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**Title:** Preventing smoking relapse using text messages: analysis of data from the txt2stop trial

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## **Abstract**

**Background:** Interactive text-message based technologies which operate in real-time have the potential to be especially effective for delivery of relapse prevention interventions. We examined predictors of use of a text-message system for providing support for lapses and cravings, describe the natural history of requests for support, and predictors of time to requests for support.

**Methods:** Data were collected prospectively from participants in the intervention arm of txt2stop, a large randomized controlled trial of an automated, text message based smoking cessation intervention. Txt2stop included 2915 men and women aged 16 to 78, recruited from London, UK from 2009-2010. Participants could text 'crave' or 'lapse' when they experienced either; an automated system registered the time of the text message to the nearest second.

**Results:** 1121 (38.5%) participants sent a lapse or crave message to request support. Women were more likely to lapse at some point during the trial. Of those who lapsed, being female, younger age and setting a Saturday quit date were predictors of sending a lapse text requesting support. Half of all crave texts arrived within 106 hours of quitting. Half of all lapse texts arrived between 4 and 17 days after the quit date. Sending a crave text, being female, younger and setting a quit date on a Saturday were associated with shorter time to sending a first lapse text.

**Conclusions:** Text based lapse support should be developed and evaluated, especially for women. Smokers may benefit from additional support to prevent lapses on days 4-17 post-quit attempt.

Words 248

## **Introduction**

Most people who are trying to quit smoking will 'lapse' to smoking again after a period of abstinence. Smokers who lapse initially after a quit attempt are less likely to be abstinent at 6 months(Kenford, et al., 1994). Preventing shorter-term, episodic lapses to smoking, and eventual longer-term relapse, therefore, is of central importance for smoking cessation interventions. Unfortunately, interventions designed to reduce relapse appear to be largely ineffective. The recently updated Cochrane review of 54 relapse prevention studies found no evidence to support any behavioural interventions to prevent relapse(Hajek, Stead, West, Jarvis, & Lancaster, 2009), although extended treatment with some pharmaceuticals showed promise(Gonzales, Jorenby, Brandon, Arteaga, & Lee, 2010; Hajek, et al., 2009).

The txt2stop trial demonstrated that smoking cessation support delivered by text messaging doubles bio-chemically verified continuous abstinence at six months (10.7% quit in the txt2stop group versus 4.9% in the control group, relative risk 2.20, 95% CI 1.80 to 2.68,  $p < 0.0001$ )(Free, et al., 2011). Part of the txt2stop intervention included the ability for participants to request support for craving and lapses in real-time during the crave or lapse event. This feature of text message based interventions may make them especially well-placed to provide support for relapse prevention. Messages received on a mobile phone can provide simple distraction from a craving, or provide useful suggestions on how to cope. Similarly, text messages designed to mitigate feelings of failure and negative affect that may result from having a lapse, encourage participants to

identify why they lapsed, and make plans to avoid lapsing in the future, could all prevent further lapses to smoking and increase the success of quit attempts.

Understanding which smokers may engage with text-message based support for relapse prevention, and when they seek support for cravings and lapses, is essential to facilitate design of the most effective interventions using this technology. Such data can also act as a measure of patterns of craving and lapses in those requesting support. Existing data on the patterns of cravings and lapses even in the general populations of smokers, and data on the timing of help-seeking behaviour for smoking cessation is limited. Shiffman outlines inherent methodological difficulties in examining the timing of smoking relapse using existing studies(Shiffman, 2008). Larger population-based studies tend to have longer measurement intervals, which preclude a detailed examination of time-sensitive effects. Participants' recall of the timing of first smoking lapse events can be 'wildly inaccurate', incorrect by 17 days on average over measurement intervals as short as 25 days(Shiffman, Hufford, et al., 1997). Most larger studies request participants to recall lapse events over periods of several months(Shiffman, 2008). However, studies with more finely spaced data tend to come from small clinical samples, thus having limited statistical power.

Extant data indicates that lapses are particularly likely during the first week after a quit attempt(Hughes, Keely, & Naud, 2004), and up to 60% of those making a quit attempt will relapse within 2 weeks(Garvey, Bliss, Hitchcock, Heinold, & Rosner, 1992). Known predictors of relapse include higher nicotine dependency as measured by the Fagerstrom score, certain genetic polymorphisms, self-efficacy to stay quit, and urges to smoke (Herd, Borland, & Hyland, 2009;

Shiffman, Engberg, et al., 1997). However, as Shiffman points out, there is actually very little research on 'dynamic factors' that predict *when* an individual is likely to relapse(Shiffman, 2008), an even less on when those individuals may seek or be in most need of support.

