TIMEVARYING PREDICTORS OF SMOKING CESSATION AMONG INDIVIDUALS IN TREATMENT FOR ALCOHOL ABUSE AND DEPENDENCE: FINDINGS FROM PROJECT MATCH

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Abstract — Aims: Individuals in treatment for alcohol use disorders are more likely to die from cigarette use than from alcohol consumption. Advanced statistical methodologies that increase study power and clinical relevance have been advocated to examine the timevarying nature of substance use relapse and abstinence, including drinking and smoking. The purpose of this investigation was to examine timevarying factors that are associated with smoking cessation among smokers in the general population, including alcohol use, self-efficacy, and depression, to determine if they were also related to smoking cessation during and after treatment for alcohol use disorders. Methods: Data were garnered from Project MATCH, a longitudinal prospective study of the efficacy of three behavioural treatments for alcohol use disorders. Timevarying covariate analyses were conducted to examine future smoking cessation. Results: Results showed that greater self-efficacy regarding resisting temptations to drink and lower levels of depression were independently associated with increased likelihood of stopping smoking. In contrast, drinks per drinking day and confidence regarding not drinking did not demonstrate such associations. Conclusions: Clinical implications of these findings suggest that interventions to help alcoholics in recovery avoid temptations to drink, as well as decrease depression, may be warranted. By using advanced statistical techniques, these results can help clinicians and organizations working with smokers in treatment for alcohol use disorders to make informed decisions regarding how best to use limited resources.

INTRODUCTION

Studies have suggested that between 60 and 95% of individuals with alcohol use disorders smoke cigarettes, with many tending to be heavy smokers (Burling and Ziff, 1988; Batel et al., 1995; Toneatto et al., 1995). Likewise, smokers are typically heavier drinkers than nonsmokers (Batel et al., 1995; Marks et al., 1997). Although interventions for alcohol problems encourages patients to stop drinking, cigarette use is often not addressed, and smokers are likely to continue smoking during and after treatment. There is mounting evidence that smokers with alcohol use disorders have worse health outcomes than individuals who do not smoke, including greater likelihood of cardiovascular disease and cancer (USDHHS, 1982; Burling et al., 1996, 2001; Hart et al., 1996; John and Hanke, 2002). In fact, smoking is more likely to kill patients in recovery than the alcohol abuse and dependence for which they are seeking treatment (Hurt et al., 1996).

Tobacco dependence treatment has proven to be efficacious in samples of problem drinkers in recovery, although low quit rates suggest that strong interventions are needed (Joseph et al., 1993; Irving et al., 1994; Bobo et al., 1998; Burling et al., 2001). Yet despite high rates of cigarette use and associated morbidity and mortality, clinicians are often reluctant to advise their patients to quit smoking (Hahn et al., 1999; Gil and Bennett, 2000). The majority of such smokers, however, are interested in stopping (Irving et al., 1994; Zullino et al., 2000). Moreover, contrary to popular belief, clinical studies indicate that continued cigarette use may jeopardize sobriety, whereas smoking cessation may enhance abstinence attempts (Joseph et al., 1993; Toneatto et al., 1995).

Certain psychological and clinical factors have been associated with increased likelihood of smoking cessation among smokers in the general population and those with alcohol use disorders in recovery specifically. These include drinking severity (Collins et al., 1993; Tritto et al., 2001; Tsuang et al., 2001), self-efficacy (Stretchter et al., 1986; Bobo et al., 1996) and depression (Kohn et al., 2003).

Drinking severity

The synergism between drinking and smoking can be accounted for by several genetic, physiological, and environmental factors. Both animal and human studies suggest that common genes may influence the prevalence of cross-addictions between alcohol and tobacco (True et al., 1999; Tritto et al., 2001; Heath et al., 2002). Nicotine and other substances also appear to share common physiological reinforcing mechanisms and show additive effects on tolerance and sensitization (Collins et al., 1993; Soderpalm et al., 2000). Smoking may lessen some of the physiological and cognitive effects resulting from alcohol over-consumption or alcohol withdrawal (Tong et al., 1974; Lyon et al., 1975; Leigh et al., 1977; Perkins, 1996; Prendergast et al., 2000). In addition, drinking may trigger smoking urges, and smoking elicit drinking cravings, because of the conditioning mechanisms whereby alcohol is often paired with smoking (e.g. at parties) (Burling et al., 1997; Ellingstad et al., 1997; Palfai et al., 2000; Tsuang et al., 2001; Sayette, 2002). In sum, these results suggest that the high smoking rate among drinkers is related to a constellation of factors that work synergistically.

