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## The Association between Alcohol Use Trajectories from Adolescence and Cannabis Use Disorder in Adulthood: A 22 Year Longitudinal Study

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### Abstract

**Background**—Due to the increasing prevalence of cannabis use disorder (CUD), the impact of cannabis use on public health may be significant.

**Objective**—The present study seeks the possible precursors (e.g., alcohol use) of CUD in order to minimize the potential negative consequences of CUD such as impaired coordination and performance.

**Method**—The Harlem Longitudinal Development Study included 674 participants (53% African Americans, 47% Puerto Ricans), with 60% females (n=405) from a six wave survey. We used a growth mixture model to obtain the trajectories of alcohol use from mean ages 14 to 36. To examine the associations between alcohol use trajectories and CUDs, we used logistic regression analyses with the indicator of CUD as the dependent variable and the indicator of membership in each trajectory group as the independent variables.

**Results**—A three alcohol use trajectory group model was selected. Male gender, higher frequency of cannabis use in adolescence, and a lower educational level were associated with an increased likelihood of having CUD. Membership in the increasing alcohol use group (OR=27.44,  $p<.01$ ; AOR=15.54,  $p<.01$ ) and the moderate alcohol use group (OR=10.40,  $p<.05$ ; AOR=8.63,  $p<.05$ ) were associated with an increased likelihood of having CUD compared with the membership in the no or low alcohol use group.

**Conclusions**—The findings of our study support the hypothesis that addressing alcohol use at an early age could impact later CUD.

### Keywords

Cannabis use disorder; alcohol use; trajectory analysis; longitudinal study

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### Declaration of Interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this paper.

## Introduction

According to the National Institute on Drug Abuse, 53% of individuals have used cannabis in their lifetime by age 25 years in the United States (1). Although cannabis use may seem to be increasingly accepted as a safe recreational drug that may have medical uses (e.g., legalization in certain states), there are a number of adverse effects from the use of cannabis (2). Cannabis consumption is also associated with an increased risk of motor vehicle crashes, especially fatal collisions (3). Among cannabis users, up to one-third may develop cannabis use disorder (CUD) (4). Research indicated that the past-year prevalence of CUD has increased from the past decades (i.e., 1.2% in 1991–1992, 1.5% in 2001–2002, and 2.9% in 2012–2013) (5, 6). Consequently, the global impact of CUD has also increased. The Global Burden of Diseases, Injuries, and Risk Factors Study 2010 (7) provides new estimates of years of life lost to premature mortality, years lived with disability, and disability-adjusted life years, and the study has resulted in more than 2 million disability-adjusted life years in 2012 (8).

Due to the increasing prevalence of CUD, the impact of cannabis use on public health may be significant. The present study seeks to examine the possible precursors of CUD in order to minimize the potential negative consequences of CUD listed above. Most studies exploring the predictors of substance use disorders have focused on psychopathology at one or two points in time (9, 10). The present study, however, examines an earlier risk factor (i.e., trajectories of alcohol use) assessed at six points in time which may be associated with later CUD.

Past research documented co-occurrence of the use of alcohol and cannabis in adolescence and young adulthood (11–13). More recently, studies have focused on diagnoses instead of a measure of the use of alcohol or cannabis. Indeed, a longitudinal research using 2,493 participants from Mater Hospital and the University of Queensland Study of Pregnancy found that earlier alcohol use in adolescence was associated with an increased odds of later CUD in emerging adulthood (14). In addition, a study which documented the association between alcohol use disorder (AUD) and CUD; that is, the significant pathway from AUDs in adolescence to CUD in young adulthood, has been conducted among 816 individuals who participated in the Oregon Adolescent Depression Project (15). However, there are no studies, to our knowledge, examining a longitudinal pattern of alcohol use from adolescence (age 14) to adulthood (age 36) as a risk factor for CUD in adulthood. The current study proposes to identify patterns of alcohol use during mid- and late-adolescence, emerging adulthood, young adulthood, and adulthood, and will examine their associations with CUD in adulthood.

