Empirical Article

Clinical Psychological Science
2016, Vol. 4(6) 1028–1046

DOI: 10.1177/2167702616630958
cpx.sagepub.com

Persistent Cannabis Dependence and Alcohol Dependence Represent Risks for Midlife Economic and Social Problems: A Longitudinal Cohort Study

Magdalena Cerdá[1], Terrie E. Moffitt[2,3,4], Madeline H. Meier[5], HonaLee Harrington[2,3], Renate Houts[2,3], Sandhya Ramrakha[6], Sean Hogan[6], Richie Poulton[6], and Avshalom Caspi[2,3,4]

[1]Department of Emergency Medicine, School of Medicine, University of California–Davis; [2]Department of Psychology and Neuroscience, Duke University; [3]Department of Psychiatry and Behavioral Sciences, Duke University Medical Center; [4]Social, Genetic, and Developmental Psychiatry Centre, Institute of Psychiatry, King's College London; [5]Department of Psychology, Arizona State University; and [6]Dunedin Multidisciplinary Health and Development Research Unit, Department of Psychology, University of Otago

Abstract

With the increasing legalization of cannabis, understanding the consequences of cannabis use is particularly timely. We examined the association between cannabis use and dependence, prospectively assessed between ages 18 and 38, and economic and social problems at age 38. We studied participants in the Dunedin Longitudinal Study, a cohort (N = 1,037) followed from birth to age 38. Study members with regular cannabis use and persistent dependence experienced downward socioeconomic mobility, more financial difficulties, workplace problems, and relationship conflict in early midlife. Cannabis dependence was not linked to traffic-related convictions. Associations were not explained by socioeconomic adversity, childhood psychopathology, achievement orientation, or family structure; cannabis-related criminal convictions; early onset of cannabis dependence; or comorbid substance dependence. Cannabis dependence was associated with more financial difficulties than was alcohol dependence; no difference was found in risks for other economic or social problems. Cannabis dependence is not associated with fewer harmful economic and social problems than alcohol dependence.

Keywords

cannabis, drug/substance abuse, adult development, antisocial behavior, epidemiology, longitudinal methods

Received 12/5/14; Revision accepted 1/9/16

The benefit and harm associated with cannabis, the most widely used illegal drug in the world, are subject to fierce debate (Degenhardt & Hall, 2012). Understanding the effects of cannabis is particularly timely today, given that historical shifts are taking place in cannabis policy. In 2013, Uruguay legalized the sale, production, and distribution of cannabis. Four states in the United States have legalized recreational use of cannabis; the District of Columbia approved a ballot initiative, which will be subject to congressional review, that legalizes recreational marijuana use; and 15 more states are considering legalizing recreational marijuana. Perceptions about the riskiness of cannabis have also changed: In the United States, the proportion of adolescents who perceive cannabis as risky has decreased to 45% (Substance Abuse and Mental Health Services Administration, SAMHSA, 2012).

Aside from the implications that cannabis use may have for physical and mental health (Callaghan, Allebeck,

Corresponding Author:
Magdalena Cerdá, Department of Emergency Medicine, School of Medicine, University of California, Davis, 2315 Stockton Blvd., Sacramento, CA, 95817
E-mails: cerda@ucdavis.edu; magda.cerda@gmail.com

& Sidorchuk, 2013; Hall & Degenhardt, 2009; Hancox et al., 2010; Lev-Ran et al., 2014; Pletcher et al., 2012; Thomson et al., 2008), long-term, heavy cannabis use may be associated with economic and social problems, such as unemployment, lost productivity, and lower financial stability (Brook, Lee, Finch, Seltzer, & Brook, 2013; Degenhardt, Chiu, Sampson, Kessler, & Anthony, 2007; Fergusson & Boden, 2008; Schmidt, Weisner, & Wiley, 1998). In addition, cannabis use has been linked to lower relationship satisfaction and domestic violence, although evidence is inconsistent (Brook et al., 2013; Brook, Whiteman, Finch, & Cohen, 1996; Dornbusch, Lin, Munroe, & Bianchi, 1999; Ellickson & McGuigan, 2000; Fergusson & Boden, 2008; Newcomb & Bentler, 1988). Cannabis use by drivers has also been associated with increased risk of motor vehicle crashes (Li et al., 2012), but lack of control for confounding, particularly by concurrent alcohol use, remains a significant concern (Elvik, 2013; Room, Fischer, Hall, Lenton, & Reute, 2010).

A key unaddressed element in the debate about the consequences of cannabis relates to the relative impact of cannabis versus alcohol on economic and social problems. Experts have proposed that heavy alcohol use has more adverse economic and social consequences than does heavy cannabis use (Babor et al., 2010; Editorial Board, 2014; Nutt, King, Phillips, & Independent Scientific Committee on Drugs, 2010; van Amsterdam, Opperhuizen, & Koeter, 2010; Weissenborn & Nutt, 2012). For example, in qualitative comparisons of substances in terms of the severity of social effects associated with heavy use, particularly traffic injuries and violence, researchers have rated alcohol use as more harmful than cannabis use (Babor et al., 2010). However, studies in which researchers quantitatively compared the economic and social impact of the two substances in the same population offer conflicting evidence: One study reported that the two substances had comparable effects on relationships, delinquency, and education (Tucker, Ellickson, Orlando, Martino, & Klein, 2005), whereas another showed that heavy cannabis-only users had worse social problems than did heavy alcohol-only users (Patton et al., 2007).

Evidence about the social and economic consequences of long-term heavy cannabis use comes from population-based longitudinal studies primarily focused on the impact of adolescent cannabis use on outcomes. Although such studies have established a temporal relation between cannabis use and economic and social problems, five key limitations remain. First, cannabis use and economic and social problems could share common antecedents related to socioeconomic adversity, childhood psychopathology, low achievement orientation, and family structure (Macleod et al., 2004). A second limitation is the potential for misclassification of cannabis use: In most studies, researchers relied solely on measures of use frequency, which provide no information about the intensity or duration of cannabis use and which could be key determinants of later outcomes. A third limitation relates to the illegal nature of cannabis use: It is unclear whether adverse social and economic outcomes associated with cannabis use are a result of cannabis use itself or of being convicted for a cannabis-related offense. Fourth, persistence of cannabis use is highly confounded by the timing of onset of use—those individuals who are chronic users are also more likely to have started early. Fifth, in prior studies, researchers have not established whether observed associations between cannabis use and later social and economic problems are unique to cannabis or are due to comorbid hard-drug and alcohol use among cannabis users.

We studied a birth cohort of 947 individuals to test whether persistent cannabis dependence, as well as regular cannabis use, prospectively assessed from ages 18 to 38, is associated with downward social-class mobility, financial difficulties, antisocial behavior in the workplace, relationship conflict, and traffic convictions. We also compared the relative impact of cannabis dependence versus alcohol dependence on the same economic and social problems. With the increasing legalization of marijuana, comparisons of its economic and social impact with that of alcohol—the most commonly used, and legal, substance—is of critical policy importance.

Method

Study participants

Participants are members of the Dunedin Multidisciplinary Health and Development Study, a longitudinal investigation of the health and behavior of a representative birth cohort of consecutive births between April 1972 and March 1973 in Dunedin, New Zealand (Poulton, Moffitt, Silva, 2015). The cohort of 1,037 children (91% of eligible births; 52% boys, 48% girls) was constituted at age 3. The cohort represents the full range of socioeconomic status on New Zealand's South Island and matches the New Zealand National Health and Nutrition Survey on adult health indicators (e.g., body mass index, smoking, general practitioner visits; Poulton et al., 2006). Cohort members are primarily White; approximately 7% self-identify as having any non-White ancestry, which matches the South Island. Follow-up assessments were conducted at ages 5, 7, 9, 11, 13, 15, 18, 21, 26, 32, and, most recently, 38 (during 2010–2012), when 95% of the 1,007 living study members underwent assessment.

This report is based on 947 participants (94% of 1,007 study members still alive) who completed at least three of the five adult cannabis assessments from ages 18 to 38, including the assessment at age 38. Study members not

currently in a relationship were excluded from analyses of relationship conflict (n = 81). Homemakers, full-time students, and welfare recipients (n = 161) were excluded from analyses of workplace behavior. (Relationship and employment status did not differ across cannabis-dependence groups.)

Study measures

Cannabis use ages 18 to 38. Past-year cannabis dependence was assessed at ages 18, 21, 26, 32, and 38 with the Diagnostic Interview Schedule (Robins, Cottler, Bucholz, North, & Rourke, 1999, 2002; Robins, Helzer, Croughan, & Ratcliff, 1981) following *Diagnostic and Statistical Manual of Mental Disorders* criteria (4th ed., *DSM–IV*; American Psychiatric Association, 1994). Prior assessment waves did not measure cannabis dependence and regular cannabis use. At the age 18 and 21 assessments, cannabis dependence was diagnosed by using *DSM–III–R* criteria (3rd ed., rev.; American Psychiatric Association, 1987), whereas at the age 26, 32, and 38 assessments, cannabis dependence was assessed by using *DSM–IV* criteria. Our main exposure, persistence of cannabis dependence, was defined as the number of study waves at which a study member met criteria for dependence: (a) never used cannabis at any study wave, (b) used cannabis at least once at one or more study waves but never diagnosed, (c) diagnosed at one wave, (d) diagnosed at two waves, and (e) diagnosed at three or more waves. In this case, *persistence* is defined as a mix of chronic, relapsing, and recurrent dependence, hereafter referred to as persistent to be consistent with prior publications of this study (Meier et al., 2012; Moffitt, Caspi, et al., 2007; Moffitt, Harrington, et al., 2007).

Given that some study members used cannabis on a regular basis but never met criteria for cannabis dependence, we repeated the analyses with persistent regular cannabis use as the exposure (ascertained identically at all ages). Persistence of regular cannabis use was defined as the number of study waves at which a study member reported using cannabis 4 or more days per week: (a) never used cannabis, (b) used but never regularly, (c) used regularly at one wave, (d) used regularly at two waves, and (e) used regularly at three or more waves (Meier et al., 2012).

The Dunedin Study uses past-year reporting to maximize validity and reliability of recall. Past research by this and other groups (Moffitt et al., 2010; Takayanagi et al., 2014) has shown that repeated prospective assessments of psychiatric symptoms provide more accurate estimates of lifetime psychiatric disorder rates than do cross-sectional studies. The longitudinal design may offer the conditions necessary for participants to be forthcoming, given that participants who have been interviewed repeatedly learn to trust the confidentiality guarantee of the study (Moffitt et al., 2010). Dunedin's prevalence of cannabis dependence has been verified by the Christchurch New Zealand longitudinal study (Boden, Fergusson, & Horwood, 2006).