Here we use finely-spaced, prospectively collected data from large sample of participants in the txt2stop smoking cessation trial. We aimed to identify which trial participants would send text messages requesting support for cravings and lapses, describe the timing of craving and lapse text messages, and predictors of faster time to sending craving and lapse text messages after a quit date. We hypothesized *a priori* that texting lapse and crave would be associated with smoking at four weeks and six months after the quit date, because urges to smoke predict relapse. We hypothesized that setting a quit date on a Friday or Saturday would be associated with shorter time to relapse, because in the UK people tend to socialize on these days and thus be in environments where cues to smoke are present.

## **Methods**

We used anonymised data from the txt2stop trial, conducted from 2009-2010 in London, UK. Txt2stop is a single-blind randomised controlled trial of an automated mobile phone based smoking cessation programme (Free, et al., 2011). Participants in the intervention group could send and/or receive text messages from a central automated system. Participants in the intervention group were asked to set a quit date, and received a series of text messages around the quit date and beyond to support their quit attempt.

Participants in the intervention group were provided with information in text messages encouraging them to text 'crave' when they experienced a craving and 'lapse' when they experienced a lapse, at any time of the day or night. The automated system recorded the time that the 'lapse' or 'crave' message was received, to the nearest second, and sent out a predetermined text or series of texts in response to the initial message from the participant as part of the txt2stop intervention. Thus, txt2stop provides real-time data on cravings and lapses for 6 months after the quit date set by each participant.

There were 5800 participants randomised in txt2stop; 2915 of those were in the intervention group and could send lapse and crave text messages. This analysis includes only those 2915 participants.

Exposure variables included the Fagerstrom score, categorized as 0 to 4, 5 to 6 and 7 to 10, representing low, medium and high levels of nicotine dependence, respectively. We created a binary variable measuring whether or not any other treatment was used to aid the quit attempt, and a binary variable representing



whether or not three or more previous quit attempts were made, and whether or not quit dates were set on Friday, or Saturday. We also controlled for sex, educational attainment, ethnicity, and employment status.

The main outcomes were characteristics of those who used the text crave or lapse functions, time from the quit date to first lapse text and time to first crave text, measured in hours. We also examined self-reported continuous abstinence at 4 weeks from the quit date, self-reported continuous abstinence at 6 months, and biochemically verified 7-day abstinence at 6 months from the quit date. We defined those who had lapsed at some point during the trial as those who reported that they had not been continuously abstinent at 4 weeks and/or 6 months, or were not biochemically verified to be abstinent at 6 months, or who texted to report a lapse.

All analyses were conducted using Stata 11.0(StataCorp., 2010). To explore associations between participants characteristics and use of the text message function, we used Chi-squared or t-tests to compare participants who 1) did not report any smoking after their quit date, 2) reported smoking again at some point after their quit date but did not use the text lapse function, and 3) used the text lapse function. To describe the natural history of sending lapse and crave messages, we plotted the frequency of lapse and crave texts over the period immediately after the quit date and used LOWESS smoothing to represent the underlying trend curve. We used Cox regressions, both with and without additional explanatory variables, to explore predictors of time to first lapse and crave texts. Timing of craving texts was a time-dependent covariate in the time

to first lapse text analysis; all other variables were constant across the analysis period. Statistical significance was set at the 5% level.

## **Results**

Of the 2915 participants who could send lapse and crave texts, 1794 (61.5%) did not send any text messages. Of the remaining 1121 (38.5%) who sent text messages, 765 people sent 2339 crave texts. Most sent only one crave message--the minimum number of crave texts per person was 1, maximum 100, and median was 1 (IQR 1-3). 778 people sent 1336 lapse messages. The minimum number of lapse texts sent by any one person was 1, maximum 9, median 1 (IQR 1-2).

Characteristics of participants who 1) did not report any smoking after their quit date, 2) reported smoking again at some point after their quit date but did not use the text lapse function, and 3) used the text lapse function are compared in Table 1. Following a quit attempt women were more likely to lapse, but no other variables were significantly different between those who lapsed and those who did not. Among those who lapsed, those who used the text lapse function were statistically significantly more likely to be female, younger, and to have set a Saturday quit date versus those who lapsed but did not text.