Self-efficacy

Bandura (1977) describes self-efficacy as a person’s perceived ability to perform on a task as a mediator of performance on future tasks. There is clear evidence that self-efficacy in a specific domain is related to increased likelihood of

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the desired outcome in that domain. Self-efficacy regarding alcohol abstinence has been shown to be a consistent predictor of sobriety. Data from Project MATCH indicated that baseline Temptation and Confidence Alcohol Abstinence Self-Efficacy scores predicted percent of days abstinent and drinks per drinking day for outpatients for up to 3 years post-treatment (DiClemente et al., 2001). Likewise, self-efficacy regarding stopping smoking has been a consistent predictor of successful smoking cessation for smokers in the general population (DiClemente et al., 1985; Stretcher et al., 1986; Grove, 1993; Meland et al., 1999). Whether self-efficacy regarding alcohol use among smokers in recovery translates to quitting smoking is unclear. In addition, if self-efficacy does translate from one domain to another, whether this self-efficacy is due to inner resources around one’s confidence not to drink, or to external manipulation of the environment to reduce behavioural risk of relapse, warrants empirical examination.

**Depression**

A compelling body of research has reported that depressed individuals, including both those in the general population and those with alcohol use disorders specifically, are more likely to smoke, less likely to quit, tend to experience more, and more severe, withdrawal symptoms, and are more likely to relapse to cigarette use than non depressed persons (Covey et al., 1990, 1993; Hughes, 1992; Pomerleau et al., 1997; Hitsman et al., 2002). In addition, there seems to be a reciprocal relationship between cigarette use and affective disorders, such that smoking increases the risk of depression (Almeida and Pfaff, 2005).

**Smoking cessation during treatment for alcohol use disorders**

Our own research, based on data from Project MATCH, showed that, of the 1307 participants who smoked at any point during the study, 12.5% quit during or after treatment (Friend and Pagano, 2005a). Approximately half of those who stopped smoking retained their non smoking status for 6 months or longer. In addition, individuals who stopped smoking were less likely to relapse to alcohol use than individuals who continued smoking. These findings suggest that there may be factors associated with quitting drinking that are associated with smoking cessation.

**Timevarying analyses in addictions research**

Addictive behaviours involve the interplay of psychological, physiological, and environmental factors such as mood, stress, social relationships, and craving, all of which may fluctuate over days, hours, or even minutes. Cross-sectional analyses of the relationships between these timevarying factors cannot adequately capture how these variables influence each other or impact drinking outcomes specifically (Stout and Panapondatos, 2003). Furthermore, analyses that compare only two timepoints cannot reveal when symptoms begin to elevate and subside in relation to a stressful event. Given the limited resources of organizations treating individuals with alcohol use disorders, use of methodologies that mirror real world situations and that can yield clinically meaningful results is vitally needed in the current cost containment realities of a managed care environment.

Our use of timevarying analyses in other studies has allowed us to draw more accurate conclusions from complex, longitudinal data. In an investigation of associations between psychosocial functioning and stress, Pagano et al. (2004) used mixed model analyses to show that Global Assessment of Functioning scores declined in the month following a stressful event and gradually increased to previous levels 6 months after the event. Similarly, in a longitudinal study of the relationship between body dysmorphic disorder and helping behaviours, Pagano et al. (2007) used proportional hazard regression analyses to demonstrate that increases in helping behaviours predicted subsequent remission from both body dysmorphic disorder and substance use disorders.