Besides the use of alcohol, a number of factors (i.e., gender, ethnicity, early cannabis use, and educational level) have been found to be related to CUD. Indeed, several studies have reported that the odds of lifetime CUD were higher for men (16, 17). Also, results based on data from the 2005–2011 National Surveys on Drug Use and Health (N=394,400) showed that the prevalence of CUD is different among Blacks (2.5%) as compared to Hispanics (1.8%) (18). Solitary cannabis use (a percentage of total use episodes) in adolescence

predicted CUD symptoms at age 25 after controlling for demographic variables and the frequency of adolescent cannabis use (19). Lastly, CUD is associated with lower educational attainment (20, 21).

Our study is unique in four ways. First, we assess the use of alcohol to predict CUD among relatively understudied minority groups (i.e., African Americans and Puerto Ricans) living in an urban area. Second, we follow our adolescent sample from mean age 14 to mean age 36, in contrast to the majority of prior research, which has been conducted using samples either of adolescents or adults. Third, we identify the trajectories of alcohol use covering several developmental stages spanning a 22 year period as risk factors for CUD. Fourth, our model examining the association between the trajectories of alcohol use and CUD included demographic factors, cannabis use in adolescence, and educational level which may have an impact on CUD.

We hypothesize that: (1) alcohol users will be divided into at least four trajectory groups that represent a) chronic alcohol use, b) moderate alcohol use, c) increasing alcohol use, and d) non- or low-alcohol use, (2) the higher levels of alcohol use trajectory groups (i.e., the chronic alcohol use trajectory group, the moderate user group, the increasing user group) will be associated with a greater likelihood of CUD when compared to the non- or low-alcohol use trajectory group, and (3) the association between earlier alcohol trajectories and later CUD will be maintained after controlling for confounding factors (e.g., early cannabis use in adolescence).

## Method

### Participants

The 6<sup>th</sup> wave of data collection was completed by 674 participants (53% African Americans; AA, 47% Puerto Ricans; PR). Sixty percent were females (n=405). The original purpose of the Harlem Longitudinal Development Study was to examine the predictors and consequences of substance use among African American and Puerto Rican adolescents. Data on the participants were first collected in 1990 (time 1; T1, N=1,332) when the participants were students attending schools in the East Harlem area of New York City. At T1, the questionnaires were administered in classrooms under the supervision of the study research staff with no teachers present. The mean age of the participants at T1 was 14.1 years (standard deviation; SD=1.3 years; inter-quartile range from 13 to 15 years). At time 2 (T2; 1994 – 1996; N=1,190), the National Opinion Research Center interviewed the participants in person or by phone. The mean age of the participants at this wave was 19.2 years (SD=1.5 years; inter-quartile range from 18 to 20 years). At time 3 (T3; 2000 – 2001; N=662 – due to budgetary limitations, we used a subsample of T2 participants), the Survey Research Center of the University of Michigan collected the data. The mean age of the participants at T3 was 24.4 years (SD=1.3 years; inter-quartile range from 23 to 25 years). At time 4 (T4), time 5 (T5), and time 6 (T6), the data were collected by our research group. At T4 (2004 – 2006; N=838), the mean age was 29.2 years (SD=1.4 years; inter-quartile range from 28 to 30 years). At T5 (2007 – 2010; N=816), the average age of the participants was 32.3 years (SD= 1.3 years; inter-quartile range from 31 to 34 years). At T6 (2011 – 2013; N=674), the

average age of the participants was 35.9 years (SD= 1.4 years; inter-quartile range from 35 to 37 years).

The Institutional Review Board (IRB) of the XXXX approved the study for T4, T5 and T6, and the IRBs of the XXXX and XXXX approved the study's procedures for data collection in the earlier waves (T1, T2, and T3). A Certificate of Confidentiality was obtained from the National Institute on Drug Abuse at T1-T4 and T6 and from the National Cancer Institute at T5. At each time wave, we obtained informed assent or consent from all of the participants. Additional information regarding the study methodology is available from a previous report (22).

At T6, we attempted to follow-up all those who participated at T1. We compared the demographic variables for the 674 adults who participated at both T1 and T6 with the 658 who participated at T1 but not at T6. There were no significant differences between the T6 non-participants and the T6 participants in the proportion of African Americans and Puerto Ricans (55% AA among the T6 non-participants vs. 51% AA among the T6 participants,  $\chi^2(1) = 0.18, p=0.7$ ), the frequency of cannabis use at T1 (1.15 among the T6 non-participants vs. 1.16 among the T6 participants,  $t=0.79, p=0.4$ ), and the frequency of alcohol use at T1 (0.30 among the T6 non-participants vs. 0.23 among the T6 participants  $t=0.82, p=0.4$ ). However, the percentage of males among T6 non-participants (53%) was significantly higher than the percentage of males who participated at T6 (40%) ( $\chi^2(1) = 26.06, p<.001$ ).