A potential consequence of using past-year reports is that individuals could have experienced dependence only during a gap between the study's five 12-month assessment windows and gone uncounted. Our "net" of 1-year assessments at ages 18, 21, 26, 32, and 38 years captured all but 4 of the cohort members who reported receiving treatment for a drug-use problem between assessment windows. Three of the 4 were hard-drug and alcohol dependent, and the remaining person sought counseling for cannabis use only as part of a child custody dispute. Given that these 4 cohort members reported cannabis use but not dependence, they were classified as "used but never diagnosed" (Meier et al., 2012).

Alcohol dependence ages 18 to 38. Past-year alcohol dependence was assessed at ages 18, 21, 26, 32, and 38 with the Diagnostic Interview Schedule (Robins et al., 1981; Robins et al., 1999, 2002) following *DSM–IV* criteria. Our main exposure, persistence of alcohol dependence, was defined as the number of study waves at which a study member met criteria for dependence: (a) no dependence at any study wave, (b) diagnosed at one wave, (c) diagnosed at two waves, and (d) diagnosed at three or more waves (Meier et al., 2013). Given that only 7% of study members had never consumed alcohol, study members who had never used alcohol and those who used but were not dependent were combined into one group.

Economic and social problems age 38. We used measures of social-class mobility, financial difficulties, antisocial behavior in the workplace, relationship conflict, and traffic convictions to characterize economic and social problems at age 38. These measures are described in the following sections.

Change in social class. Childhood social class was defined as the average of the highest occupational status level of either parent across study assessments from the study member's birth through 15 years (1 = unskilled laborer; 6 = professional) on New Zealand's occupational rating of the 1970s (Elley & Irving, 1976). Adulthood social class was assigned based on the study member's current or most recent occupation at age 38, and the same 6-point scale, updated in 2006 (Milne, Byun, & Lee, 2013), was used. Examples of occupations in the six categories include medical practitioner, legal professional (6); financial broker, engineering professional (5); database administrator, electrician (4); printing trades worker, personal assistant (3); office cashier, floor finisher (2); cleaner, fish filleter (1). Change scores were computed

by subtracting the child social class from the adult social class.

Financial difficulties. Measures of financial difficulties included net worth, troubles with debt and cash flow, difficulty to pay basic expenses, food insecurity, welfare benefit receipt, and credit ratings. For the measure of *net worth*, study members were asked to estimate the value of 10 different types of personal assets (e.g., rental property, managed funds, home ownership) as well as 6 different types of debt value (e.g., mortgage, student loans, credit card bills, other unpaid bills). Assets and debts were each summed, and net worth was calculated by subtracting debts from assets. Net worth was deciled. To assess *troubles with debt and cash flow*, interviewers asked study members about 8 types of trouble with debt and with cash flow (e.g., being turned down for a credit card, defaulting on a credit card payment, missing a bill, mortgage, or loan payment). The number of troubles was summed (α = .59). For the measure of *difficulty to pay basic expenses*, study members reported whether they had difficulty meeting the costs of 12 basic expenses (e.g., rent, mortgage, or contribution for keep; bills for things such as insurance, phone, or heating; α = .91). To assess *food insecurity*, interviewers asked study members about food insecurity and classified them as food secure versus food insecure by using the short form of the USDA Household Food Security Survey Module (Economic Research Service, 2012; α = .84). Linked New Zealand government records (via the New Zealand Ministry of Social Development) were used to determine *welfare benefit receipt* by ascertaining whether study members received any of the following welfare benefits: unemployed benefit, invalids benefit, sickness and emergency benefits, domestic purposes benefit–sole parent and emergency maintenance allowance, training benefit, and emergency benefit (for those individuals who did not usually meet entitlement conditions). Only one benefit could be received at any given time. The measure of *credit ratings* assessed creditworthiness by linking to administrative records of study members' credit scores, which were acquired from the Veda Company, the largest credit reference agency in New Zealand and Australia. The proprietary Veda score is a numerical expression based on an analysis of a person's credit history that represents the creditworthiness of the person.

Antisocial behavior in the workplace. Measures of antisocial behavior in the workplace included interpersonal deviance, productivity deviance, and property deviance (Piquero & Moffitt, 2012). For the measure of *interpersonal deviance*, study members reported about four forms of interpersonal problems in the workplace (e.g., lying to get a job, quitting without notice, having conflicts with coworkers; α = .52). For the measure of *productivity deviance*, study members reported about nine counterproductive behaviors in the workplace (e.g., taking an additional/longer break than acceptable, purposely working slower than one could have; α = .59). *Property deviance* was assessed through study members' reports about seven forms of property-related deviance (e.g., stealing money, reporting working hours or days that they did not work; α = .33).

Relationship conflict. Measures of relationship conflict included relationship quality, intimate-partner physical abuse, and intimate-partner controlling abuse. The measure of *relationship quality* included 28 questions about shared activities and interests, balance of power, respect and fairness, emotional intimacy and trust, and open communication (α = .93). For the measure of *intimate-partner physical abuse*, study members reported about perpetration of and victimization by 13 forms of physical abuse in the past year (e.g., slapping, strangling, kicking, hitting; αs = .72 and .84 for perpetration and victimization, respectively). Participants who reported perpetrating at least 1 form of physical abuse were classified as perpetrators; those experiencing at least 1 form of physical abuse were classified as victims (Ehrensaft, Moffitt, & Caspi, 2004). For the measure of *intimate-partner controlling abuse*, study members reported about perpetration of and victimization by 12 forms of controlling behavior (e.g., telling a partner that he or she could not work or study, stopping a partner from seeing family or friends, following or stalking; αs = .49 and .68, respectively). Participants who reported perpetrating at least 1 form of controlling abuse were classified as perpetrators; those experiencing at least 1 form of controlling abuse were classified as victims (Ehrensaft, Langhinrichsen-Rohling, Heyman, O'Leary, & Lawrence, 1999).

Traffic convictions. Linked New Zealand government records (via the New Zealand Ministry of Justice criminal and traffic history database) were used to determine whether study members were convicted of traffic offenses between ages 32 and 38 years (including excess blood alcohol, speeding, driving without a license, causing injury, and hit and run).

Because financial difficulties, workplace behavior, and relationship conflict were assessed via multiple measures—and to avoid concerns about multiple testing—the primary analyses of these three domains were conducted by using a summary composite measure of each. A confirmatory factor analysis was conducted by using full information maximum likelihood in Mplus 7.11: The three outcome domains were covaried in a single model. This allowed us to properly estimate factor scores by using a mix of categorical and continuous indicators. The three-factor model fit the data well: $\chi^2(74, N = 961) = 175.63$, $p = .0000$, root-mean-square error of approximation = .038 (95%

confidence interval = [.031, .045]), comparative fit index = .976, Tucker-Lewis index = .971.

Higher factor scores denote more adverse problems; for example, a higher factor score for relationship conflict denotes lower relationship quality, more partner physical violence, and more partner controlling behavior.

Potential confounders. Although this observational study cannot confirm causation, we used covariates to address leading alternative explanations based on theory and a review of the literature (Rutter & Academy of Medical Sciences Working Group, 2007). Analyses controlled for sex, ethnicity, social class of origin, family history of substance dependence, low childhood self-control, childhood IQ, adolescent psychopathology (depression and conduct disorder), and achievement orientation at age 18. These variables were chosen to separate out the effect of persistent cannabis dependence from the constellation of risk factors that could increase both cannabis dependence and adult economic/social problems. Furthermore, to establish an equitable comparison of adult problems, we controlled for differences in study members' adult family structure (marital status and number of children). Table S1 in the online Supplemental Material provides measurement details and reports about the associations of the control variables with cannabis dependence and economic and social problems.

A measure of early (i.e., by age 18) versus late (i.e., ages 21–38) onset of cannabis dependence was used to test whether the associations between cannabis dependence and later problems were due to earlier onset of cannabis dependence.

Measures of alcohol and hard-drug dependence were used to test whether the observed associations between cannabis use and later problems were due to comorbid hard-drug and alcohol use among cannabis users. We assessed alcohol dependence at ages 18, 21, 26, 32, and 38 years and hard-drug dependence (e.g., heroin, cocaine, amphetamines) at ages 26, 32, and 38 years. Persistent alcohol dependence was defined as dependence at three or more waves, whereas persistent hard-drug dependence was defined as dependence at two or more waves.

Statistical analysis

Our analysis followed five major steps. First, we used linear (in the case of change in social class, financial difficulties, workplace behavior, and relationship conflict) or logistic (in the case of traffic convictions) regression to test whether persistent cannabis dependence predicted each economic/social problem independent of all aforementioned covariates. Second, we tested whether associations between persistent cannabis dependence and midlife problems were due to cannabis-related court conviction by restricting our analyses to study members with no history of cannabis-related convictions. Third, we tested whether persistent cannabis dependence's prediction of midlife problems depended on the age of onset of cannabis dependence. Fourth, we tested whether associations between persistent cannabis dependence and midlife problems were due to comorbid alcohol and hard drug dependence by restricting analyses to study members with no history of persistent alcohol or hard-drug dependence. Fifth, we compared the magnitude of the association of persistent cannabis dependence and persistent alcohol dependence with each economic/social problem. For this analysis, and to establish comparability between the alcohol- and cannabis-user groups, we compared four groups for each of the two substances: (a) no dependence at any study wave, (b) diagnosed at one wave, (c) diagnosed at two waves, and (d) diagnosed at three or more waves. We used the "test" command in proc glm to conduct two nonsymmetric tests: (a) testing whether the regression coefficients estimated for cannabis dependence were different from the regression coefficients that had been estimated for alcohol dependence (H_{01}: $\beta_{cannabis} = \beta_{alcohol}$) and (b) testing whether the regression coefficients estimated for alcohol dependence were different from the regression coefficients for cannabis dependence (H_{02}: $\beta_{alcohol} = \beta_{cannabis}$). Results were replicated with persistence of regular cannabis use as the exposure variable.