**Purpose of this paper**

The purpose of this paper is twofold. First, we examine timevarying predictors of smoking cessation, including drinking severity, self-efficacy, and depression, during and after treatment for alcohol use disorders. Our choice of predictors was based in part on the selection of variables that have been shown to be associated with stopping smoking among smokers in the general population. Second, we highlight the use of advanced statistical methodologies, specifically timevarying analyses, to further our understanding of the factors associated with smoking cessation among individuals with alcohol problems who are in recovery. Project MATCH data was ideal for this purpose because of the large sample size (N = 1726), frequency of follow-ups (every 90 days), and prospective data collection. We hypothesized that the following would be positively associated with increased likelihood of quitting smoking: (i) fewer drinks per drinking day; (ii) higher Alcohol Abstinence Self-Efficacy Confidence scores; (iii) lower Alcohol Abstinence Self-Efficacy Temptation scores; and (iv) lower Beck Depression Inventory scores.

**PARTICIPANTS AND METHODS**

Our study was based on Project MATCH, a longitudinal investigation of the efficacies of three different behavioural interventions for individuals with alcohol use disorders that were each delivered over the course of 12 weeks (NIAAA, 2001). No tobacco dependence treatment was offered. Data on timevarying predictor variables were available at baseline and every 3 months for the first 15 months of the project. Project MATCH included 1726 patients with alcohol abuse and dependence in outpatient treatment and aftercare. Participants in outpatient treatment were recruited directly from the community or outpatient centres. Participants from aftercare were enrolled from intensive inpatient or day-hospital programs. Inclusion criteria included participation in either current outpatient treatment or 3 months prior to aftercare and a DSM-III-R diagnosis of alcohol abuse or dependence. Exclusion criteria included current DSM-III-R diagnosis of sedative/hypnotic drug, stimulant, cocaine, or opiate dependence; intravenous drug use during the previous 6 months;
current danger to self or others; symptoms of acute psychosis; and/or severe organic impairment. Participants provided informed consent, in accordance with the standards of the Committee on Human Experimentation with the Helsinki Declaration of 1975 (Project MATCH Research Group, 1993).

MEASURES

Dependent variable
Cigarette use. Cigarette use and smoking cessation were measured using the Form 90-I, developed specifically for Project MATCH (Project MATCH Research Group, 1993). Questions regarding cigarette use included (i) ever cigarette use (yes/no), (ii) number of lifetime weeks of use, and (iii) number of cigarettes smoked per day in the current period (preceding 90 days), which was used to determine whether a participant was a current smoker. A participant with a score of ‘0’ was designated as a current nonsmoker, and a participant with any other score was classified as a current smoker.

Timevarying variables
Drinking severity. Drinking severity was assessed using percent of drinks per drinking day, as measured by the Timeline Follow-Back (TimeLine Follow-Back; Sobell and Sobell, 1992). The TimeLine Follow-Back is a calendar-assisted daily drinking estimation method that provides a comprehensive assessment of a person’s drinking over a designated period (in this investigation, 90 days). It has demonstrated adequate psychometric properties in a variety of patient samples (NIAAA, 1995).

Self-efficacy. Self-efficacy regarding alcohol abstinence was assessed with the Alcohol Abstinence Self-Efficacy Scale (DiClemente et al., 1994). The Alcohol Abstinence Self-Efficacy, based on Marlatt’s cognitive-behavioural model of relapse (1980) is an easily used, psychometrically sound, 20-item self-report measure designed to assess Bandura’s construct of self-efficacy applied to alcohol abstinence. Subjects rate their vulnerability to drink (Temptation Subscale) and confidence to abstain from alcohol (Confidence Subscale) across 20 different high-risk situations on a 5-point Likert scale. For each subscale, a summary score is created that reflects the average score across the 20 high-risk situations. Scores range from 1 to 5, with lower Temptation Subscale scores reflecting lower levels of perceived temptation to drink, and higher Confidence Subscale scores reflecting higher levels of perceived confidence to abstain from alcohol. The correlation between the Temptation and Confidence Subscales was −0.41, suggesting that these subscales measured related but distinct constructs.

Depression. Depression was assessed with the Beck Depression Inventory. The Beck Depression Inventory is one of the most widely used self-report instruments for assessing depression severity (Beck et al., 1961). Each of the 21 items is scored on a 4-point Likert scale ranging from 0 (neutral) to 3 (maximum severity). The Beck Depression Inventory has been used for over 25 years to identify depressive symptoms and has been reported to be highly reliable regardless of the population studied (Beck et al., 1988). It has good internal consistency (coefficient alpha = 0.8), adequate construct validity, and successfully differentiates depressed from non-depressed patients. The items are summed to obtain a total score that can range from 0 to 63, with higher total scores indicating more severe depressive symptoms. Thirteen percent of the sample had a total baseline Beck Depression Inventory score of 20 or more, classifying them as showing moderate to severe depression.