## Measures

### Control variables at T1

- a) Gender (1=female, 2=male)
- b) Ethnicity (1=African American, 2=Puerto Rican)
- c) Cannabis use was a single item, i.e., "How often have you ever used cannabis?" with a 5-point ordinal scale that ranged from "never" to "once a week or more."

### Control variable at T6

- d) Educational level was a single item "What is the last year of school you completed? The answer options were: 11<sup>th</sup> grade or below (0), 12<sup>th</sup> grade or GED (1), business or technical school (2), college freshman (3), college sophomore or associate's degree (4), college junior (5), college senior (Bachelor's degree) (6), postgraduate business, law, medical, masters, or doctoral programs (7).

**Alcohol use (T1–T6)**—The participants reported on their use of alcohol at each wave between T1 and T6. Participants were asked "How often do you drink beer, wine, or hard liquor?" at T1 and "On average, how many drinks (beer, wine, or hard liquor) did you have in the past 5 years?" at T2 through T6 with a 5-point ordinal scale that ranged from: none (0), less than once a week (1), once a week to several times a week (2), 1 or 2 drinks everyday (3), and three or more drinks every day (4).

**Cannabis use disorder (CUD) at T6**—Cannabis use disorder was diagnosed (23) if the participant answered yes to 2 or more of the following 11 questions: In the past 5 years, a) did you ever find that you had to use more cannabis to get the same effect that you did when you first started taking it?; b) when you reduced or stopped using cannabis, did you have withdrawal symptoms (e.g., aches, shaking, fever, weakness, diarrhea, nausea, sweating, heart pounding, difficulty sleeping, or feeling agitated, anxious, irritable or depressed) or did you use alcohol or sedatives to keep yourself from getting sick (withdrawal symptoms)?; c) did you find that when you used cannabis you ended up taking more than you thought you would?; d) did you try to reduce or stop taking cannabis but failed?; e) on the days that you used cannabis, did you spend a lot of time obtaining, using, or recovering from cannabis, or thinking about cannabis?; f) did you spend less time working, enjoying hobbies, or being with family or friends because of your cannabis use?; g) did you keep on using cannabis even though it caused you health or mental problems?; h) has being repeatedly intoxicated, high, or hungover from cannabis when you had other responsibilities at work or at home caused problems for you?; i) were you, more than once, high or intoxicated from cannabis in any situation where you were physically at risk-like when driving a car, using knives or machinery, crossing against traffic, or swimming?; j) did you have legal problems (e.g., an arrest or disorderly conduct) more than once because of your use of cannabis?; and k) did you keep on using cannabis even though it caused problems with your family or other people?

**Analytic Procedure**—We utilized a growth mixture model to obtain the trajectories of alcohol use from T1 to T6 using Mplus software (24). Alcohol use at each point in time was treated as a censored normal variable. We applied the full information maximum likelihood approach for missing data (24). We used the optimal Bayesian Information Criterion (BIC) to estimate the number of trajectory groups, and each participant was assigned to the trajectory group with the largest Bayesian posterior probability (BPP) to produce Figure 1.

To examine the associations of membership in a trajectory group, we used logistic regression analyses (25) with the indicator of CUD as the dependent variable and the indicator of membership in each trajectory group and the control variables as the independent variables. The membership in the no or low alcohol trajectory group was used as the reference variable. Gender, ethnicity, cannabis use at T1, and educational level at T6 were used as control variables. Cannabis use at T1 and educational level at T6 were also treated as categorical variables in the bi-variate logistic regression analyses.