Results

Cannabis and economic and social problems

Persistent cannabis users experienced downward social-class mobility (see full-cohort results of upward and downward social-class mobility in Fig. 1a and Fig. S1 in the Supplemental Material). At age 38, study members diagnosed with cannabis dependence at one, two, and three or more waves ended up 0.34, 0.40, and 0.79 rungs lower, respectively, than their parents (on New Zealand's 6-point occupation scale; standard deviation of the social-class difference = 1.50), whereas those who did not use cannabis ended up 0.20 rungs higher than their parents (see Table 1 for associations between cannabis dependence and midlife economic and social problems). As a sensitivity test, we restricted our analysis to study members reared in middle-class homes. On average, persistent cannabis users from middle-class origins attained lower adult socioeconomic status than did their parents, even after we controlled for sex, ethnicity, family substance-dependence history, childhood self-control, childhood IQ, history of psychopathology, achievement orientation, and adult family structure. Figure 1b shows the results of this restricted analysis and indicates that

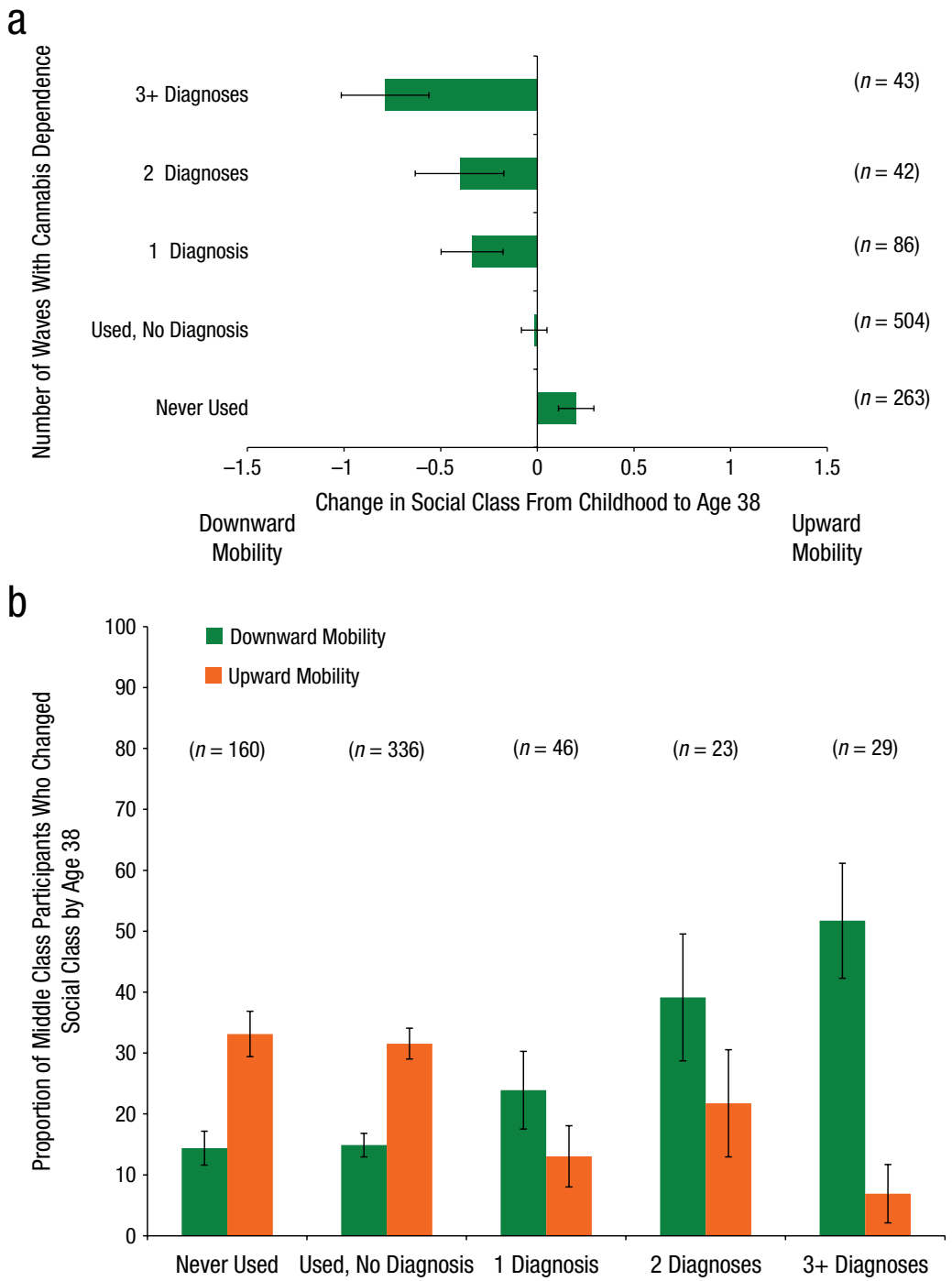


Fig. 1. Social-class mobility as a function of persistence of cannabis dependence in the full cohort and a subsample. The graph in (a) shows change in social class from childhood to age 38 in the full cohort. In a model adjusting for sex, European ancestry, proportion of first-degree relatives with substance dependence, low childhood self-control, childhood IQ, adolescent psychopathology (major depressive disorder and conduct disorder), achievement orientation at age 18, living with partner or spouse at age 38, and number of children at age 38, study members with more persistent cannabis dependence exhibited larger social-class decline than did members with no dependence ($b = -0.16$, $SE = 0.06$, $t = -2.76$, $p = .006$). Analysis results shown in (b) are restricted to a subsample of study members who grew up in middle-class families. Outcomes are the observed proportion of members who experienced a decline from childhood middle-class origins (Classes 3 and 4) to a lower adult social class (Classes 1 and 2), as well as the proportion of members who experienced an increase to a higher adult social class (Classes 5 and 6). Findings in this subsample ($b = -0.14$, $SE = 0.07$, $t = -2.17$, $p = .031$) replicated results from the full sample shown in (a). Error bars represent standard errors.

Table 1. Economic and Social Problems at Age 38, Given Persistence of Cannabis Dependence From Ages 18 to 38 (n = 947)

Economic/social problem	No cannabis use (n = 266)		Cannabis use, no dependence (n = 508)		Dependence at 1 phase (n = 86)		Dependence at 2+ phases (n = 44)		Dependence at 3+ phases (n = 43)		Effect Size (r)	Linear trend test[a,b]	p	Linear trend test[a,c]	p
	M	95% CI	M	95% CI	M	95% CI	M	95% CI	M	95% CI					
Social mobility[d]	0.20 (0.09)		–0.02 (0.07)		–0.34 (0.16)		–0.40 (0.23)		–0.79 (0.23)		.13	–4.06	< .0001	–2.76	.006
Financial difficulties[e,f]	–0.20 (0.06)		–0.11 (0.04)		0.40 (0.10)		0.78 (0.14)		0.86 (0.14)		.31	10.03	< .0001	5.93	< .0001
Antisocial behavior in workplace[f,g]	–0.29 (0.07)		–0.04 (0.05)		0.36 (0.11)		0.81 (0.17)		0.69 (0.17)		.26	7.48	< .0001	4.98	< .0001
Relationship conflict[f,h]	–0.24 (0.06)		–0.06 (0.04)		0.52 (0.11)		0.44 (0.16)		0.72 (0.16)		.25	7.55	< .0001	4.34	< .0001
Traffic convictions[e] (%)	0.3	[0.0, 2.0]	2.4	[1.3, 4.4]	9.2	[4.3, 19.7]	19.8	[8.8, 45.0]	11.5	[4.4, 29.7]	.37	27.53	< .0001	3.35	.0671

Note: Standard errors are shown in parentheses. Mean z scores and proportions are taken from crude linear or logistic regression models. Test statistics and means can be used to calculate effect sizes. From t tests, effect sizes can be calculated as $r = \sqrt{[t^2/(t^2 + df)]}$. From means, effect sizes can be calculated as Cohen's $d = M1 - M2 / \sqrt{[(\text{Standard Deviation}_1^2 + \text{Standard Deviation}_2^2)/ 2]}$. From odds ratios (in the case of traffic convictions), effect sizes can be calculated as ln(OR)/1.81. Please recall that effect sizes can be interpreted as small (r = .1 or d = 0.2), medium (r = .3 or d = 0.5), and large (r = .5 or d = 0.8). CI = confidence interval.

[a]All statistical tests are t tests with an independent variable (i.e., number of waves with cannabis dependence) coded 0 to 4 and with n – 1 degrees of freedom except for traffic convictions, in which Wald chi-square tests with 1 degree of freedom were used. All tests were obtained from regression models. [b]Data were adjusted for sex. [c]Data were adjusted for sex, European ancestry, parental socioeconomic status, proportion of first-degree relatives with substance dependence, low childhood self-control, childhood IQ, adolescent psychopathology (major depressive disorder and conduct disorder), achievement orientation at age 18, living with partner or spouse at age 38, and number of children at age 38. [d]Data represent change in social class from childhood to age 38 (not adjusted for parental socioeconomic status). [e]Data were adjusted for percentage of months in New Zealand from ages 32 to 38. [f]Data are z scores (M = 0, SD = 1). [g]Analyses were restricted to respondents who were currently or formerly employed (n = 786). [h]Analyses were restricted to study members currently in a relationship (n = 866).

51.7% of formerly middle-class persistent cannabis users experienced downward mobility compared with 14.4% of study members who never used cannabis. In contrast, whereas 33.1% of formerly middle-class study members who never used cannabis experienced upward mobility, only 6.9% of persistent cannabis users did so.

Persistent cannabis users experienced more financial difficulties, engaged in more antisocial behavior in the workplace, and reported more relationship conflict (see Table 1). Persistent cannabis dependence was fairly uniformly associated with multiple economic and social difficulties rather than with any specific difficulty (tables with results are available at moffittcaspi.com).

Results of analyses for persistent cannabis dependence and persistent regular use were similar (see Table S2 in the Supplemental Material).

Associations between persistent cannabis dependence and social and economic problems remained statistically significant after we controlled for potential confounders with one exception: The association between persistent cannabis dependence and traffic convictions became nonsignificant (see Table 1).

The association between cannabis dependence and social and economic problems was not due to the inclusion of never users in the analysis. Instead, associations between persistent cannabis dependence and social and economic problems remained statistically significant after we removed never users from the sample (see Table S3 in the Supplemental Material). Furthermore, we found evidence of a linear relationship between levels of cannabis dependence and social and economic problems (see Table S4 in the Supplemental Material). With the exception of traffic convictions, "departure-from-linearity" tests were not significant, which led us to conclude that "variability of the sample means around the best fitting straight line is assumed to represent error variability" (Kirk, 2013, p. 217).

Is the association between persistence of cannabis dependence and economic and social problems due to criminal conviction of cannabis users?

According to the New Zealand Ministry of Justice database, 7.0% of Dunedin Study members were convicted of cannabis-related offenses (possession, sale, or cultivation). Persistent cannabis users were more likely to be convicted of these offenses—$\chi^2(4, N = 941) = 201.05$, $p < .0001$. However, having a conviction record did not account for the association of persistent cannabis dependence with downward social mobility, financial difficulties, workplace problems, or relationship problems. Even among cannabis users who were never convicted for a cannabis offense, persistent cannabis use was significantly linked to these economic and social problems (see Table 2 for associations).

Is the association between persistence of cannabis dependence and economic and social problems due to early onset of cannabis use?

