Applying the Transtheoretical Model of Behavioral Change to Reddit Data: A Pilot Study of Cessation Strategies and Outcomes among Tobacco Users

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Abstract

Despite the existence of numerous studies demonstrating that tobacco use is strongly associated with cancer, heart disease, stroke, and other health problems, tobacco continues to be a major public health threat worldwide. Social media provides a rich resource for population-level, health-based monitoring and understanding of tobacco cessation efforts and trends. In this pilot study, we identified common and emerging tactics used by Reddit users for tobacco cessation and demonstrated that the Transtheoretical Model — an established and widely used behavioural change theory – could be leveraged to track and identify successful cessation of tobacco usage within this population.

1 Introduction

Globally, tobacco usage continues to be a major public health crisis with nearly 6 million mortalities annually and a projected 8 million mortalities annually by 2030 [1]. Although tobacco control programs have been shown to reduce tobacco usage in Western countries [2][1], it is estimated that about 25% of individuals smoke cigarettes worldwide [4]. In recent years, tobacco control research initiatives have begun to utilise the abundant, naturalistic data social media provides as a powerful resource for understanding tobacco use patterns and aiding in smoking cessation efforts [5, 6].

1.1 Perceptions and sentiments toward tobacco usage

Researchers have studied social media data to understand smokers' perceptions of tobacco safety, the contexts in which tobacco products are used, and geographical variations in tobacco product use [7]. For example, Rose et al. performed content and sentiment analysis to understand user perceptions of menthol cigarettes, observing that current smokers more often express positive sentiment towards menthol cigarettes, while former smokers more often express negative sentiment towards the product [8]. Myslin et al. also observed positive sentiment toward emerging tobacco products (i.e. electronic cigarettes and hookah) among Twitter users [9], noting that, at least for some younger users, hookah smoking was not conceptualised as tobacco use. Chen et al. demonstrated that users of electronic cigarette discussion forums are typically focussed on symptoms and symptom management, whereas users of smoking cessation forums are more interested in psychological strategies associated with successful smoking cessation [10]. Meng et al. quantified national substance use patterns by assessing and visualizing the relationship between positive sentiment and smoking behavior on Twitter using choropleth maps [11].

1.2 Modeling and tracking tobacco cessation tactics and outcomes

Another, related strand of research has involved exploring the utility of social media for population health monitoring [12, 13, 14]. Prochaska et al. observed that few Twitter accounts provided personal communications to support cessation [15]; most accounts linked to commercial sites for smoking cessation, electronic cigarettes, and published news alerts. Tamersoy et al. demonstrated that Reddit forums (*subreddits*) like r/stopsmoking and r/stopdrinking could be utilized to understand abstinence from tobacco or alcohol [16]. Leveraging self-reported "badge" information derived from nearly 1,000 Reddit users (redditors) as a gold standard for abstinence status, they demonstrated that long-term abstinence from smoking or drinking (1 year) is highly distinguishable from short-term abstinence (40 days) using user language and social interaction data.

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[1]In context of the the United Kingdom, adult male smoking rates decreased from 61% in 1960 to 22% in 2010, while adult female smoking rates decreased from 42% to 21% in the same time period [3].

Finally, few researchers address social media-based tobacco cessation research using psychological theories of behaviour change. Thurl et al. conducted an experiment using Facebook groups to engage with smokers to identify — based on the transtheoretical model of behavioral change (TTM) [17] — which intervention generated the highest engagement among participants in pre-action stages of change (*precontemplation*, *contemplation*, and *preparation*) [18] (see **Figure 1** for definitions). They observed that in *precontemplation* and *contemplation*, decisional balance posts generated above average engagement; whereas in *preparation*, consciousness raising posts generated above average engagement. Murnane et al. identified Twitter users who are also smokers with an intention to quit, encoded their tweets according to TTM, and analyzed their behaviors and language. They showed that those who fail or relapse are heavier posters and express less positive language. In contrast, those who succeed are more sociable in both network ties and in directed communication [19]. They also observed that those that relapse linger longer in the earlier stages of the TTM (*pre-contemplation*, *contemplation*, and *preparation*) than individuals who successfully ceased smoking.

