



Full length article

Time-varying effects of a text-based smoking cessation intervention for urban adolescents



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ABSTRACT

Introduction: Craving to smoke is understood as an important mechanism for continued smoking behavior. Identifying how smoking interventions operate on craving with particular populations is critical for advancing intervention science. This study's objective was to investigate the time-varying effect of a text-delivered smoking cessation intervention.

Methods: Toward this end, we used ecological momentary assessment (EMA) data collected from a five-day, automated text-messaging smoking cessation randomized clinical trial with 200 urban adolescents. We employed a time-varying effect model (TVEM) to estimate the effects of stress (time-varying covariate) and baseline nicotine dependence level (time-invariant covariate) on craving over six months by treatment condition. The TVEM approach models behavioral change and associations of coefficients expressed dynamically and graphically represented as smooth functions of time.

Results: Controlling for gender, age, and current smoking, differences in trajectories of craving between intervention and control conditions were apparent over the course of the study. During months 2 to 3, the association between stress and craving was significantly stronger among the control group, suggesting treatment dampens this association during this time period. The intervention also reduced the salience of baseline dependence among treatment adolescents, with craving being reduced steadily over time, while the control group increased craving over time.

Conclusions: These results provide insight into the time-varying nature of treatment effects for adolescents receiving a text-based smoking cessation intervention. The ability to specify when in the course of an intervention the effect is strongest is important in developing targeted and adaptive interventions that can adjust strategically with time.

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1. Introduction

Understanding interventions focused on tobacco use prevention and cessation among adolescents offers the possibility of preventing adverse health outcomes in adulthood. The earlier a person starts smoking, the more likely he or she is to become an adult smoker (Yu et al., 2012; U.S. Department of Health and Human Services (DHHS), 2012), with 90% of adult smokers reporting that they began smoking prior to age 18 (CDC, 2013). Among racial/ethnic groups, African Americans are at elevated risk for smoking related illness and deaths including cancer (CDC, 2014;

National Cancer Institute, 2008). From 2012 to 2014, African American high school seniors' past 30 day cigarette use has increased from 8.6% to 9.6% while White and Hispanic seniors have reduced their use during the same time period (Johnston et al., 2015). Cigar smoking among African American teens is also on the rise with 16.7% of African American teens smoking cigars—more than twice the 2009 rate (CDC, 2013). Consequently, developing smoking cessation and reduction aids that are available to, and effective for, African American youth is crucial for improving public health and reducing health disparities.

Craving is understood as an important mechanism for continued smoking behavior, and thus needs to be more thoroughly examined (Wray et al., 2013). Identifying how particular smoking interventions operate on craving with particular populations is critical for advancing intervention science. Less is known about

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adolescent craving within the context of randomized clinical trials as compared with adults, with limited research supporting the linkage between craving scores and cigarettes smoked per day (Bagot et al., 2007). Variations in measurement may play a role in understanding craving and smoking behavior. In a recent review of craving, Wray et al. (2013) found support for the statistical use of continuous data in explicating the relationship between predictor variables such as craving and treatment outcomes. While adolescents also experience craving, which has been linked to negative cessation treatment outcomes (Upadhyaya et al., 2004), the connection between adolescent craving and smoking cessation has not been thoroughly researched. Thus, the need exists to better understand the time-varying effects of treatment on craving and its correlates for adolescent smokers.

Closely related to craving is the perception of stress and how these are linked to smoking uptake. These constructs are closely interconnected, where increased levels of perceived stress have been found to activate craving, which then leads to increased smoking (Shiffman et al., 1997). Stress can serve as a trigger of smoking behavior in that smokers use tobacco to reduce tension associated with stress. For example, as many as 50% of smokers indicate that stress contributes to a smoking lapse (Kotlyar et al., 2011). In particular, higher levels of psychosocial stress have been linked with greater odds of continued smoking over the course of a decade in a national cohort of US adults (Slopen et al., 2013). Research has shown that craving is in part, a product of decreased self-efficacy related to the social skills necessary to cope with social stress (Niaura et al., 2002). For adolescents with decreased self-efficacy, interacting with peers may increase perceived stress due to social skills deficit (Myers and Macpherson, 2009). In contrast, social support can serve as a buffer to social stress and has been implicated in reducing relapse in smoking cessation trials (Creswell et al., 2015). Understanding the role of stress on craving within the context of a smoking cessation trial is important for the refinement of interventions. Identifying when stress plays the biggest role in activating craving could provide specific time-windows within an intervention that then could be leveraged for better outcomes.