Study members who were persistently dependent on cannabis were more likely to have earlier ages of dependence onset; for example, 61% of those dependent on three or more waves versus 24.4% of those dependent at one wave had experienced onset by age 18, $\chi^2(4, N = 934) = 370.33$, $p < .0001$, raising the possibility that the findings depended on early onset. To test this premise, we estimated crude and adjusted associations between persistence of cannabis dependence and midlife problems with controls for early cannabis-dependence onset (i.e., by age 18). Age of onset did not account for the association of persistent cannabis dependence with economic and social problems (see Table 3 for associations).

Is the association between persistence of cannabis dependence and economic and social problems due to co-occurrence of persistent alcohol or hard-drug dependence?

Cannabis dependence often co-occurs with dependence on other licit and illicit substances. Dunedin Study members who were dependent on cannabis were more likely during the course of their lives to be dependent on alcohol than were study members who were not dependent on cannabis (69.9% vs. 26.7%), and the longer study members were dependent on cannabis, the longer they were dependent on alcohol ($r = .44$, $p < .0001$). Similarly, study members who were dependent on cannabis were more likely to be dependent on hard drugs than were study members who were not dependent on cannabis (11.6% vs. 0.5%), and the longer they were persistent on cannabis, the longer they were dependent on hard drugs ($r = .23$, $p < .0001$). Such comorbidity raises the possibility that associations observed with cannabis dependence actually reflect alcohol or hard-drug effects.

Figure 2 compares the association between persistent cannabis dependence and midlife economic and social problems in the full cohort and in three subsamples that exclude from analysis those study members who (a) had persistent alcohol dependence, (b) had persistent hard-drug dependence, and (c) had either persistent alcohol or persistent hard-drug dependence (adjusted associations are presented in Table S5 in the Supplemental Material). In general, the exclusion of study members with persistent alcohol or hard-drug dependence had very little

Table 2. Economic and Social Problems at Age 38, Given Persistence of Cannabis Dependence From Ages 18 to 38, Among Respondents With No History of Cannabis Convictions (n = 877)

Economic/social problem	No cannabis use (n = 262)		Cannabis use, no dependence (n = 494)		Dependence at 1 phase (n = 64)		Dependence at 2+ phases (n = 34)		Dependence at 3+ phases (n = 23)		Linear trend test[a,b]	p	Linear trend test[a,c]	p
	M	95% CI	M	95% CI	M	95% CI	M	95% CI	M	95% CI				
Social mobility[d]	0.21 (0.09)		0.01 (0.07)		–0.22 (0.18)		–0.15 (0.26)		–0.83 (0.31)		–3.00	.003	–2.85	.005
Financial difficulties[e,f]	–0.21 (0.06)		–0.13 (0.04)		0.43 (0.12)		0.71 (0.16)		0.66 (0.19)		7.59	< .0001	5.02	< .0001
Antisocial behavior in workplace[f,g]	–0.29 (0.07)		–0.04 (0.05)		0.35 (0.13)		0.66 (0.18)		0.49 (0.23)		5.87	< .0001	4.32	< .0001
Relationship conflict[f,h]	–0.24 (0.06)		–0.06 (0.04)		0.38 (0.13)		0.32 (0.18)		0.60 (0.22)		5.53	< .0001	3.58	.0004
Traffic convictions[e] (%)	0.3	[0.0, 2.0]	2.0	[1.0, 4.1]	6.9	[2.6, 18.3]	13.3	[4.6, 38.0]	3.4	[0.4, 26.6]	12.12	.0005	2.84	.09

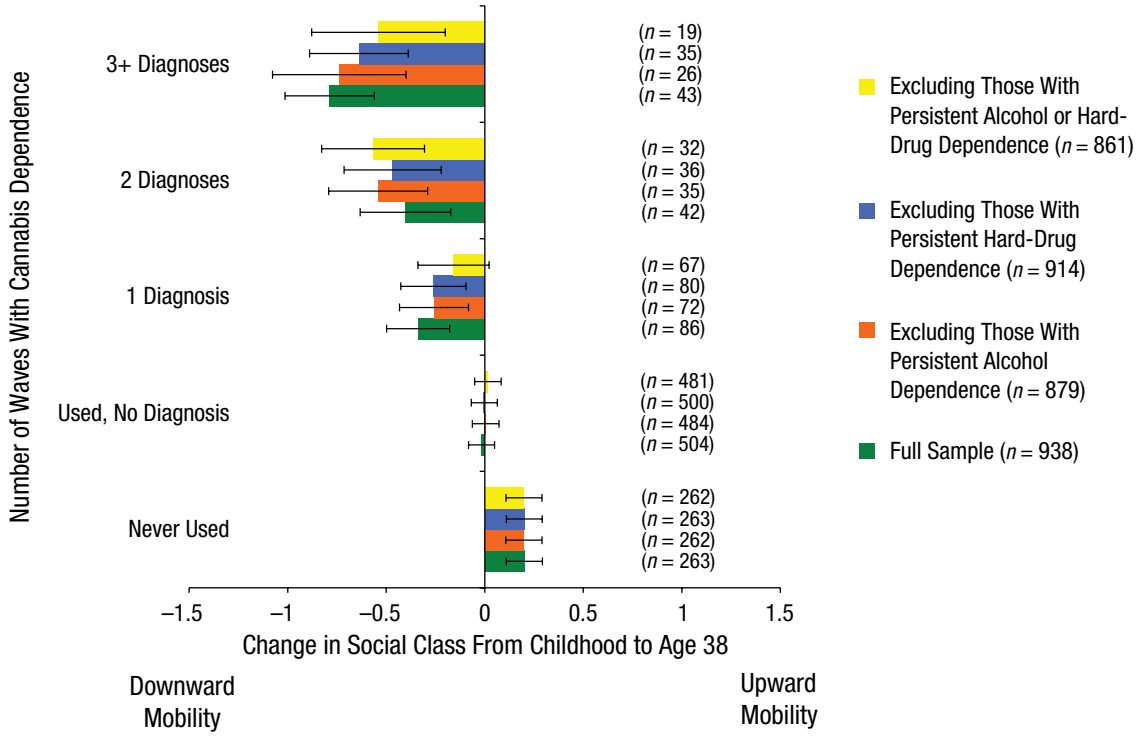
Note: Standard errors are shown in parentheses. Mean z scores and proportions are taken from crude linear or logistic regression models. CI = confidence interval.
[a]All statistical tests are t tests with an independent variable (i.e., number of waves with cannabis dependence) coded 0 to 4 and with n – 1 degrees of freedom except for traffic convictions, in which Wald chi-square tests with 1 degree of freedom were used. All tests were obtained from regression models. [b]Data were adjusted for sex. [c]Data were adjusted for sex, European ancestry, parental socioeconomic status, proportion of first-degree relatives with substance dependence, low childhood self-control, childhood IQ, adolescent psychopathology (major depressive disorder and conduct disorder), achievement orientation at age 18, living with partner or spouse at age 38, and number of children at age 38. [d]Data represent change in social class from childhood social class of origin to social class at age 38 (not adjusted for parental socioeconomic status). [e]Data were adjusted for percentage of months in New Zealand from ages 32 to 38, given that some study members lived outside New Zealand for spells during this time period. [f]Data are z scores. [g]Analyses were restricted to study members currently employed (n = 735). [h]Analyses were restricted to study members currently in a relationship (n = 803).

Table 3. Economic and Social Problems at Age 38, Given Persistence of Cannabis Dependence From Ages 18 to 38 (With Controls for Age of Cannabis-Dependence Onset)

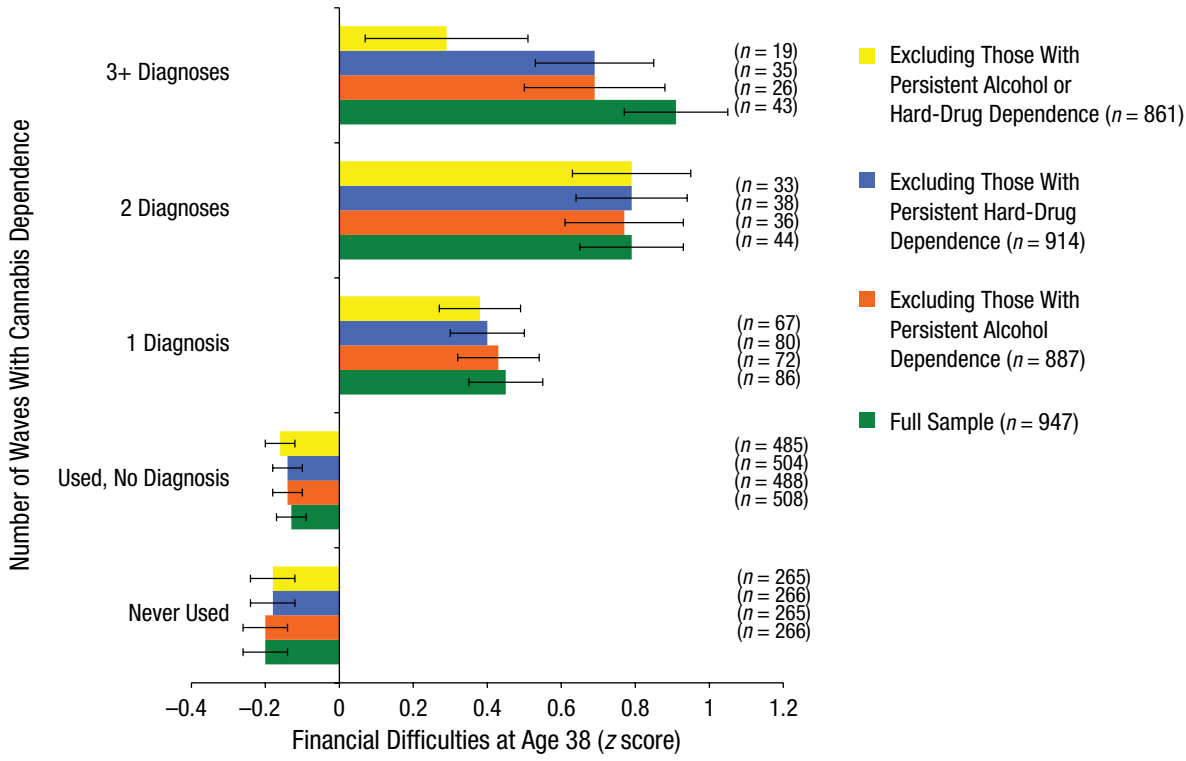
Economic/social problem	No cannabis use		Cannabis use, no dependence		Dependence at 1 phase		Dependence at 2+ phases		Dependence at 3+ phases		Linear trend test[a,b]	*p*	Linear trend test[a,c]	*p*
	M	95% CI	*M*	95% CI	*M*	95% CI	*M*	95% CI	*M*	95% CI				
Crude model														
n	266		508		86		44		43					
Social mobility[d]	0.20		–0.02		–0.34		–0.40		–0.79		–4.06	< .001		
	(0.09)		(0.07)		(0.16)		(0.23)		(0.23)					
Financial difficulties[e,f]	–0.20		–0.11		0.40		0.78		0.86		10.03	< .0001		
	(0.06)		(0.04)		(0.10)		(0.14)		(0.14)					
Antisocial behavior in workplace[f,g]	–0.29		–0.04		0.36		0.81		0.69		7.48	< .0001		
	(0.07)		(0.05)		(0.11)		(0.17)		(0.17)					
Relationship conflict[f,h]	–0.24		–0.06		0.52		0.44		0.72		7.55	< .0001		
	(0.06)		(0.04)		(0.11)		(0.16)		(0.16)					
Traffic convictions[e] (%)	0.3	[0.0, 2.0]	2.4	[1.3, 4.4]	9.2	[4.3, 19.7]	19.8	[8.8, 45.0]	11.5	[4.4, 29.7]	27.53	< .0001		
Crude model (with controls for early onset of cannabis dependence)														
n	266		508		78		41		41					
Social mobility[d]	0.18		–0.04		–0.18		–0.29		–0.57		–2.34	.02		
	(0.09)		(0.07)		(0.17)		(0.25)		(0.27)					
Financial difficulties[e,f]	–0.21		–0.12		0.46		0.88		1.01		8.39	< .0001		
	(0.06)		(0.04)		(0.11)		(0.15)		(0.17)					
Antisocial behavior in workplace[f,g]	–0.28		–0.03		0.34		0.82		0.63		5.60	< .0001		
	(0.07)		(0.05)		(0.12)		(0.19)		(0.20)					
Relationship conflict[f,h]	–0.24		–0.06		0.47		0.45		0.81		6.05	< .0001		
	(0.06)		(0.05)		(0.12)		(0.18)		(0.19)					
Traffic convictions[e] (%)	0.2	[0.0, 1.9]	2.2	[1.1, 4.3]	7.3	[3.0, 18.0]	20.4	[8.0, 51.5]	12.0	[3.9, 36.9]	21.61	< .0001		
Adjusted model (with controls for early onset of cannabis dependence)														
n	228		468		70		37		37					
Social mobility[d]	0.09		–0.08		0.13		–0.21		–0.24				–1.18	.24
	(0.09)		(0.07)		(0.18)		(0.26)		(0.29)					
Financial difficulties[e,f]	–0.15		–0.07		0.32		0.54		0.79				5.35	< .0001
	(0.06)		(0.04)		(0.11)		(0.15)		(0.17)					
Antisocial behavior in workplace[f,g]	–0.20		–0.01		0.19		0.55		0.39				3.69	.0002
	(0.07)		(0.05)		(0.13)		(0.20)		(0.22)					
Relationship conflict[f,h]	–0.18		–0.04		0.35		0.21		0.48				3.58	.0004
	(0.07)		(0.05)		(0.12)		(0.19)		(0.20)					
Traffic convictions[e] (%)	0.0	[0.0, 0.9]	0.1	[0.2, 1.7]	1.0	[0.2, 4.1]	3.8	[0.8, 17.3]	0.5	[0.1, 4.0]			3.83	.050

