that the more stop messages a participant receives, the greater the probability of attrition. In Model 3, rurality of the program site impacts attrition, as the addition of the Rural-Urban Continuum Code increases the hazard ratio to 11.60. Living in a metro county with populations under 250,000 (RUCC=3) is associated with higher probability of dropping out of the program, whereas living in a nonmetro county with a population between 2,500 and 19,999 people (RUCC=6) is associated with lower probability of dropping out of the program, respectively, compared with living in a metro county with populations greater than one million (RUCC=1).

In Model 4, the final model in this analysis, interaction terms between the total number of stop messages and message types are included. The effect of the interaction term was explored through pairwise comparisons by message type (see Pairwise Comparisons by Message Type section). The addition of all the covariates and the interaction terms to the model leads to a 99% decrease in the effect of stop message only from Model 1, and the association is no longer statistically significant (p>0.05). The interaction between stop messages and the total number of stop messages received, however, has the largest effect on likelihood of dropping out of the program (HR = 3.31, 95% CI: 2.35, 4.64), suggesting a possible moderating effect of the total number of stop messages on the association between receiving stop messages and attrition rate in the program.

### Table 3. Predictors of Attrition by Message Type

<table>
<thead>
<tr>
<th></th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical Activity Message</td>
<td>2.50 (1.36-4.58)**</td>
<td>0.76 (0.39-1.47)</td>
<td>0.88 (0.45-1.74)</td>
<td>0.17 (0.06-0.49)**</td>
</tr>
<tr>
<td>Stop Message</td>
<td>51.5 (32.46-81.7)**</td>
<td>10.36 (6.14-17.46)***</td>
<td>11.60 (6.78-19.84)***</td>
<td>0.43 (0.16-1.16)</td>
</tr>
<tr>
<td>Other Message</td>
<td>1.82 (0.87-3.80)</td>
<td>1.00 (0.46-2.22)</td>
<td>0.45 (0.19-1.08)</td>
<td>0.21 (0.04-1.08)</td>
</tr>
<tr>
<td>Total Stop Messages Received</td>
<td>0.04 (0.02-0.05)**</td>
<td>0.03 (0.02-0.04)***</td>
<td>0.02 (0.01-0.03)***</td>
<td></td>
</tr>
<tr>
<td>County RUCC of 3</td>
<td>4.27 (2.33-7.83)***</td>
<td>3.05 (1.65-5.64)***</td>
<td>0.45 (0.27-0.76)**</td>
<td></td>
</tr>
<tr>
<td>County RUCC of 6</td>
<td>0.63 (0.39-1.02)</td>
<td></td>
<td></td>
<td>1.76 (1.21-2.57)**</td>
</tr>
<tr>
<td>^Physical Activity x Total Stop</td>
<td></td>
<td></td>
<td></td>
<td>3.31 (2.35-4.64)**</td>
</tr>
<tr>
<td>^Stop Message x Total Stop</td>
<td></td>
<td></td>
<td></td>
<td>1.43 (0.82-2.50)</td>
</tr>
<tr>
<td>^Other Message x Total Stop</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Hazard ratios for Cox Proportional Hazard models (95% CI)
^Interaction term
*p < 0.05, **p <0.01, ***p<0.001
1. Unadjusted model
2. Model 1 + Total # of stop messages
3. Model 2 + County RUCC
4. Model 3 + Interaction term between message type and total # of stop messages

**Pairwise Comparisons by Message Type**

The effect of the number of stop messages differs by message type (see Table 4). To further explore these relationships, two different values representing the 10th and 90th percentile for total number of stop messages received were chosen. These values were used to estimate the hazard ratios for different pairwise comparisons of message types. The effect of the number of stop messages received had differing effects for different pairwise comparisons. Most notably, the impact of the number of stop messages was particularly pronounced when comparing the probability of dropout after receiving a stop message to the probability of dropping out after receiving another type of message. For example, the stop message and nutrition message
comparison shows that receiving a stop message had a 15 times greater probability of resulting in a dropout than receiving a nutrition message with three stop messages received, but once six stop messages had been received, receiving a stop message had a 557 times greater probability of resulting in a dropout than a nutrition message. A similar pattern was observed when comparing stop and physical activity messages, as well as stop and other types messages.

<table>
<thead>
<tr>
<th>Pairwise Comparison</th>
<th>3 stop messages</th>
<th>6 stop messages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other v. Nutrition</td>
<td>0.62 (0.44-0.89)</td>
<td>1.84 (0.89-2.55)</td>
</tr>
<tr>
<td>Physical Activity v. Nutrition</td>
<td>0.91 (0.73-1.23)</td>
<td>5.1 (1.68-8.64)</td>
</tr>
<tr>
<td>Physical Activity v. Other</td>
<td>1.47 (1.09-1.88)</td>
<td>2.74 (1.79-3.14)</td>
</tr>
<tr>
<td>Stop v. Nutrition</td>
<td>15.44 (12.92-18.31)</td>
<td>557.6 (506.33-604.51)</td>
</tr>
<tr>
<td>Stop v. Physical Activity</td>
<td>16.89 (9.61-22.04)</td>
<td>110.1 (76.33-132.63)</td>
</tr>
<tr>
<td>Stop v. Other</td>
<td>24.84 (12.3-37.5)</td>
<td>303.89 (230.45-374.69)</td>
</tr>
</tbody>
</table>

*Hazard ratios for Cox Proportional Hazard models (95% CI)

Discussion

Principal Results and Comparison with Prior Work

The objective of this study was to examine the effect of message type and number of stop messages received on attrition in Text2BHealthy, a text-based health promotion program. We found that overall attrition differed by message type; in particular, sending a stop message substantially increased the risk of participants dropping out of the program compared to other types of messages including nutrition, physical activity, and others. While providing information about how to withdraw from a program may be necessary, the way in which this information is provided has important implications for program attrition.