The growth of mobile technology has begun to offer behavioral health researchers new tools with which to develop novel interventions. Mobile phone-based interventions that are evidence-based, are a recommended approach toward substance use prevention (Abrams et al., 2014; CDC, 2011a; Whittaker et al., 2012). Evidence-based, text-delivered interventions address critical gaps in human-delivered intervention approaches. Text-delivered interventions provide anonymity, in that these can be delivered directly to individuals thereby forgoing the need to come to a provider's office. Text interventions can be delivered any time, allowing for convenient and personalized intervention, and are delivered with 100% fidelity in that there is no drifting from the intervention protocol and no therapist effects to control for. The ubiquitous nature of texting across racial, socioeconomic, and demographic subgroups holds promise to reach underserved populations. Recent research reveals that African Americans utilize texting more than whites, and individuals with lower levels of education and income text more often compared to those with more education and income (Lenhart, 2012).

As evidence grows for the efficacy of text-based behavioral interventions (CDC, 2011b; Cunningham et al., 2011; Mason et al., 2015; Newman et al., 2011), there is a growing need to understand the dynamic mechanisms of change through new analytic approaches. For example, the utilization of mobile technology is capable of producing large, densely packed data sets within clinical trials. Mobile data assessment approaches have allowed researchers to capture these data in real-time such as what is derived from ecological momentary assessment (EMA) methods. EMA methods collect concurrent data within participants' natural

settings, using repeated measurements of momentary states and behaviors which characterize participants' real-world experiences over a given period of time (Shiffman, 2007). Allowing research participants to answer questions about their smoking, craving, stress, etc., with the clause "...right now" decreases recall bias (Shiffman, 2009a) as well as producing a more realistic picture of the individual's experience within the study, the ebbs and flows of moods, cravings, and behaviors.

An important issue to consider when employing EMA methods is that of reactivity, the possible influence that EMA may have on the particular behavior under study, thereby potentially biasing results. EMA methods would appear to be particularly vulnerable to reactivity as assessments are completed repeatedly, in close proximity to the behavior under study, increasing the chance to affect results (Shiffman, 2009b). However, there are studies that have examined EMA reactivity within smoking cessation trials and have found minimal to no behavioral changes due to EMA (Shiffman et al., 2002; Rowan et al., 2007). In a recent study designed to test EMA reactivity within a smoking cessation trial using randomly assigned EMA frequency conditions, researchers found that EMA frequency was unrelated to cessation or prolonged abstinence (McCarthy et al., 2015). Given these findings, it is reasonable to assume that EMA is an appropriate measurement method, particularly for smoking cessation clinical trials.

A new statistical approach that allows for the testing of real-time data and the dynamic associations that unfold over time, is time-varying effect modeling (TVEM). TVEM models behavioral change as coefficients which are expressed dynamically and are graphically represented as smooth functions of time (Lanza et al., 2014b). TVEM is exceptionally well suited for capturing complex change in momentary associations, such as those measured using EMA. This approach does not assume that levels or outcomes or effects of covariates change as a parametric function of time; rather, the direction and potency of coefficients can be estimated as a flexible function of time using EMA that varies across individuals in timing and spacing of observations (Lanza et al., 2014a). The recent developments of a SAS macro suite, %TVEM (Li et al., 2014) allows for fitting models with time-varying effects (see Shiyko et al., 2012 for details).

1.1. Randomized controlled trial results of original study

The current study is a secondary analysis of data from our text-delivered randomized control trial of an adapted Motivational Interviewing-based peer network counseling substance use intervention (Mason et al., 2011). We summarize the trial findings to provide a context for interpreting the current study. We recruited 200 current smoking adolescents (90.5% African American) between the ages of 14 and 18 in the Richmond Virginia area from May 2013 to August 2014 from a community adolescent substance abuse facility (66%), public health clinics (21%), university medical center pediatric clinics (10%), and dorms and high schools (3%) using in-person recruitment and flyers. Adolescents were screened with the Modified Version of the Fagerström Tolerance Questionnaire (Prokhorov et al., 1996), a screening measure that assesses the level of nicotine dependence. Screening scores of 1 were used as a cutoff score to include adolescents with potential tobacco use problems, as well as those with moderate to severe dependence levels. Participants were randomized into an automated texting intervention where they received either the experimental intervention of 30 personalized motivational interviewing-based peer network counseling messages, or the attention control intervention, consisting of text messages covering general (non-smoking related) health habits. The intervention lasted five days targeting urban adolescents. Our intervention followed the U.S. Department of Health and Human Services Clinical

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