Note: Standard errors are shown in parentheses. Mean *z* scores and proportions are taken from crude linear or logistic regression models. CI = confidence interval.
[a]All statistical tests are *t* tests with an independent variable (i.e., number of waves with cannabis dependence) coded 0 to 4 and with $n - 1$ degrees of freedom except for traffic convictions, in which Wald chi-square tests with 1 degree of freedom were used. All tests were obtained from regression models. [b]Data were adjusted for sex. [c]Data were adjusted for sex, European ancestry, parental socioeconomic status, proportion of first-degree relatives with substance dependence, low childhood self-control, childhood IQ, adolescent psychopathology (major depressive disorder and conduct disorder), achievement orientation at age 18, living with partner or spouse at age 38, and number of children at age 38. [d]Data represent change in social class from childhood to age 38 (not adjusted for parental socioeconomic status). [e]Data were adjusted for percentage of months in New Zealand from ages 32 to 38. [f]Data are *z* scores ($M = 0$, $SD = 1$). [g]Analyses were restricted to respondents who were currently or formerly employed ($n = 786$ in crude model; $n = 773$ when adjusted for early onset of cannabis dependence; $n = 705$ in adjusted model). [h]Analyses were restricted to study members currently in a relationship ($n = 866$ in crude model; $n = 854$ when adjusted for early onset of cannabis dependence; $n = 769$ in adjusted model).

a

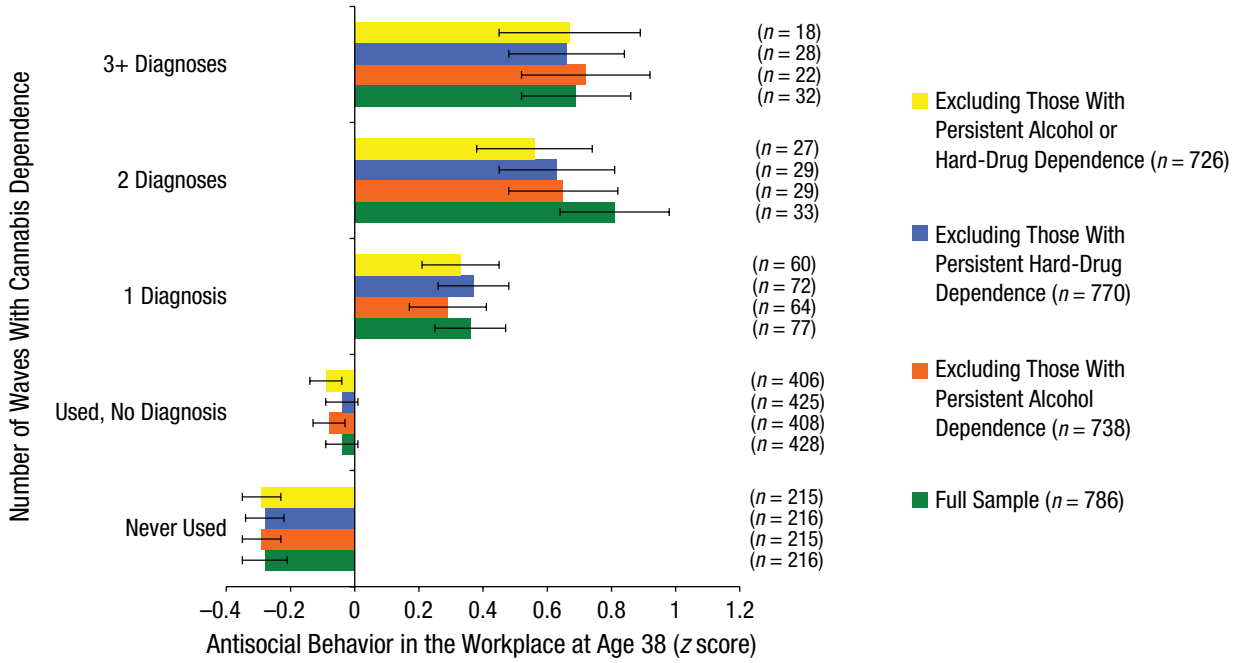


b

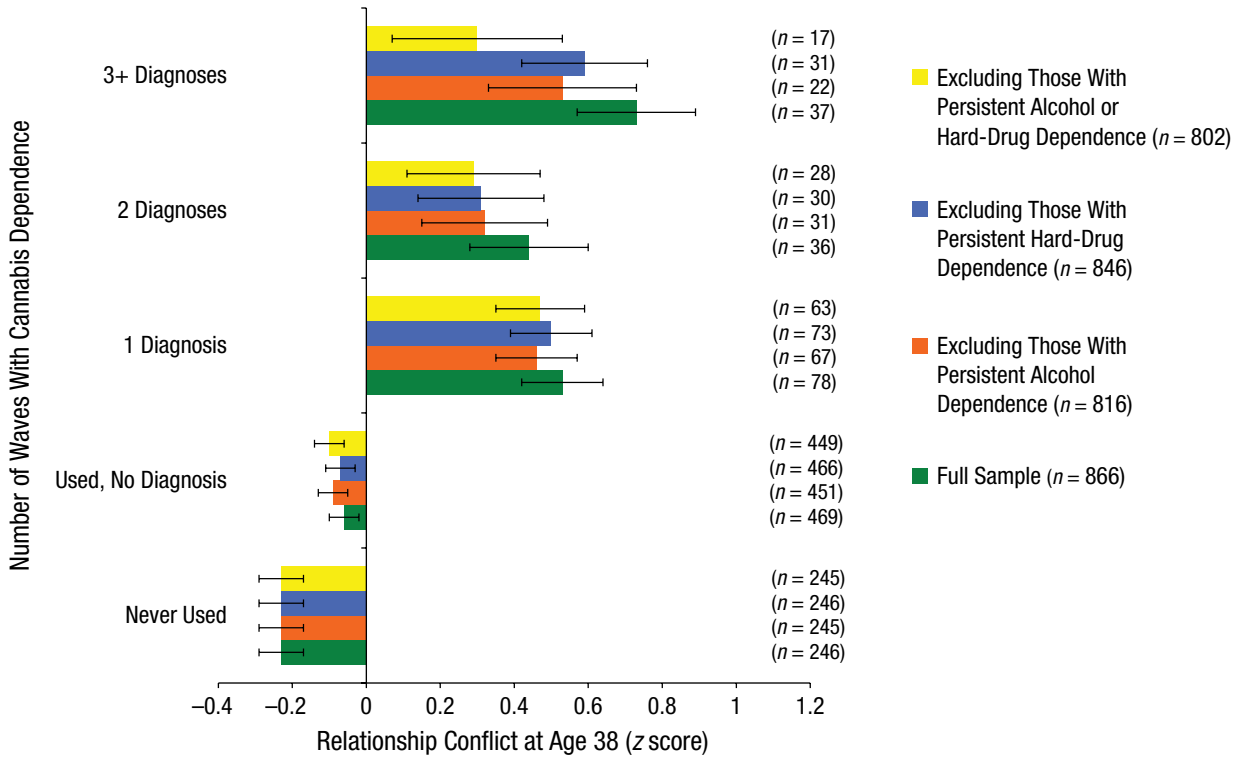


(Continued)

c



d



(Continued)