Motivation. Motivation, one of our static variables, was assessed with the University of Rhode Island Change Assessment (University of Rhode Island Change Assessment; DiClemente and Hughes, 1990). The University of Rhode Island Change Assessment, used to assess motivation for change in Project MATCH (Kadden et al., 2003), is a 32-item self-report measure that includes four subscales measuring four stages of change: precontemplation, contemplation, action, and maintenance. Responses are measured on a 5-point Likert scale ranging from 1 (strong disagreement) to 5 (strong agreement). Each subscale contains eight items, with higher subscale scores indicating that someone is higher on that particular stage of change. The University of Rhode Island Change Assessment has shown adequate psychometric properties among individuals in treatment for alcohol use disorders, differentiating patients on use severity, urges to drink, and other relevant variables (DiClemente and Hughes, 1990).

DATA analysis. Statistical analyses were conducted using SAS version 8.0 (SAS Institute Inc., 1999), using PROC FREQ, PROC ANOVA, and PROC PHREG. Depending on the type of variables (continuous or discrete), analysis of variance (ANOVA) or chi-square analyses were performed to evaluate demographic and clinical differences between groups. Covariate static predictors included treatment arm (outpatient or aftercare), gender, age, education, race, ethnicity, marital status, Stage of Change as a proxy for motivation, and lifetime history of cigarette use (lifetime weeks of cigarette use). Our dependent variable, smoking cessation, was calculated using the number of cigarettes smoked daily at each assessment timepoint. Timevarying independent variables; including drinks per drinking day, Alcohol Abstinence Self-Efficacy Temptation and Confidence scores, and Beck Depression Inventory scores; were assessed in the preceding visit to examine smoking cessation in the consecutive visit. Proportional hazards regressions were conducted to determine associations between static predictors, measured only at baseline, and timevarying predictors in relation to the likelihood of quitting smoking. We reported all two-tailed tests with significance values greater than 95% (P < 0.05).

RESULTS

Sample baseline characteristics
Sociodemographic and clinical characteristics of our sample are reported in Table 1. Our final sample consisted of 1193 participants who smoked at baseline and completed the 3-month assessment. There were no significant differences between study participants (N = 1193) and participants who smoked at baseline but did not have complete 3-month data (N = 52) in gender, race, age, education, lifetime weeks of smoking.
More specifically, for each unit increase in the Temptation score, the likelihood of quitting smoking decreased by an estimated 32%. For each unit increase in Beck Depression Inventory score, the likelihood of quitting smoking decreased by an estimated 4%. In contrast, drinks per drinking day and Alcohol Abstinence Self-Efficacy Confidence scores were not significantly associated with stopping smoking.

**DISCUSSION**

Our results showed that some of our hypotheses were confirmed. Consistent with our hypotheses, results indicated that lower Alcohol Abstinence Self-Efficacy Temptation scores and lower Beck Depression Inventory scores were significantly and positively associated with greater likelihood of stopping smoking. In contrast, drinks per drinking day and Alcohol Abstinence Self-Efficacy Confidence scores showed no relation to smoking cessation.

Of the two components of self-efficacy measured, only one, temptation, was significantly associated with smoking cessation, whereas confidence was not. These findings reaffirm that the two Alcohol Abstinence Self-Efficacy subscales represent distinct constructs, which is consistent with Marlatt’s heuristic model of relapse (1980). Marlatt’s model (1980) conceptualizes relapse as having behavioural and cognitive components. The fact that perceived ability to resist drinking temptation was correlated with increased probability of smoking cessation may be attributable in part to the fact that temptation resides in behavioural adjustment to external stimuli in the environment. In addition, these findings suggest that the ability to resist temptations to drink may translate to parallel capacities in a related but separate domain (tobacco use). In contrast, the reason why perceived self-confidence regarding stopping smoking was not a predictor of smoking cessation is unclear. It may be because confidence is based on a cognitive internal self-assessment, as opposed to temptation’s residing in the external environment. Additional investigations that empirically validate this hypothesis are warranted.