### **Timing of lapse and crave texts**

The timing of crave and lapse texts received by participants over the first seven days after quitting are shown in Supplementary Figures 1 and 2. All quit dates started at midnight on the chosen quit day. There is a cyclical pattern, with lower numbers of texts received during the night and peaks in craving texts in the afternoons and evenings. Half of all 2339 crave texts were received within the first 106 hours of quitting. Half of all 1336 lapse texts arrived between 122-

418 hours from the quit date (between four and seventeen days) with peaks in lapse texts in the morning of day five and the afternoon of day 7. People in txt2stop most commonly set quit dates on a Monday (Supplementary Figure 3). Craving texts were sent most often on Saturdays, Sundays and towards the beginning of the week, and lapse texts were most commonly received on a Friday (Supplementary Figures 4 and 5).

### **Associations between lapse, crave and smoking outcomes.**

Texting lapse within 3 days was strongly associated with texting crave within 3 days; similarly, texting lapse before 4 weeks was associated with texting crave before 4 weeks and abstinence at 4 weeks, and texting lapse at any point over the 6 months of the trial was associated with texting crave and with abstinence over 6 months (Table 2). Those who texted crave before four weeks were more likely to report being quit at four weeks, while those who texted lapse before 4 weeks were more likely to report smoking at 4 weeks. However, those who reported texting crave at any point over the trial were no more or less likely to reported continuous abstinence or biochemically verified cessation at six months.

### **Predictors of time to 1<sup>st</sup> lapse text**

In unadjusted analyses, women, younger participants, those employed in a non-manual job and those with more than 11 years of education were likely to have a shorter time to first lapse text. The strongest smoking-related predictor of shorter time to first lapse was texting crave. Unexpectedly, higher Fagerstrom scores (higher levels of nicotine dependence) were associated with longer time

to first lapse text. Having made more than 3 previous quit attempts and setting the quit date for a Saturday were associated with shorter time to first lapse text (Table 3).

In the fully adjusted model, texting crave remained the strongest single predictor of shorter time to first lapse text. Associations with being female, younger age and having a non-manual occupation remained significant, but education, Fagerstrom score and previous quit attempts were no longer significant after accounting for other variables. The effect of setting a quit date on a Saturday was of borderline statistical significance after adjustment ( $p=0.06$ ).

#### **Predictors of time to 1<sup>st</sup> crave text**

Women, younger participants, those were White British, who had more than 11 years of education and had more than 3 previous quit attempts has a shorter time to first crave text in both adjusted and unadjusted analyses. Setting a quit date on a Saturday was not statistically significantly related to the timing of crave texts in unadjusted or adjusted analyses (Table 4).

## **Conclusions**

### **Our main findings**

In our trial, women and younger participants were more likely to use the text messaging function to request support for lapses and cravings in real time. People sent crave texts towards the beginning of the week, usually with 96 hours of their quit date, and lapse texts were most commonly received on Fridays, usually 4-8 days after the quit date. Among those who did lapse, those who set their quit date on a Saturday were statistically significantly more likely to text 'lapse'.

### **Strengths and Limitations**

This study makes use of prospectively collected data from a large sample of participants, thus avoiding the recall bias associated typically associated with large-scale surveys of smoking relapse (Shiffman, 2008). However, although participants were offered the use of these functions specifically as a way to receive real-time support for dealing with cravings and lapses, it is also possible that participants used the functions sometime after they actually experienced a craving or a lapse. In the txt2stop trial, use of the lapse and crave text functions was optional, and not all participants chose to send these messages. Our results on the natural history of lapses and cravings represent those who used the text message system, and should not be interpreted as representative of the natural history among all smokers who are trying to quit. Obviously, we could not assess predictors of use of the text messaging function or registering of lapses or cravings that were not measured in the trial. Other known predictors of relapse

and cravings which are important for the broader population of smokers may also be important for those who are willing to send a text message to register relapse or cravings.

### **Findings from other studies**

The natural history of craving and lapse messages documented in our sample of smokers who used the text messaging function is broadly similar to other studies of the general population of smokers making a quit attempt. Other studies with a range of measurement intervals from days to months also report increased lapses and cravings in the weeks immediately following a cessation attempt, with most quitters relapsing within 8 days (Hughes, et al., 2004). Shiffman et al. also report on finely-spaced lapse/ craving measurement intervals (7 times a day) in a small study with 108 participants (Shiffman, Paty, Gnys, Kassel, & Hickcox, 1996). Reported lapses peaked at 2 days post cessation, and trailed off at 7 days (Shiffman, et al., 1996). In our sample, craving texts were very common during this time period, but most lapse texts were not received until 4-8 days post cessation.