## Results

The mean and SD scores of alcohol use at each point in time were 0.2 (0.4), 0.7 (0.7), 1.2 (0.9), 1.0 (0.9), 1.3 (0.9), and 1.3 (1.0) for T1-T6, respectively. We computed solutions for 2 through 5 trajectory groups. The BICs for each number of groups were 9374, 9151, 9134, and 9126 for 2, 3, 4, and 5 group models, respectively. We chose the 3 trajectory group model because the 4 and 5 trajectory group model had a group which had less than the 5% estimated prevalence even though each of those models had a smaller BIC than that of the 3 trajectory group model (See Figure 1). After assigning each participant to the group with

modal BPP, the mean BPP of the groups ranged from 0.89 to 0.99, which indicated a good classification.

As shown in Figure 1, we labeled the three alcohol use trajectory groups as follows. The no or low alcohol use trajectory group had an estimated prevalence of 8% and included participants who reported no use of alcohol at age 14, use of alcohol much less than once a week (i.e., on average 0.4 use) at ages 19 and 24, and no use at ages 29, 32, and 36. The moderate alcohol use group included participants who reported almost no use of alcohol at age 14, but use of alcohol less than once a week at age 19, and much less than several times a week thereafter. This group had an estimated prevalence of 83%. The increasing alcohol use group included participants who reported almost no use of alcohol at age 14, but use of alcohol less than once a week at age 19 (i.e., on average 1.0 use), more than several times a week at ages 24, less than one or two drinks a day at age 29, less than three or four drinks a day at age 32, and about one or two drinks a day at age 36. This group had an estimated prevalence of 9%.

Table 1 contains the means, SDs, or percentages in each trajectory group for the variables used in this study. Table 2 presents the odds ratios (OR) without the control variables and adjusted odds ratios (AOR) with the control variables for CUD at T6. Males had a greater likelihood of having CUD than females (OR=3.76,  $p<.001$ ; AOR=2.99,  $p<.001$ ). More frequent cannabis use at T1 was associated with an increased likelihood of CUD at T6 (OR=1.31,  $p<.05$ ; AOR=1.31,  $p<.05$ ). Higher educational level at T6 was associated with a decreased likelihood of having CUD at T6 (OR=0.79,  $p<.001$ ; AOR=0.85,  $p<.01$ ). Membership in the increasing alcohol use trajectory group (OR=27.44,  $p<.01$ ; AOR=15.54,  $p<.01$ ) and for the moderate alcohol use trajectory group (OR=10.40,  $p<.05$ ; AOR=8.63,  $p<.05$ ) were associated with an increased likelihood of having CUD at T6 compared with the membership in the no or low alcohol use trajectory group.

## Discussion

Our data showed a higher prevalence of CUD (16.8%) than in another study (2.5% Blacks, 1.8% Hispanics) (18). In contrast to the study by Wu and colleagues (18) who used the DSM-IV criteria for the past year CUD, we followed the Diagnosis Statistical Manual (DSM) – 5 criteria for the past 5 year CUD.

Our hypotheses are partially supported by the findings. As regards the first hypothesis, we obtained 3 trajectory groups of alcohol use (i.e., increasing, moderate, and no or low alcohol use trajectory groups). However, the chronic alcohol use trajectory group did not emerge. This might be due to the fact that our data included the use of alcohol in mid adolescence (mean age 14). The results examining the association between the trajectories of alcohol use and CUD provide support for the last two hypotheses.

Our results indicate a greater likelihood of CUD among males than among females. This is consistent with findings from several investigators (16, 26, 27). Males and females experience different pressures to endorse typical male and female behaviors and attitudes reflecting masculinity and femininity during gender role socialization. In the U.S. and many

other societies, for example, males are encouraged to engage in substance use (28). It may be that risk-taking in the form of substance use is an effective means for acquiring, maintaining, and restoring manhood status (29). This might explain in part why men are more likely to have CUD than women.

No statistical ethnic difference has been found in terms of having CUD in our data. The proportion of African American increased from 47.3% in the no or low alcohol use group to 54.4% in the increasing alcohol use group. Research showed that residential neighborhood characteristics have an impact on the use of cannabis (30, 31). All participants in our sample, however, grew up under similar circumstances since they were attending schools in the East Harlem area of New York City, and most of them still reside in an urban area. Thus, our participants may have been exposed to the same environmental influences (e.g., school, neighborhood) on cannabis use regardless of their ethnicity. In contrast, a study reporting a difference in the prevalence of CUD between Blacks and Hispanics, even it is not a huge, used a sample drawn from different states which provided totally different residential neighborhood characteristics (18).