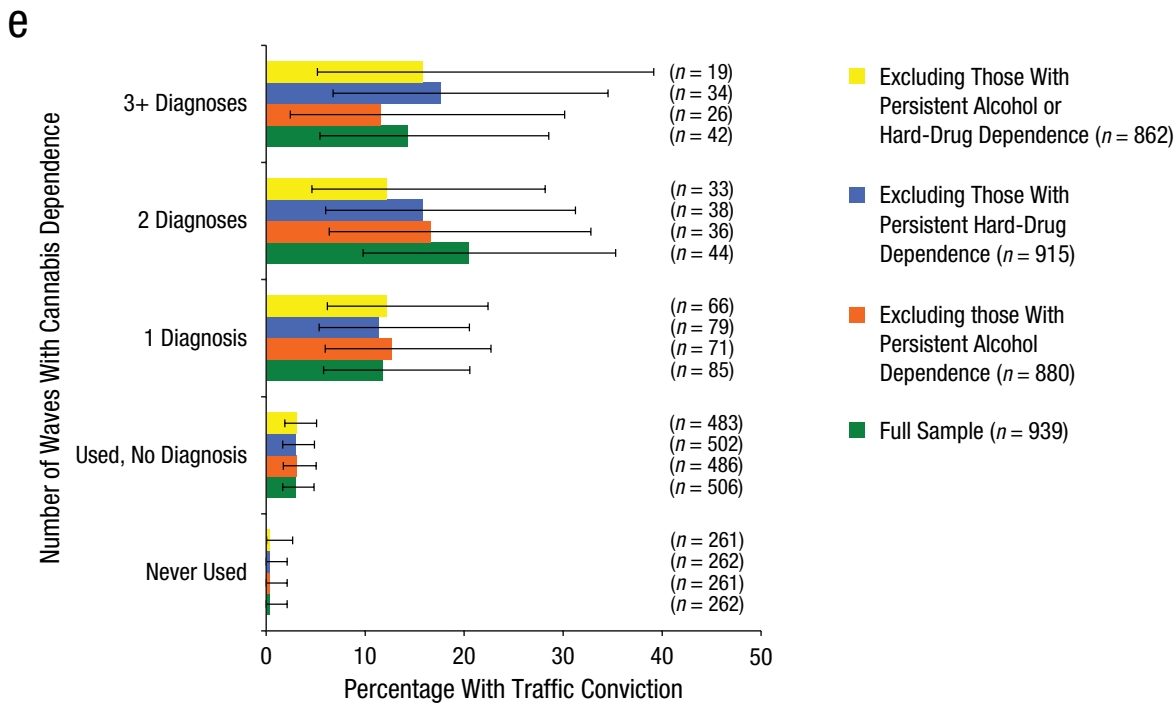


Fig. 2. Association between persistent cannabis dependence and midlife economic and social problems in the full cohort and in three subsamples. Results are taken from unadjusted models and shown separately for (a) change in social class from childhood to adulthood, (b) financial difficulties, (c) antisocial behavior in the workplace, (d) relationship conflict, and (e) traffic convictions. Error bars represent standard errors.

impact on the association of cannabis dependence with social mobility, financial difficulties, workplace trouble, relationship conflict, and traffic convictions.

Comparison of alcohol dependence versus cannabis dependence

At comparable levels of persistence, cannabis and alcohol dependence were similarly linked to downward mobility, antisocial behavior in the workplace, relationship conflict, and traffic conviction (see Table 4 for associations). Findings were unchanged after we controlled for all potential confounders.

The coefficients for cannabis dependence were not different from the coefficients for alcohol dependence for social class, $F(1, 935) = 1.82$, $p = .18$, antisocial behavior in the workplace, $F(1, 783) = 0.02$, $p = .88$, relationship conflict, $F(1, 863) = 0.02$, $p = .90$, and traffic convictions, $\chi^2(1, N = 935) = 0.38$, $p = .54$. In the same way, the coefficients for alcohol dependence were not different from the coefficients for cannabis dependence for social class, $F(1, 935) = 1.33$, $p = .25$, antisocial behavior in the workplace, $F(1, 783) = 0.01$, $p = .90$, relationship conflict, $F(1, 863) = 0.01$, $p = .91$, and traffic convictions $\chi^2(1, N = 935) = 0.39$, $p = .53$. Cannabis dependence was more strongly linked to financial difficulties than was alcohol dependence: The coefficient of the association of cannabis dependence with financial difficulties was significantly stronger than the coefficient of the association of alcohol dependence with financial difficulties, $F(1, 941) = 22.92$, $p < .0001$, and the coefficient of the association of alcohol dependence with financial difficulties was weaker than the coefficient of the association of cannabis dependence with financial difficulties, $F(1, 941) = 17.64$, $p < .0001$.

The special case of education

This study focused on adult social and economic outcomes, measured at age 38 years, as a function of persistent cannabis use during the years before the outcomes (from ages 18–38 years). An additional outcome that researchers have explored in previous studies of the social and economic correlates of cannabis use and dependence is educational attainment (Fergusson & Boden, 2008; Macleod et al., 2004). However, in previous studies, researchers have examined the association between adolescent cannabis use and adult educational attainment, in which the temporal order between exposure and outcome is clear. In our study, the temporal relation between persistent cannabis use (measured from ages 18–38 years) and educational attainment is less clear and difficult to sort out because (a) study members in our New Zealand birth cohort were able to leave school already at age 15 years and (b) study members were able

Table 4. Economic and Social Problems at Age 38, Given Persistence of Cannabis and Alcohol Dependence From Ages 18 to 38: A Comparative Analysis (n = 947)

	No dependence		Dependence at 1 phase		Dependence at 2+ phases		Dependence at 3+ phases		Linear trend test[a,b]		Linear trend test[a,c]	
Economic/social problem	*M*	95% CI	*M*	95% CI	*M*	95% CI	*M*	95% CI		*p*		*p*
Cannabis dependence												
n	774		86		44		43					
Social mobility[d]	0.06		–0.34		–0.4		–0.79		–3.69	.0002	–2.41	.02
	(0.05)		(0.16)		(0.23)		(0.23)					
Financial difficulties[e,f]	–0.14		0.4		0.78		0.86		10.36	< .0001	6.18	< .0001
	(0.03)		(0.1)		(0.14)		(0.14)					
Antisocial behavior in workplace[f,g]	–0.12		0.36		0.81		0.69		6.80	< .0001	4.45	< .0001
	(0.04)		(0.11)		(0.17)		(0.17)					
Relationship conflict[f,h]	–0.13		0.52		0.44		0.72		7.10	< .0001	3.91	.0001
	(0.04)		(0.11)		(0.16)		(0.16)					
Traffic convictions[e] (%)	1.64	[0.90, 2.99]	9.35	[4.39, 19.93]	20.05	[8.87, 45.31]	11.62	[4.50, 29.98]	22.96	< .0001	1.46	.23
Alcohol dependence												
n	619		185		83		60					
Social mobility[d]	0.07		–0.11		–0.33		–0.56		–2.95	.003	–1.69	.09
	(0.06)		(0.11)		(0.16)		(0.19)					
Financial difficulties[e,f]	–0.14		0.16		0.15		0.66		7.02	< .0001	3.86	.0001
	(0.04)		(0.07)		(0.1)		(0.12)					
Antisocial behavior in workplace[f,g]	–0.17		0.04		0.55		0.87		8.23	< .0001	6.18	< .0001
	(0.04)		(0.08)		(0.11)		(0.14)					
Relationship conflict[f,h]	–0.18		0.18		0.26		0.92		8.32	< .0001	6.07	< .0001
	(0.04)		(0.08)		(0.11)		(0.14)					
Traffic convictions[e] (%)	1.40	[0.71, 2.76]	5.50	[2.80, 10.81]	10.82	[5.12, 22.87]	9.34	[3.88, 22.49]	16.94	< .0001	5.16	.02

Note: Standard errors are in parentheses. Mean z scores and proportions are taken from crude linear or logistic regression models. CI = confidence interval.
[a]All statistical tests are t tests with an independent variable (i.e., number of waves with cannabis dependence) coded 0 to 3 and with $n - 1$ degrees of freedom except for traffic convictions, in which Wald chi-square tests with 1 degree of freedom were used. All tests were obtained from regression models. [b]Data were adjusted for sex. [c]Data were adjusted for sex, European ancestry, parental socioeconomic status, proportion of first-degree relatives with substance dependence, low childhood self-control, childhood IQ, adolescent psychopathology (major depressive disorder and conduct disorder), achievement orientation at age 18, living with partner or spouse at age 38, and number of children at age 38. [d]Data represent change in social class from childhood to age 38 (not adjusted for parental socioeconomic status). [e]Data were adjusted for percentage of months in New Zealand from ages 32 to 38. [f]Data are z scores (M = 0, SD = 1). [g]Analyses were restricted to respondents who were currently or formerly employed (n = 786). [h]Analyses were restricted to study members currently in a relationship (n = 866).

to pursue their education (e.g., going in and out of educational settings) throughout the exposure period (between ages 18 and 38 years). That is, highest educational attainment could occur before, during, or after our exposure measure, and the temporal ordering is very difficult to establish. It is possible that cannabis use interfered with education, thereby causing a person to stop education, or it is possible that stopping education freed up a person to use cannabis more regularly. Nevertheless, to explore the issue of the association between cannabis use and educational attainment, we conducted supplementary analyses among a subsample of study members who completed secondary school qualifications. We used logistic regression to test whether persistent cannabis dependence predicted completion of a tertiary degree. Among study members who had completed secondary school, persistent cannabis users were less likely to complete a tertiary degree than were less persistent cannabis users (see Table S6 in the Supplemental Material).

Discussion

Against the backdrop of increasing legalization of cannabis around the world, and decreasing social perception of risk associated with cannabis use (Johnston, O'Malley, Bachman, & Schulenberg, 2009; Johnston, O'Malley, Bachman, & Schulenberg, 2010), this study provides evidence that many persistent cannabis users experience downward socioeconomic mobility and a wide range of associated problems. Individuals with a longer history of cannabis dependence (or of regular cannabis use) were more likely to experience financial difficulties, including having troubles with debt and cash flow (such as defaulting on a credit card payment or missing a loan payment), difficulty paying basic expenses (such as food and rent), food insecurity, being on welfare, and having a lower consumer credit rating. Persistent cannabis dependence (and regular cannabis use) was also associated with antisocial behavior in the workplace and higher rates of intimate relationship conflict, including physical violence and controlling abuse. The results are consistent with findings from studies that have shown that cannabis was associated with reduced income and education, increased welfare dependence, crime, and lower relationship satisfaction (Arria, Garnier-Dykstra, Caldeira, et al., 2013; Arria, Garnier-Dykstra, Cook, et al., 2013; Arseneault, Moffitt, Caspi, Taylor, & Silva, 2000; Brook et al., 2013; Brook, Zhang, & Brook, 2011; Fergusson & Boden, 2008; Horwood et al., 2010; Pedersen, 2011; Schmidt et al., 1998; Silins et al., 2014).