Contrary to our hypothesis, participants in our trial who texted crave before four weeks were *more* likely to report being abstinent at four weeks. This could suggest that texting crave may have had some beneficial effect on early quit success. Conversely, it is also possible that people who were more motivated to quit were more engaged with the trial and thus more likely to send the text messages as well as being more likely to successfully quit at 4 weeks.

In our sample, being female was the only variable we tested which predicted lapse within six months of the quit attempt. This finding is consistent with the broader literature on help-seeking behaviour, which indicates that in general, men are less likely to seek help to change behaviour or treat medical conditions versus women (Galdas, Cheater, & Marshall, 2005). Demographic variables, Fagerstrom score, number of previous quit attempts, and use of a cessation aid were not associated with lapsing, or with texting lapse among those who did lapse. Shiffman also found that Fagerstrom score was not associated with lapsing in his study (Shiffman, et al., 1996). Texting crave was the best predictor of shorter time to first lapse text. This is consistent with findings from other studies showing that urges to smoke are associated with relapse (Shiffman, Engberg, et al., 1997),

### **Implications for interventions and future research**

Women in our study were more likely to send both lapse and crave texts. This indicates women engage with text-message based technology, and illuminates a potential avenue for intervention to prevent relapse. If an effective relapse prevention program could be designed, delivering it via text message may be a particularly effective way to provide support to female smokers.

Our data regarding the timing of cravings and lapses from the quit date, diurnal patterns in craving and the timing of peaks in lapses could inform the development of future text messaging or other smoking cessation interventions to provide additional support at peak times for lapse and cravings. Further research should also explore the relationship between setting a quit date on a Saturday and lapse patterns.



These findings may also help improve current provision. A recent survey of NHS Stop Smoking Services in England shows support for lapse prevention following a quit attempt is mainly delivered by telephone (Agboola, Coleman, Leonardi-Bee, McEwen, & McNeill, 2010), but the effectiveness of such support has not been demonstrated (Hajek, et al., 2009). Augmenting existing telephone surveys to provide additional support at peak times may improve effectiveness. In the longer term, the effectiveness of both telephone and lower cost text message based support to prevent relapse should be evaluated.

### **Final word**

Interventions using text-message based technology to prevent relapse in women and other smokers should be developed and tested. Smokers who use text-message based technology may benefit from additional support to prevent lapses 4-17 days post-quit attempt.

Words: 3533

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**Declaration of interests.** We have no competing interests.

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Table 1. Characteristics of participants		I	II + III	II	III			
		Did not lapse	Lapsed	Did lapse, but didn't text	Lapsed and texted	p-value (II+III vs I)	p-value (III vs. II)	p-value (III vs. I)
Characteristic		(n=440)	(n=2306)	(n=1541)	(n=765)			
Sex	Male	18.5	81.5	58.1	23.4			
	Female	13.0	87.0	53.7	33.3	<0.001	<0.001	<0.001
Age	Mean age, years	37.6	37.1	37.8	35.8	0.429	<0.001	<0.001
Ethnicity	White British	15.8	84.2	55.8	28.4			
	Other	16.9	83.2	57.3	25.8	0.560	0.303	0.297
Employment	Unemployed	16.3	83.7	59.1	24.6			
	Manual	16.2	83.8	57.2	26.6			
	Non-manual	15.8	84.3	53.8	30.5	0.932	0.211	0.015
Fagerstrom score	0 to 4	18.2	81.8	51.1	30.7			
	4 to 7	14.8	85.2	58.4	26.8			
	7 to 10	15.2	84.8	58.8	26.0	0.095	0.448	0.001
Education	More than 11 yrs	16.4	83.6	53.1	30.5			
	11 years	15.9	84.1	58.7	25.3			
	Less than 11 years	14.7	85.3	61.8	23.6	0.742	0.870	0.010
Previous quit attempts	3 or less	16.0	84.0	58.5	25.5			
	More than 3	16.0	84.0	52.9	31.1	0.994	0.101	0.001
Use of quit aid	No	15.7	84.3	56.6	27.8			
	Yes	18.4	81.6	53.0	28.6	0.183	0.434	0.470
Friday quit date	No	16.0	84.0	56.2	27.8			
	Yes	16.2	83.8	55.0	28.8	0.928	0.889	0.656
Saturday quit date	No	16.4	83.6	56.2	27.4			
	Yes	12.4	87.6	54.7	32.9	0.111	0.040	0.168

Table 2. Association between lapse, crave and smoking outcomes

	Text LAPSE 3d	Text LAPSE 4wk	% Self- reported Quit at 4wk	Text LAPSE 6mo	Self-reported Continuous abstinence 6mo	Biochemically verified abstinence at 6mo
Text CRAVE 3d	18.16*					
Did not	1.29					
Text CRAVE 4wk		51.46**	35.8***			
Did not		15.07	26.71			
Text CRAVE 6mo				54.24***	20.51	9.36
Did not				16.05	19.74	7.85
Text LAPSE 4wk			14.75***			
Did not			33.87			
Text LAPSE 6mo					13.52***	4.03***
Did not					22.21	9.85

\*\*\*p<0.001.