Our findings further indicated that decreases in depression were associated with an increased likelihood of quitting smoking. Individuals whose depression improves in the year following alcohol treatment may be more willing to endure the initial discomfort of cigarette withdrawal compared to those whose depression remains constant or worsens (Covey et al., 1997). Patients should be screened and assessed to determine the level of depressive symptoms and, if they appear to be remitting, interventions to help the individual quit smoking should be introduced.

Contrary to our hypothesis, drinking severity was not significantly related to the probability of quitting smoking. There are several factors that might help to account for this outcome. First, our analyses of the static variable motivation, as assessed by the Stages of Change, indicated that individuals with higher sobriety Maintenance scores were significantly more likely to stop smoking than individuals with lower scores. Significant findings were also noted with the Action Stage of Change but in the opposite direction. Scores on the two lower levels of the Stages of Change Ladder were not significantly associated with stopping smoking. Together, these results suggest that individuals who have

| Table 1. Baseline demographic and clinical characteristics Total 1193 (100%) |
|---------------------------------|------------------|
| Gender | Male 909 (76%) Female 284 (24%) |
| Race | Caucasian 969 (81%) African-American 134 (11%) Other 90 (8%) |
| Marital status | Married 370 (31%) Single 823 (69%) |
| Age (M, SD) | 39.12 (10.27) |
| Education (M, SD) | 13.03 (2.03) |
| Lifetime tobacco use, years (M, SD) | 2.96 (1.60) |
| Drinks per drinking day | 17.69 (11.23) |
| Stages of change (M, SD) | Precontemplation 13.19 (4.46) Contemplation 35.68 (3.63) Action 33.61 (4.06) Maintenance 30.31 (5.41) Beck depression inventory (M, SD) 10.44 (8.37) Alcohol Abstinence Self-Efficacy Confidence (M, SD) 2.92 (0.91) Self-efficacy confidence (M, SD) 3.07 (0.91) |

...
successfully decreased their alcohol consumption and are focused on alcohol relapse prevention may be better able to make additional lifestyle modifications, including smoking cessation, than those who are in the process of changing their drinking behaviours or those who are not motivated to address their alcohol consumption. Since participants were roughly evenly distributed across these stages of change, the heterogeneity of the sample in terms of motivation to change drinking behaviours may have masked group differences regarding willingness to change smoking behaviours. Second, the majority of MATCH participants resumed pre-treatment drinking levels 1 year after treatment (Cisler et al., 2005). It is possible then that, if smoking cessation is associated with long-term alcohol abstinence, the lack of relationship between drinking and smoking in this sample is a function of the absence of sobriety maintenance. Third, the tobacco use outcome used in this study was complete smoking cessation, rather than reduction in cigarette consumption levels. In previous work, we have shown that decreases in alcohol consumption are related to reductions in cigarette consumption (Friend and Pagano, 2005b). It is plausible that inclusion of outcomes other than smoking cessation may have yielded different results regarding associations between drinking severity and smoking.

There are several limitations of this study that should be noted. First, we used a conservative approach in determining smoker status (no cigarettes vs one or more cigarettes daily) in order to identify an event of smoking cessation. Second, the number of quit events in the sample limited the number of predictor variables that we could include in our time-varying covariate model. Third, no experimental manipulation was conducted, so our results, while compelling, provide only associations and do not indicate causality. Finally, Project MATCH was not designed to determine which elements are the most important contributors to smoking cessation.

Despite these limitations, our study offers a unique contribution to the literature for several reasons, including the use of novel statistical methods for alcohol and smoking research, timevarying covariate analyses, to examine factors related to quitting smoking during and after treatment for alcohol use disorders and how such factors may interwine over time. Although our investigation cannot establish causality, it adds to the growing number of empirical studies advancing the understanding of how smoking cessation naturally occurs among alcoholics in recovery. Future research is warranted that capitalizes on the methodologies and results of this study to help identify additional clinical characteristics and process mechanisms that are associated with quitting smoking among individuals with alcohol use disorders in recovery.