There is evidence that early cannabis use increases the risk for CUD. Indeed, our findings show that cannabis use in mid adolescence is still associated with CUD in the mid thirties. A number of basic science research studies using animals shows cannabis' subsequent potential for addiction in later life (32–35). In a related vein, adolescent responses to the use of substances (e.g., cannabis) might be understood utilizing a biobehavioral perspective.

With regard to the educational level, our findings are consistent with the results from other research papers (21). The heavy cannabis users might have exhibited lower educational attainment because chronic cannabis intoxication seriously compromised their academic functioning. Alternatively, pre-morbid traits, such as limited career aspirations, might predispose individuals to lower educational attainment.

Adolescent substance use is one of the noticeable behaviors of an underlying addiction-prone diathesis associated with conduct problems (36, 37), and may be associated with an increased risk of problematic behaviors such as misuse or abuse of alcohol, and other drugs later in life. This perception is also consistent with Problem Behavior Theory, which posits that some individuals possess a personality proneness, environmental proneness, and behavioral proneness to engage in multiple problem behaviors such as substance abuse that depart from social and legal norms and can result in social reproof or social rejection (38, 39).

## Limitations

The sample consisted of an African American and Puerto Rican inner city population. Further studies should include other ethnic groups for generalization to the U.S. population. The significant drop out rate of the male participants might affect the results given the relationship between gender, alcohol use and CUD. While problematic polysubstance use is evident, the current study focuses on CUD only. Our data are also based on self-reports which can lead to biased results since people may under-report their experiences with drug

use. However, studies have shown that the use of this type of self-report data yields reliable results (40).

Despite these limitations, the study supports and adds to the literature on this topic in a number of ways. First, we assess alcohol use at six points in time over a span of up to 22 years, whereas most research studies in this area focus on one point in time. The prospective nature of the data allowed us to go beyond a cross-sectional analysis and to consider the temporal sequencing of variables. Second, a major contribution of the study is a unique set of findings associated with different trajectories of alcohol use beginning in adolescence as related to adult CUD in a sample of African Americans and Puerto Ricans living in an urban area of New York City. Third, the association between earlier alcohol use trajectories and later CUD was maintained after controlling for gender, ethnicity, and cannabis use at age 14, and educational level at age 36.

## Conclusions

The clinical implications of this study for prevention of CUD may focus on the early use of both cannabis and alcohol. Prevention efforts must occur prior to the development of CUD. It is clear that CUD is the final stage of progression of behaviors starting with substance intention, followed by initiation, sporadic experimentation, regular use, and finally substance abuse or dependence. Our findings indicated that early cannabis use is a significant risk factor for CUD. Thus, delaying initiation is a reasonable prevention goal.

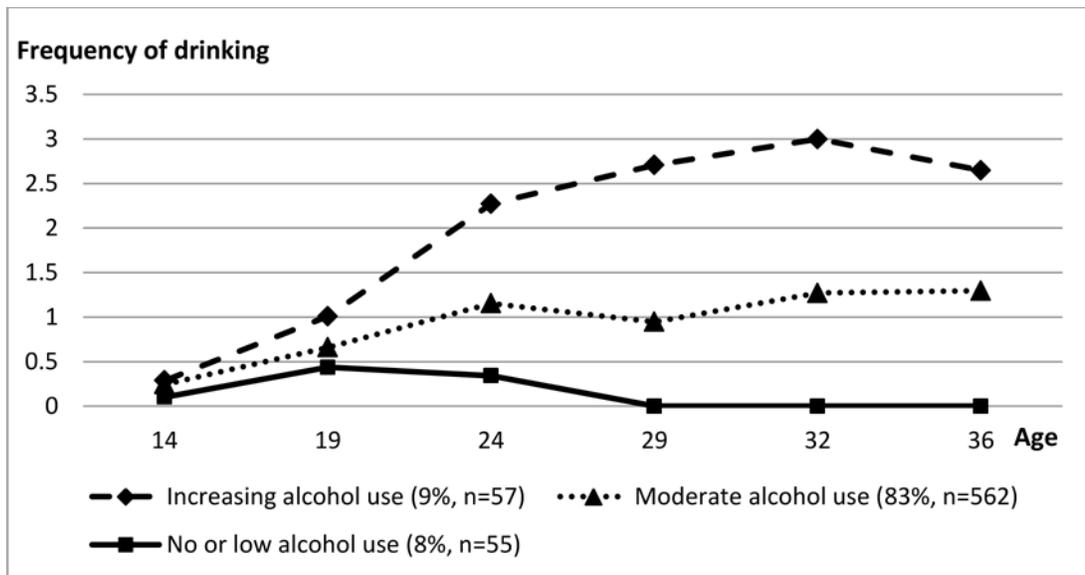
As policy shifts toward legalization of cannabis use for recreational purposes, it is reasonable to expect that its use will increase and that, by extension, so will the number of persons for whom there will be negative health consequences (21). Our longitudinal study was designed to examine the association between earlier alcohol use trajectories and later CUD. The findings of our study support the hypothesis that addressing alcohol use at an early age could impact later CUD.