The study advances knowledge in five ways. First, our results were robust to control for potential sources of confounding present in childhood, adolescence, and adulthood, as well as to alternative approaches to address confounding, including stratification and statistical control for potential confounders. In particular, we ruled out family substance-dependence history, childhood socioeconomic adversity, childhood low self-control, childhood low IQ, adolescent psychopathology, and low achievement orientation, plus sex, ethnicity, and adult family structure as alternative causal explanations for the observed associations between cannabis dependence (and regular cannabis use) and adult economic and social problems. Second, contrary to prior claims, the associations were not an artifact of criminal conviction of cannabis users, earlier age of onset among the more persistent cannabis users, or their dependence on alcohol or hard drugs. Third, we generally observed a dose-response contingency: The more years of cannabis dependence (or regular cannabis use), the worse the economic and social problems. Fourth, the findings were not due to respondent self-report bias: Comparable results were obtained for economic and social problems whether measured by using self-report or administrative record data, such as credit ratings, court records, and government social-welfare-benefit records. Fifth, the findings were not contingent on historically dependent operational definitions of persistent cannabis dependence/regular use. Whereas the definition of cannabis dependence changed slightly across the 20-year longitudinal-assessment window (as a result of changes in the *DSM*), persistence of cannabis use was defined in the same way across the 20-year longitudinal-assessment window. Yet the results were replicated by using both cannabis dependence and persistence of regular cannabis use as the exposure.

Cannabis dependence was more strongly linked to financial difficulties than was alcohol dependence; it was not associated with less downward mobility, antisocial behavior in the workplace, and relationship conflict than was alcohol dependence. This finding stands in contrast to popular and expert opinion, which states that heavy alcohol use imposes more economic and social costs than does heavy cannabis use (Editorial Board, 2014; Weissenborn & Nutt, 2012). Our results are consistent with findings from the few previous existing studies in which researchers compared the impact of the two substances and found comparable (or stronger) economic and social effects of cannabis use compared with alcohol use (Patton et al., 2007; Tucker et al., 2005). It is important to note that our findings are limited to the economic and social problems studied here and, thus, do not provide any information about the relative association of cannabis and alcohol dependence with outcomes such as physical- and mental-health problems. Furthermore, although cannabis and alcohol dependence have comparable effects on economic and social problems, the higher

prevalence of alcohol dependence in the general population means that the population burden posed by alcohol dependence may be greater than that posed by cannabis dependence. The burden posed by cannabis use may increase, however, if cannabis use increases after legalization of cannabis use.

Study findings should be considered in light of limitations. First, the study took place in a setting in which cannabis is illegal—the question remains whether the same consequences would arise in a setting in which cannabis is legal. A study in Amsterdam, where cannabis use is quasilegal, showed that longer duration of cannabis use was associated with lower wages among prime-age male workers (van Ours, 2007). Legalization of cannabis in certain states in the United States and other countries brings opportunities to test this question. Second, economic and social problems were restricted to age 38, the most recent assessment of the Dunedin cohort. In future studies, researchers should investigate whether adversity persists into older adulthood; this is a question of policy importance because rates of cannabis use by people aged 50 to 64 are rising as the baby boom cohort ages (SAMHSA, 2013). Third, the findings are particular to a cohort of individuals born in Dunedin, New Zealand, in the 1970s and may not generalize to groups exposed to different social norms regarding cannabis use or a different set of economic and social circumstances. The prevalence of cannabis dependence is higher among New Zealanders than in other developed nations (Moffitt et al., 2010), but the potency of cannabis is comparable across settings (McLaren, Swift, Dillon, & Allsop, 2008). Furthermore, the comparability of findings from this study and studies conducted in places as diverse as the United States, Europe, and Australia (Degenhardt et al., 2007; Dornbusch et al., 1999; Fergusson & Boden, 2008; Horwood et al., 2010) suggests that the relationships are not context specific.

Fourth, we do not purport to report a causal relationship between cannabis dependence and economic/social problems; cannabis dependence could be a marker of a life trajectory characterized by social and economic adversity (Macleod et al., 2004). Analyses accounted for early life factors, such as childhood socioeconomic adversity, family substance dependence, adolescent psychopathology, and low achievement orientation, which covary with cannabis dependence and adult economic/social problems, thereby allaying this concern somewhat. Of importance, any concerns about residual confounding in this study must apply to analyses of alcohol as well as cannabis. Fifth, the label *persistent* in this study describes individuals who met diagnostic criteria for substance dependence (in the past 12 months) on multiple measurement occasions. The label makes no assumptions about what happened in the intervals between the measurement occasions (i.e., remission, relapse); it is simply a label to note that the study member was diagnosed on multiple occasions. Sixth, *DSM–III–R* criteria were used to diagnose dependence at ages 18 and 21, whereas *DSM–IV* criteria were used at ages 26 to 38. Our results do not, however, depend on *DSM* definitions of dependence; we obtained the same results defining the cannabis exposure variable as persistent heavy use rather than meeting *DSM* criteria for cannabis dependence. Seventh, stratification by cannabis persistence produced small subgroups of more persistent cannabis users. Three factors allay concerns about the use of stratification with small subgroup size. First, we show, de facto, that there is enough power to detect an association, and we report standardized mean scores to allow readers to assess the magnitude, and not just the statistical significance, of the effect. Second, given that this representative birth-cohort study of children born in Dunedin in 1972 to 1973 has suffered minimal attrition, the small subgroups of persistent users are likely representative of persistent users in the population from which they are drawn. Third, reported findings generally show a linear, dose-response relationship and, thus, do not rely on the patterns observed in a single outlying group of persistent cannabis users.

Our data indicate that persistent cannabis users constitute a burden on families, communities, and national social-welfare systems. Moreover, heavy cannabis use and dependence was not associated with fewer harmful economic and social problems than was alcohol dependence. Our study underscores the need for prevention and early treatment of individuals dependent on cannabis. In light of the decreasing public perceptions of risk associated with cannabis use, and the movement to legalize cannabis use, we hope that our findings can inform discussions about the potential implications of greater availability and use of cannabis.

Author Contributions

M. Cerdá, T. E. Moffitt, and A. Caspi contributed to the study design. T. E. Moffitt, H. Harrington, R. Poulton, S. Ramrakha, S. Hogan, and A. Caspi collected the data. M. Cerdá, T. E. Moffitt, R. Houts, and A. Caspi analyzed the data. M. Cerdá, T. E. Moffitt, M. H. Meier, and A. Caspi drafted the manuscript, and all authors approved the final version of the manuscript.

Acknowledgments

We thank the Dunedin Longitudinal Study members, their families, the Dunedin Multidisciplinary Health and Development Research Unit staff, and study founder Phil Silva. The study protocol was approved by the institutional ethical review boards of the participating universities. Study members gave informed consent before participating.

Declaration of Conflicting Interests

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

Funding

The Dunedin Multidisciplinary Health and Development Research Unit is supported by the New Zealand Health Research Council. This research received support from the U.S. National Institute on Aging (Grant AG032282), the UK Medical Research Council (Grant MR/K00381X), and the Jacobs Foundation. M. Cerdá was supported by a grant from the U.S. National Institute on Drug Abuse (DA030449).

Supplemental Material

Additional supporting information may be found at http://cpx.sagepub.com/content/by/supplemental-data

References

American Psychiatric Association. (1987). *Diagnostic and statistical manual of mental disorders* (3rd ed., rev.). Washington, DC: Author.

American Psychiatric Association. (1994). *Diagnostic and statistical manual of mental disorders* (4th ed.). Washington, DC: Author.

Arria, A. M., Garnier-Dykstra, L. M., Caldeira, K. M., Vincent, K. B., Winick, E. R., & O'Grady, K. E. (2013). Drug use patterns and continuous enrollment in college: Results from a longitudinal study. *Journal of Studies on Alcohol and Drugs*, *74*, 71–83.

Arria, A. M., Garnier-Dykstra, L. M., Cook, E. T., Caldeira, K. M., Vincent, K. B., Baron, R. A., & O'Grady, K. E. (2013). Drug use patterns in young adulthood and post-college employment. *Drug and Alcohol Dependence*, *127*, 23–30.

Arseneault, L., Moffitt, T. E., Caspi, A., Taylor, P. J., & Silva, P. A. (2000). Mental disorders and violence in a total birth cohort: Results from the Dunedin Study. *Archives of General Psychiatry*, *57*, 979–986.

Babor, T. F., Caulkins, J. P., Edwards, G., Fischer, B., Foxcroft, D. R., Humphreys, K., . . . Reuter, P. (2010). *Drug policy and the public good*. New York, NY: Oxford University Press.

Boden, J. M., Fergusson, D. M., & Horwood, L. J. (2006). Illicit drug use and dependence in a New Zealand birth cohort. *Australian and New Zealand Journal of Psychiatry*, *40*, 156–163.

Brook, J. S., Lee, J. Y., Finch, S. J., Seltzer, N., & Brook, D. W. (2013). Adult work commitment, financial stability, and social environment as related to trajectories of marijuana use beginning in adolescence. *Substance Abuse*, *34*, 298–305.

Brook, J. S., Whiteman, M., Finch, S. J., & Cohen, P. (1996). Young adult drug use and delinquency: Childhood antecedents and adolescent mediators. *Journal of the American Academy of Child and Adolescent Psychiatry*, *35*, 1584–1592.

Brook, J. S., Zhang, C., & Brook, D. W. (2011). Developmental trajectories of marijuana use from adolescence to adulthood: Personal predictors. *Archives of Pediatrics and Adolescent Medicine*, *165*, 55–60.

Callaghan, R. C., Allebeck, P., & Sidorchuk, A. (2013). Marijuana use and risk of lung cancer: A 40-year cohort study. *Cancer Causes Control*, *24*, 1811–1820.

Degenhardt, L., Chiu, W. T., Sampson, N., Kessler, R. C., & Anthony, J. C. (2007). Epidemiological patterns of extramedical drug use in the United States: Evidence from the National Comorbidity Survey Replication, 2001-2003. *Drug and Alcohol Dependence*, *90*, 210–223.

Degenhardt, L., & Hall, W. (2012). Extent of illicit drug use and dependence, and their contribution to the global burden of disease. *Lancet*, *379*, 7–13.

Dornbusch, S. M., Lin, I. C., Munroe, P. T., & Bianchi, A. J. (1999). Adolescent polydrug use and violence in the United States. *International Journal of Adolescent Medicine and Health*, *11*, 197–220.