There are several clinical implications of these results that should be noted. First, these findings suggest that interventions that target only alcohol use may generalize to other maladaptive behaviour, including cigarette use. We anticipate that even more powerful results may have been realized if tobacco dependence treatment had been offered as part of Project MATCH. Second, our results appear to indicate that strategies to increase behaviour skills related to not smoking may yield more beneficial results than efforts to increase self-confidence regarding relapse. Third, findings from the current investigation suggest that smoking cessation interventions are likely to be more successful among individuals who have been abstinent from alcohol use for a period of time. Project MATCH, however, did not include an intervention that targeted tobacco use. Thus, we can form reasonable hypotheses, but experimental studies are merited to examine these issues. Fourth, our findings also suggest that psychological and pharmaceutical interventions to treat depression among alcoholics in recovery appear warranted to increase the likelihood of successful quit attempts, particularly in light of the risk of increased depressive symptoms during the first two- to four-week period of nicotine withdrawal (West et al., 1987; Pomerleau et al., 2001). Given these individuals’ increased vulnerability to cigarette use both because of their alcohol consumption and because of their

<table>
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<tr>
<th>Static variables, baseline</th>
<th>Parameter Variable</th>
<th>Standard Estimate</th>
<th>Chi-Square Error</th>
<th>Pr &gt; ChiSq</th>
<th>Hazard Ratio</th>
<th>95% CI Lower</th>
<th>95% CI Upper</th>
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<tbody>
<tr>
<td>Age</td>
<td>0.04808</td>
<td>0.01170</td>
<td>16.8960</td>
<td>&lt;0.0001</td>
<td>1.049</td>
<td>1.025</td>
<td>1.074</td>
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<td>Marital status</td>
<td>−0.00817</td>
<td>0.06967</td>
<td>0.0138</td>
<td>0.9066</td>
<td>0.992</td>
<td>0.865</td>
<td>1.137</td>
</tr>
<tr>
<td>Gender</td>
<td>−0.36412</td>
<td>0.25981</td>
<td>1.9643</td>
<td>0.1611</td>
<td>0.695</td>
<td>0.418</td>
<td>1.156</td>
</tr>
<tr>
<td>Race</td>
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<td>0.04856</td>
<td>0.0246</td>
<td>0.9101</td>
<td>0.991</td>
<td>0.845</td>
<td>1.121</td>
</tr>
<tr>
<td>Education</td>
<td>0.06151</td>
<td>0.05321</td>
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<td>0.2476</td>
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<td>0.958</td>
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</tr>
<tr>
<td>Treatment arm</td>
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<td>0.23538</td>
<td>0.0911</td>
<td>0.7628</td>
<td>0.931</td>
<td>0.587</td>
<td>1.477</td>
</tr>
<tr>
<td>Lifetime weeks of tobacco use</td>
<td>−0.00208</td>
<td>0.00022</td>
<td>89.1413</td>
<td>&lt;0.0001</td>
<td>0.998</td>
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<tr>
<td>Drinks per drinking day</td>
<td>−0.01081</td>
<td>0.01215</td>
<td>0.7916</td>
<td>0.3736</td>
<td>0.989</td>
<td>0.966</td>
<td>1.013</td>
</tr>
</tbody>
</table>

| Stages of change          |                   |                  |                 |           |            |             |             |
| Maintenance               | 0.05873           | 0.02484          | 5.5921          | 0.0180    | 1.060      | 1.010       | 1.113       |
| Action                    | −0.06545          | 0.03118          | 4.4065          | 0.0358    | 0.937      | 0.881       | 0.996       |
| Contemplation             | −0.05626          | 0.03467          | 2.6331          | 0.1047    | 0.945      | 0.883       | 1.012       |
| Precontemplation          | −0.02559          | 0.02644          | 0.9362          | 0.3333    | 0.975      | 0.926       | 1.027       |

| Time-varying variables, follow-up | Beak depression inventory | −0.03711 | 0.01835 | 4.0893 | 0.0432 | 0.964 | 0.930 | 0.999 |
| Self-efficacy, temptation     | −0.38548          | 0.15329          | 6.3233          | 0.0119    | 0.680      | 0.504       | 0.918       |
| Self-efficacy, confidence     | −0.00385          | 0.10042          | 0.0015          | 0.9694    | 0.996      | 0.818       | 1.213       |
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and abstinence from alcohol and drugs at 12-month follow-up. Drug and Alcohol Dependence 69, 61–71.