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**Figure 1. Trajectories of alcohol use from adolescence to the mid thirties**

Note: Answer options for alcohol use at T1 (mean age 14) through T6 (mean age 36): none (0), less than once a week (1), once a week to several times a week (2), one or two drinks a day (3), and three or more drinks a day (4)

**Table 1**

Summary statistics (means with standard deviations, or percentages) by each of the three alcohol use trajectory groups

	<b>Increasing alcohol use trajectory group (9%, n=57)</b>	<b>Moderate alcohol use trajectory group (83%, n=562)</b>	<b>No or low alcohol use trajectory group (8%, n=55)</b>	<b>Whole sample (N=674)</b>
<i>Control variables</i>				
Gender-Female	31.6% (n=18)	61.9% (n=348)	70.9% (n=39)	60.1% (n=405)
Ethnicity-African American	54.4% (n=31)	53.2% (n=299)	47.3% (n=26)	52.8% (n=356)
Cannabis use at T1	1.2 (0.7)	1.2 (0.7)	1.1 (0.3)	1.2 (0.7)
Educational level at T6	2.1 (2.2)	3.1 (2.3)	3.6 (2.6)	3.1 (2.3)
<i>Dependent variable</i>				
Cannabis use disorder at T6	35.1% (n=20)	16.4% (n=92)	1.8% (n=1)	16.8% (n=113)

Note. Answer options for cannabis use at T1 were: never (0), a few times a year or less (1), about once a month (2), several times a month (3), once a week or more (4).

Answer options for educational level were: 11th grade or below (0), 12th grade or GED (1), business or technical school (2), college freshman (3), college sophomore or associate's degree (4), college junior (5), college senior (Bachelor's degree) (6), postgraduate business, law, medical, masters, or doctoral programs (7).

**Table 2**

Odds ratios (OR) and adjusted odds ratios (AOR) with 95% confidence interval for trajectories of alcohol use with nonusers as the reference group on cannabis use disorders (CUDs) at T6

N=674	CUDs at T6	
	OR (95% CI)	AOR (95% CI)
Gender	3.76 (2.45, 5.77)***	2.99 (1.90, 4.70)***
Ethnicity	1.08 (0.72, 1.62)	1.01 (0.65, 1.55)
Cannabis use at T1	1.31 (1.03, 1.68) *	1.31 (1.00, 1.70) *
Educational level at T6	0.79 (0.72, 0.88)***	0.85 (0.77, 0.95)**
Increasing alcohol use trajectory group T1–T6 vs. No or low alcohol use trajectory group T1–T6	27.44 (3.51, 214.31)**	15.54 (1.95, 124.14)**
Moderate alcohol use trajectory group T1–T6 vs. No or low alcohol use trajectory group T1–T6	10.40 (1.42, 76.18)*	8.63 (1.16, 64.01)*

Notes: 1. Male gender and Puerto Ricans coded higher number.

2. \*  $p < 0.05$ ; \*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$

3. T1=time 1 (mean age 14); T6= time 6 (mean age 36)

4. The Wald chi-square test statistics also showed the significant associations with CUDs when cannabis use at T1 ( $\chi^2(4) = 10.05, p < 0.05$ ) and educational level at T6 ( $\chi^2(7) = 22.34, p < 0.01$ ) were treated as categorical variables in the bi-variate logistic regression analyses.