Our pilot study builds upon these related works by determining tactics used by redditors to quit smoking and by applying the TTM to their Reddit posts to identify and track successful cessation of tobacco usage within this population.

2 Methods

For this ethics committee exempted pilot study, we sampled the top-rated threads from redditors of the r/stopsmoking forum from January 1, 2012 through December 31, 2015. We hypothesised that redditors initiating posts — i.e. the first post in a given thread — are more likely to contain information related to changes in smoking status. Therefore, to identify tactics for smoking cessation by redditors and to track their progress through the TTM proposed by Prochaska et al. [17, 20], we identified all unique redditors posting initiating posts for each calendar year between 2012 and 2015. For this study, we reviewed posts for each unique redditor with at least one initiating post in 2012, then characterised each redditor regarding his or her participation e.g., the proportion of redditors with single versus consecutive years of participation. We leveraged this subset of redditor's posts to understand strategies, outcomes, and relapse within Reddit posts.

First, to understand the most common approaches leveraged for tobacco cessation, we applied a content analysis approach using manual annotation to identify and annotate themes related to <u>strategies</u> given within each thread. This approach has been successfully used to understand themes related to diabetes [21], weight loss [22], and childhood vaccinations [23] expressed by users within online forums. Second, we annotated each redditor's posts (initiating and responding) according to the following smoking cessation <u>outcome</u> categories from TTM: *precontemplation, contemplation, preparation, action, maintenance* (see **Figure 1** for example posts). To understand reasons for failed attempts at tobacco cessation, we annotated their mentions of <u>relapse</u>.
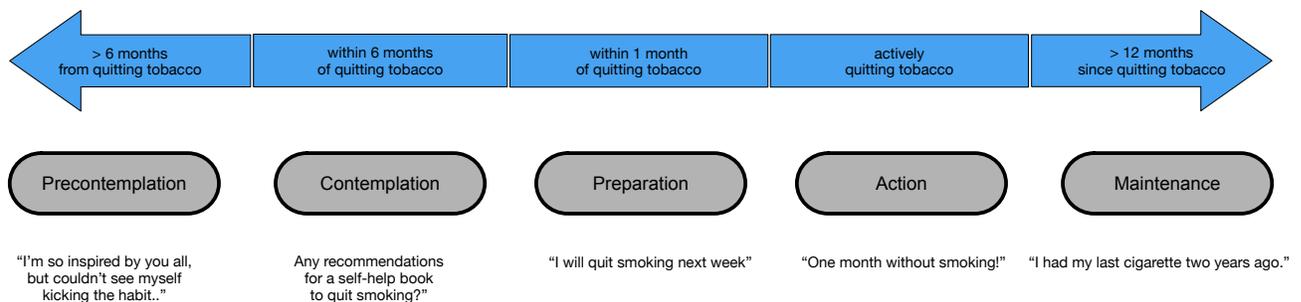

Figure 1: TTM applied to tobacco cessation with exemplar Reddit posts.

3 Results

Our overall goal is to understand the smoking cessation strategies of tobacco users participating in the online Reddit forum r/stopsmoking using the TTM theory of behaviour change.

3.1 Dataset

We observed 7,392 unique redditors contributing to the top-rated threads of the r/stopsmoking forum from January 1, 2012 through December 31, 2015 (n=17,752 threads; n=27,531 posts). 12% (863/7,392) of redditors in our sample contributed with one or more posts to the r/stopsmoking forum for 2 or more years. We observed the following distribution of unique redditors posting initiating posts for each year (YR): 109 (YR 2012), 221 (YR 2013) 161 (YR 2014), and 158 (YR 2015). We identified 104 redditors with initiating posts and with 2 or more years of participating on the r/stopsmoking forum since 2012 to 2015 achieving top rank (n=7,241 posts).