Economic Research Service. (2012). *USDA Household Food Security Survey Module: Six-item short form*. Retrieved from http://www.ers.usda.gov/datafiles/Food_Security_in_the_United_States/Food_Security_Survey_Modules/short2012.pdf

Editorial Board. (2014, January 4). Editorial: The marijuana experiment. *New York Times*. Retrieved from http://www.nytimes.com/2014/01/05/opinion/sunday/the-marijuana-experiment.html

Ehrensaft, M. K., Langhinrichsen-Rohling, J., Heyman, R. E., O'Leary, K. D., & Lawrence, E. (1999). Feeling controlled in marriage: A phenomenon specific to physically aggressive couples? *Journal of Family Psychology*, *13*, 20–32.

Ehrensaft, M. K., Moffitt, T. E., & Caspi, A. (2004). Clinically abusive relationships in an unselected birth cohort: Men's and women's participation and developmental antecedents. *Journal of Abnormal Psychology*, *113*, 258–270.

Elley, W. B., & Irving, J. C. (1976). Revised socio-economic index for New Zealand. *New Zealand Journal of Educational Studies*, *11*, 25–36.

Ellickson, P. L., & McGuigan, K. A. (2000). Early predictors of adolescent violence. *American Journal of Public Health*, *90*, 566–572.

Elvik, R. (2013). Risk of road accident associated with the use of drugs: A systematic review and meta-analysis of evidence from epidemiological studies. *Accident Analysis & Prevention*, *60*, 254–267.

Fergusson, D. M., & Boden, J. M. (2008). Cannabis use and later life outcomes [Target article and commentaries]. *Addiction*, *103*(6), 969–978.

Hall, W., & Degenhardt, L. (2009). Adverse health effects of non-medical cannabis use. *Lancet*, *374*, 1383–1391.

Hancox, R. J., Poulton, R., Ely, M., Welch, D., Taylor, D. R., McLachlan, C. R., . . . Sears, M. R. (2010). Effects of cannabis on lung function: A population-based cohort study. *European Respiratory Journal*, *35*, 42–47.

Horwood, L. J., Fergusson, D. M., Hayatbakhsh, M. R., Najman, J. M., Coffey, C., Patton, G. C., . . . Hutchinson, D. M. (2010). Cannabis use and educational achievement: Findings from three Australasian cohort studies. *Drug and Alcohol Dependence*, *110*, 247–253.

Johnston, L. D., O'Malley, P. M., Bachman, J. G., & Schulenberg, J. E. (2009). *Monitoring the Future national survey results*

on drug use, 1975-2008. Volume II: College students (NIH Publication No. 10-7586). Bethesda, MD: National Institute on Drug Abuse.

Johnston, L. D., O'Malley, P. M., Bachman, J. G., & Schulenberg, J. E. (2010). *Monitoring the Future national survey results on drug use, 1975-2009. Volume I: Secondary school students* (NIH Publication No. 10-7584). Bethesda, MD: National Institute on Drug Abuse.

Kirk, R. E. (2013). *Experimental design: Procedures for the behavioral sciences* (4th ed.). Thousand Oaks, CA: SAGE Publications.

Lev-Ran, S., Roerecke, M., Le Foll, B., George, T. P., McKenzie, K., & Rehm, J. (2014). The association between cannabis use and depression: A systematic review and meta-analysis of longitudinal studies. *Psychological Medicine*, *44*, 797–810.

Li, M. C., Brady, J. E., DiMaggio, C. J., Lusardi, A. R., Tzong, K. Y., & Li, G. (2012). Marijuana use and motor vehicle crashes. *Epidemiologic Reviews*, *34*, 65–72.

Macleod, J., Oakes, R., Copello, A., Crome, I., Egger, M., Hickman, M., . . . Davey Smith, G. (2004). Psychological and social sequelae of cannabis and other illicit drug use by young people: A systematic review of longitudinal, general population studies. *Lancet*, *363*, 1579–1588.

McLaren, J., Swift, W., Dillon, P., & Allsop, S. (2008). Cannabis potency and contamination: A review of the literature. *Addiction*, *103*, 1100–1109.

Meier, M. H., Caspi, A., Ambler, A., Harrington, H., Houts, R., Keefe, R. S., . . . Moffitt, T. E. (2012). Persistent cannabis users show neuropsychological decline from childhood to midlife. *Proceedings of the National Academy of Sciences, USA*, *109*, E2657–E2664.

Meier, M. H., Caspi, A., Houts, R., Slutske, W. S., Harrington, H., Jackson, K. M., . . . Moffitt, T. E. (2013). Prospective developmental subtypes of alcohol dependence from age 18 to 32 years: Implications for nosology, etiology, and intervention. *Developmental Psychopatholy*, *25*, 785–800.

Milne, B. J., Byun, U, & Lee, A. (2013). *New Zealand socio-economic index 2006*. Wellington: Statistics New Zealand. Retrieved from http://www.stats.govt.nz/methods/research-papers/nz-socio-economic-index-2006.aspx

Moffitt, T. E., Caspi, A., Harrington, H., Milne, B. J., Melchior, M., Goldberg, D., & Poulton, R. (2007). Generalized anxiety disorder and depression: Childhood risk factors in a birth cohort followed to age 32. *Psychological Medicine*, *37*, 441–452.

Moffitt, T. E., Caspi, A., Taylor, A., Kokaua, J., Milne, B. J., Polanczyk, G., & Poulton, R. (2010). How common are common mental disorders? Evidence that lifetime prevalence rates are doubled by prospective versus retrospective ascertainment. *Psychological Medicine*, *40*, 899–909.

Moffitt, T. E., Harrington, H., Caspi, A., Kim-Cohen, J., Goldberg, D., Gregory, A. M., & Poulton, R. (2007). Depression and generalized anxiety disorder: Cumulative and sequential comorbidity in a birth cohort followed prospectively to age 32 years. *Archives of General Psychiatry*, *64*, 651–660.

Newcomb, M. D., & Bentler, P. M. (1988). Impact of adolescent drug use and social support on problems of young adults: A longitudinal study. *Journal of Abnormal Psychology*, *97*, 64–75.

Nutt, D. J., King, L. A., & Phillips, L. D., & Independent Scientific Committee on Drugs. (2010). Drug harms in the UK: A multicriteria decision analysis. *Lancet*, *376*, 1558–1565.

Patton, G. C., Coffey, C., Lynskey, M. T., Reid, S., Hemphill, S., Carlin, J. B., & Hall, W. (2007). Trajectories of adolescent alcohol and cannabis use into young adulthood. *Addiction*, *102*, 607–615.

Pedersen, W. (2011). Cannabis and social welfare assistance: A longitudinal study. *Addiction*, *106*, 1636–1643.

Piquero, N. L., & Moffitt, T. E. (2012). Can childhood factors predict workplace deviance? *Justice Quarterly*, *2012*, 1–29.

Pletcher, M. J., Vittinghoff, E., Kalhan, R., Richman, J., Safford, M., Sidney, S., . . . Kertesz, S. (2012). Association between marijuana exposure and pulmonary function over 20 years. *Journal of the American Medical Association*, *307*, 173–181.

Poulton, R., Hancox, R., Milne, B., Baxter, J., Scott, K., & Wilson, N. (2006). The Dunedin Multidisciplinary Health and Development Study: Are its findings consistent with the overall New Zealand population? *New Zealand Medical Journal*, *119*, 45–55.

Poulton, R., Moffitt, T. E., & Silva, P. A. (2015). The Dunedin Multidisciplinary Health and Development Study: Overview of the first 40 years, with an eye to the future. *Social Psychiatry and Psychiatric Epidemiology*, *50*, 679–693.

Robins, L. N., Cottler, L. B., Bucholz, K. K., North, C., & Rourke, B. P. (1999). *Diagnostic Interview Schedule for* DSM–IV. St. Louis: Washington University School of Medicine, Department of Psychiatry.

Robins, L. N., Cottler, L. B., Bucholz, K. K., North, C., & Rourke, B. P. (2002). *Diagnostic Interview Schedule for DSM–IV*. St. Louis: Washington University School of Medicine, Department of Psychiatry.

Robins, L. N., Helzer, J. E., Croughan, J., & Ratcliff, K. S. (1981). National Institute of Mental Health Diagnostic Interview Schedule: Its history, characteristics, and validity. *Archives of General Psychiatry*, *38*, 381–389.

Room, R., Fischer, B., Hall, W., Lenton, S., & Reute, P. (2010). *Cannabis policy: Moving beyond stalemate*. New York, NY: Oxford University Press.

Rutter, M., & Academy of Medical Sciences Working Group. (2007). *Identifying the environmental causes of disease: How should we decide what to believe and when to take action?* London, England: Academy of Medical Sciences.

Schmidt, L., Weisner, C., & Wiley, J. (1998). Substance abuse and the course of welfare dependency. *American Journal of Public Health*, *88*, 1616–1622.

Silins, E., Horwood, L., Patton, G. C., Fergusson, D. M., Olsson, CA, & Hutchinson, D. M., . . . Cannabis Cohorts Research Consortium. (2014). Young adult sequelae of adolescent cannabis use: An integrative analysis. *Lancet Psychiatry*, *1*, 286–293.

Substance Abuse and Mental Health Services Administration. (2012). *Results from the 2011 National Survey on Drug Use and Health: Summary of national findings*. Rockville, MD: Author.

Substance Abuse and Mental Health Services Administration. (2013). *Results from the 2012 National Survey on Drug*

Use and Health: Summary of national findings (National Survey on Drug Use and Health Series H-46). Rockville, MD: Author.

Takayanagi, Y., Spira, A. P., Roth, K. B., Gallo, J. J., Eaton, W. W., & Mojtabai, R. (2014). Accuracy of reports of lifetime mental and physical disorders: Results from the Baltimore Epidemiological Catchment Area Study. *Journal of the American Medical Association Psychiatry*, *71*, 273–280.

Thomson, W. M., Poulton, R., Broadbent, J. M., Moffitt, T. E., Caspi, A., Beck, J. D., . . . Hancox, R. J. (2008). Cannabis smoking and periodontal disease among young adults. *Journal of the American Medical Association*, *299*, 525–531.

Tucker, J. S., Ellickson, P. L., Orlando, M., Martino, S. C., & Klein, D. J. (2005). Substance use trajectories from early adolescence to emerging adulthood: A comparison of smoking, binge drinking, and marijuana use. *Journal of Drug Issues*, *35*, 307–331.

van Amsterdam, J., Opperhuizen, A., & Koeter, M. (2010). Ranking the harm of alcohol, tobacco and illicit drugs for the individual and the population. *European Addiction Research*, *16*, 202–207.

van Ours, J. C. (2007). The effects of cannabis use on wages of prime-age males. *Oxford Bulletin of Economics and Statistics*, *69*, 619–634.

Weissenborn, R., & Nutt, D. J. (2012). Popular intoxicants: What lessons can be learned from the last 40 years of alcohol and cannabis regulation? *Journal of Psychopharmacology*, *26*, 213–220.