Note: unless other wise noted, 3d means within 3 days; 4wk means within 4 weeks, 6mo means within 6 months.

Table 3. Cox proportional hazards regression of predictors of time to first LAPSE text					
Characteristic		HR	95% CI	aHR	95% CI
Sex	Male				
	Female	1.51	( 1.31 to 1.74 )	1.37	( 1.18 to 1.59 )
Age	Years	0.99	( 0.98 to 0.99 )	0.99	( 0.98 to 1.00 )
Ethnicity	White British				
	Other	0.86	( 0.71 to 1.03 )	0.92	( 0.76 to 1.12 )
Employment	Unemployed				
	Manual	1.10	( 0.90 to 1.35 )	1.21	( 0.98 to 1.49 )
	Non-Manual	1.32	( 1.10 to 1.58 )	1.22	( 1.01 to 1.48 )
Education	More than 11 years				
	11 years	0.79	( 0.68 to 0.93 )	0.90	( 0.76 to 1.06 )
	Less than 11 years	0.74	( 0.58 to 0.95 )	0.93	( 0.72 to 1.20 )
Fagerstrom score	0 to 4				
	4 to 7	0.88	( 0.75 to 1.04 )	0.97	( 0.82 to 1.14 )
	7 to 10	0.83	( 0.68 to 1.00 )	0.96	( 0.79 to 1.17 )
Previous quit attempts	3 or less				
	More than 3	1.26	( 1.09 to 1.45 )	1.11	( 0.96 to 1.28 )
Quit aid used	No				
	Yes	1.02	( 0.82 to 1.25 )	0.97	( 0.78 to 1.20 )
Friday quit date	No				
	Yes	1.08	( 0.87 to 1.33 )	n/a	
Saturday quit date	No				
	Yes	1.32	( 1.04 to 1.67 )	1.23	( 0.97 to 1.57 )
Cravings	Hours from quit	6.28	( 5.43 to 7.27 )	5.88	( 5.06 to 6.82 )
*total n=2910, 764 lapses; **adjusted analyses, n=2894, 760 lapses					

Table 4. Cox proportional hazards regression of predictors of time to first CRAVE text					
Characteristic		HR	95% CI	aHR	95% CI
Sex	Male	1.29	( 1.12 to 1.48 )	1.28	( 1.10 to 1.48 )
	Female				
Age	Years	0.99	( 0.98 to 1.00 )	0.99	( 0.98 to 1.00 )
Ethnicity	White British				
	Other	0.80	( 0.66 to 0.96 )	0.76	( 0.63 to 0.92 )
Employment	Unemployed				
	Manual	0.94	( 0.78 to 1.14 )	1.01	( 0.83 to 1.23 )
	Non-Manual	1.01	( 0.85 to 1.21 )	0.96	( 0.80 to 1.15 )
Education	More than 11 years				
	11 years	0.83	( 0.71 to 0.97 )	0.83	( 0.70 to 0.98 )
	Less than 11 years	0.78	( 0.61 to 0.98 )	0.81	( 0.63 to 1.03 )
Fagerstrom score	0 to 4				
	4 to 7	1.04	( 0.88 to 1.22 )	1.10	( 0.93 to 1.30 )
	7 to 10	0.94	( 0.78 to 1.14 )	1.03	( 0.84 to 1.25 )
Previous quit attempts	3 or less				
	More than 3	1.21	( 1.05 to 1.40 )	1.22	( 1.06 to 1.41 )
Quit aid used	No				
	Yes	0.99	( 0.81 to 1.23 )	0.99	( 0.80 to 1.23 )
Friday quit date	No				
	Yes	1.02	( 0.82 to 1.27 )	n/a	
Saturday quit date	No				
	Yes	1.20	( 0.95 to 1.53 )	1.23	( 0.97 to 1.56 )
*total n=2910, 778 lapses; **adjusted analyses, n=2894, 773 lapses					