Most participants did not drop out of Text2BHealthy; 86% percent were retained through the end of the school year, indicating possible exposure to key messages over a lengthy period. This is consistent with other literature, which has found high retention rates across text-based programs [8–11]. High retention may reflect that passively remaining in a text-based program is easier than taking action to drop out. Future research should move beyond looking at retention to also explore the extent of participants’ active engagement (e.g., opening, reading, and acting on messages received).

We also found that the majority of participants who dropped out (61%) did so after 90 days, while the other 39% dropped out during the first 90 days. The participants who dropped out during the first 90 days represent 6% of all program participants. This observation is inconsistent with research conducted by Coa and Patrick [12] showing that attrition tends to occur within the first two weeks of a program. While it is unclear why results from these studies differ, program planners should assess the likelihood of attrition at various points in their own programs, determine program length taking into account when participant fatigue is likely to occur, and consider over-enrolling participants to limit the impact of attrition on program evaluation. Text message program formats are both effective in the short term [18,19] and beneficial in extending
contact with participants beyond an initial intervention period [20], but more research is needed to examine the conditions under which participants tolerate longer program durations.

In examining the context of program participants, we found that parents living in rural counties were less likely to drop out than parents living in more metropolitan counties. This finding may be explained by the relative scarcity of health services and programs in rural areas [15]. It is likely that many other contextual factors may impact attrition, but more research is needed to identify such factors and mitigate their unique impact in text message programs.

We found that the effect of the number of stop messages received during the program period differs by message type. In particular, receiving six stop messages results in greater probabilities of attrition for all message types than receiving three stop messages, suggesting a possible dose-response relationship between number of stop messages received and the likelihood of dropping out of the program. Additionally, the interaction between stop messages and the total number of stop messages received yields the largest effect on attrition compared to the interaction between other message types and the number of stop messages received. While we were unable to find any other research examining the effect of stop message receipt on attrition, these findings may echo dose-response observations in another study showing that number of messages received was associated with positive behavior changes related to weight management [20]. These findings are also consistent with previous research emphasizing the importance of message characteristics, including content and the number of text messages received, in achieving high retention rates in text-message based health promotion programs [21–23]. Program planners needing to send instructions on how to drop out of a program should consider limiting the number of times this information is provided, as it is possible that a greater frequency of such information has negative implications for program retention.

Limitations
This study has a number of important limitations. First, we were unable to control for individual demographic characteristics that may explain differences in attrition. Second, while the data analysis accounts for different frequencies with which particular messages were sent, the relatively small number of messages combining nutrition content with a stop message and physical activity with a stop message implies a small number of possible dropout events to observe and limited or inadequate statistical power. We, therefore, combined these two message types with stand-alone stop messages into one group for analysis, which may obscure differences that may have been detected with more observations. It is also possible that certain messages within a message category impacted attrition differentially, but due to somewhat varied content across schools, we were unable to examine attrition probabilities for each unique message. Third, while we are able to link attrition events to the most recently sent message, this does not necessarily indicate that a participant chose to drop out of the program because of the content of this particular message. Additionally, program data indicate only that messages were sent to a functioning cellular number, not whether participants read the messages they receive or whether the messages are impactful. Therefore, participant retention is not itself an indication of either participant engagement or program efficacy.

Conclusions
This study of attrition in the Text2BHealthy program demonstrates the potential of text message programs to retain participants over a long program duration. In examining the patterns of attrition, we have provided evidence that the probability of attrition increases when participants receive messages with instructions about withdrawing from the program. Program planners should carefully consider how and how often to provide such information in order to minimize its effect on retention and determine other possible message content and characteristics that may undermine retention. Despite substantial progress in understanding best practices in text message program design and implementation, more research is needed to determine participant, programmatic, and contextual predictors of program duration and attrition in order to mitigate their impact in text message programs. Further, the relationship between program duration and attrition and targeted behavioral outcomes also necessitates examination.

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Author Contributions: SG, AM, KS, EBD, LW, and LL contributed to the formative evaluation, design, development, and implementation of the Text2BHealthy program, and SG, AM, KS, and LL contributed to the design and implementation of the broader Text2BHealthy program evaluation. SG, KS, EBD, and LW recruited and enrolled participants in the program and evaluation. LW managed program recruitment activities, wrote and sent Text2BHealthy messages, managed the web platform database, and facilitated the acquisition of data. SG, EBD, and LL facilitated the acquisition of funding for the program and contributed to project administration, coordination, and supervision. SG served as the principal investigator for Text2BHealthy evaluation research, and LL is the Director and principal investigator for the Maryland SNAP-Ed program. SG, AM, and KS contributed to the conception and design of the current study. SG and YV extracted, cleaned, and coded data, while EH conducted data analyses. SG directed data preparation and analysis, and SG and AM co-wrote initial drafts of the manuscript. KS and YV contributed to multiple drafts, provided substantial edits and revisions, and organized references. All authors reviewed and approved the final manuscript.

Conflicts of Interest: None declared.

Abbreviations:
SMS: short message service
USDA: United States Department of Agriculture
RUCC: Rural-Urban Continuum Codes
FARM: Free and Reduced Meals
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