3.2 Smoking Cessation Strategies

A total of 64 posts described specific cessation methods, most frequently, exercise 25% (16/64), cold turkey 18% (11/64), software/applications 8% (5/64), and motivation from a family member or the recent birth of a baby within their family 8% (5/64) (**Figure 2**).
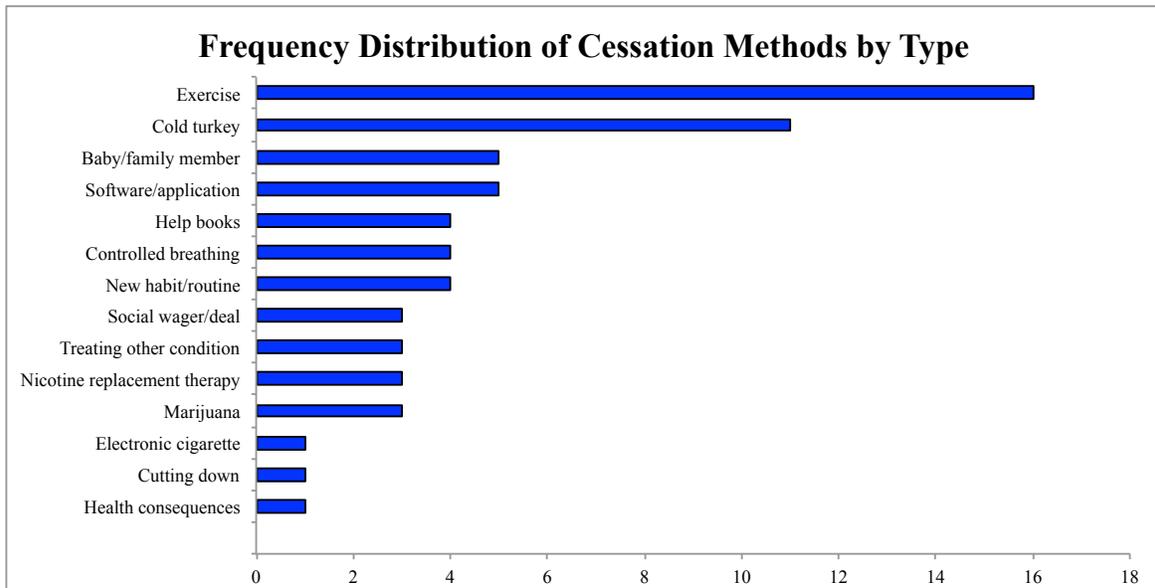

Figure 2: Counts of cessation method types discussed.

3.3 Smoking Cessation Outcomes

Of the 104 redditors identified with initiating posts and with 2 or more years of participation in r/stopsmoking, 74% (77/104) provided adequate information to infer one or more stages of the TTM (**Figure 3**). For redditors with initiating posts in 2012, 16% (12/77) of redditors described their experiences through 2 or more stages over three years with the distribution: *contemplation-to-maintenance*: 1, *preparation-to-action*: 1, and *action-to-maintenance*: 10. 65% of redditors (50/77) described *actions* for cessation. 33% of redditors (26/77) reached the *maintenance* stage. We observed 12 mentions of relapse (not shown).
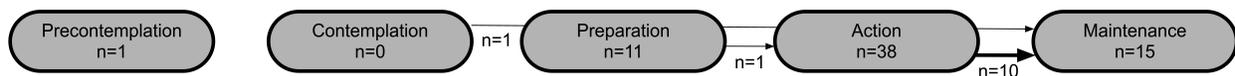

Figure 3: Count of redditors characterized by progression through the TTM according to post histories.

4 Discussion

We aimed to determine strategies used by redditors to quit smoking and demonstrate the feasibility of applying TTM to track and identify successful cessation of tobacco usage within this population.

4.1 Smoking Cessation Strategies

A variety of cessation methods were discussed within these threads (**Figure 2**). The most common method of cessation was *exercising* (e.g., "Find stuff to replace smoking. I finished Couch to 5K. . . " and "I exercise daily, alternating between jogging and strength.") Many redditors describe quitting *cold turkey* (e.g., "When I stopped smoking it was just that. I stopped" and "I smoked for 7 years and quit cold turkey.") Some redditors were motivated by *family* (e.g., "[I] . . . use my wife and my kids to essentially guilt me into behaving") or a friendly wager among fellow redditors and friends (e.g., "For every upvote 5 minutes no smoking.") Others found success using *software/applications* such as **Quit Now**, **iQuit**, and **My Last Cigarette** (e.g., "I used a couple apps also and they were helpful early on.") as well as self help books like **The Easy Way to Stop Smoking** (e.g., "The Allen Carr book did it for me.") or *controlled breathing* in the form of meditation and deep breaths (e.g.,"I meditate daily"). Additionally, redditors used prescribed and over-the-counter therapies, NRTs and medications, (e.g., "Chantix ultimately has saved my life") as a means of coping with nicotine withdrawal. We did observe utility of other combustible smoking agents such as *marijuana* (e.g., "I do smoke marijuana, and that helped a lot") and *electronic cigarettes* (e.g., "I used an e cig for the first three days..it did help") to manage physical cravings. In some cases, tobacco was being used to *treat other conditions*. For example, several redditors found success using medications like celexa and adderall to treat their underlying depression and anxiety. Others described simply *cutting down* motivated by the *health consequences* of prolonged tobacco use.

4.2 Smoking Cessation Outcomes

The majority of redditors with initiating posts provided adequate information to infer one or more stages of the TTM (**Figure 3**). Although few redditors described their experiences through two or more stages over three years, the majority of redditors described *actions* for cessation and about a third of redditors *maintained* successful tobacco cessation. In terms of automating this manual pilot work using natural language processing (NLP), we identified patterns that can be leveraged to infer TTM stages. Posts suggesting early TTM stages contained negated cessation terms (e.g., "I still haven't quit, but I have been following this sub.") For later TTM stages, posts more commonly contain temporal expressions, in particular, normalized durations in days or years without smoking tobacco relative to their cessation date (e.g., "24 Hours without smoking", and "Wow! I'm a non smoker 1 YEAR"), suggesting accurate mapping of most posts to later TTM stages using NLP is feasible. However, some redditors placed emphasis on the current cessation attempt with regards to their commitment (e.g., ". . . this time is the one. . . " or failure e.g., "I smoked a cigarette last night. I regret nothing."), while others redditors described prior attempts (e.g., ". . . this was my 4th attempt. . . "). These descriptions could pose an interesting challenge when tracking redditor's cessation trajectories through the TTM. To correctly discern current *relapse* from prior *relapse* events, our model may require more advanced temporal modeling and reasoning. We did observe redditors using badges from the forum to gauge their progress and define success in cessation (e.g.,"come back and reset your badge, I certainly had to a couple of times"), but this information was not reliably updated by redditors and hence its usefulness is doubtful.

5 Limitations

Our sample size is small, but we observed several novel smoking cessation strategies, including the use of marijuana and electronic cigarettes as a means to quit tobacco. We will utilize this pilot work in the development of a detailed annotation schema to better understand the relationship between marijuana and electronic cigarettes in the context of tobacco cessation [24]. Given the aim of this pilot study was to determine the feasibility of applying the TTM model to Reddit data, only one author annotated each mention. Future work will involve annotation by multiple domain experts of all redditor's initiating posts (including those that are not top-ranked) over several years and the development of NLP methods for classifying smoking cessation methods and smoking cessation outcomes as TTM stages.

6 Conclusion

In conclusion, we have identified common and emerging tactics used by redditors for tobacco cessation and demonstrated that the TTM model could be leveraged to track and identify successful cessation of tobacco usage within the Reddit population. In the future, we aim to conduct a large-scale corpus annotation study to determine both successful and unsuccessful smoking cessation strategies adopted by redditors.

7 Acknowledgments

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