

Associations of Cannabis Use across Adolescence and Early Adulthood With Health and Psychosocial Adjustment in Early Adulthood and Midadulthood in Men

Deborah M Capaldi , Stacey S Tiberio, David CR Kerr and Lee D Owen

Oregon Social Learning Center, Eugene, OR, USA.

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ABSTRACT

BACKGROUND: Associations between men's prior cannabis use and their physical and psychosocial adjustment were examined using prospective data across adolescence (ages 13–20 years), early adulthood (ages 20–30 years), and midadulthood (ages 30–38 years). The theoretical framework was based in developmental-contextual and lifespan approaches.

METHOD: Models were tested using men in the Oregon Youth Study who had been studied since ages 9 to 10 years and who, in childhood, lived in neighborhoods with higher than average rates of delinquency. Cannabis use in adolescence was used to predict early adult outcomes (and early adult use to midadult outcomes). In addition, a set of covariates was added to the models, including childhood risk factors assessed at age 9 years (ie, family socioeconomic status; externalizing behaviors; and if available, the childhood proxy for the outcome [eg, age 9 intelligence scale]) and alcohol use in adolescence (or early adulthood). Physical health outcomes included accidental injuries, problems resulting from a prior injury, body mass index, self-report health, and also pain and cardiovascular risk (blood pressure and pulse rate) in midadulthood. Psychosocial outcomes included income, housing insecurity, intelligence, depressive symptoms, psychosis symptoms, hostility/aggression, social problems, and attention problems.

RESULTS: Whereas there was almost no prediction from prior cannabis use to the physical health outcomes, there were comprehensive associations of cannabis use from the prior developmental period and psychosocial outcomes in both early adulthood and midadulthood.

CONCLUSION: Cannabis use in prior developmental periods was associated with a broad range of types of poor psychosocial adjustment in adulthood.

KEYWORDS: Cannabis use, at-risk men, physical health, psychosocial adjustment, longitudinal

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CORRESPONDING AUTHOR: Deborah M Capaldi, Oregon Social Learning Center, 10 Shelton McMurphy Blvd, Eugene, OR 97401, USA. Email: deborahc@oslc.org

Introduction

Our understanding of the associations between adolescent and early adult cannabis use and subsequent health and psychosocial outcomes in early and midadulthood for U.S. samples is limited. Relatively few prospective, longitudinal studies focus on cannabis use and extend to the late 30s, and a number of those with regular prospective assessments are of non-U.S. samples.^{1–3} In a recent press release from the Coalition for Cannabis: Policy, Education, and Regulation, Andrew Freedman, the Executive Director, stated that “It is imperative that we continue to conduct advanced research to better understand the potential harms and benefits of cannabis and its effects on consumers’ mental health.”

Adolescent onset and heavier use of cannabis over time has been found to predict cognitive impairment, affective disorders, psychosis, anxiety disorders, and physical disease mainly involving respiratory and cardiovascular disease (CVD).^{4,5} Terry-McElrath et al⁶ examined health correlates of differential patterns of cannabis use across ages 18 to 50 years for individuals in the Monitoring the Future Study. After adjusting for

covariates such as parental education and use of other substances, they found cannabis use to be associated with dichotomous indicators of past 12-month health visits for both physical and psychological problems and with lifetime psychiatric problems. Many findings however are based on retrospective reports and have not adequately controlled for other known risk factors, including early indications of disease and maladjustment that may have predated cannabis use and use of alcohol. As has been recommended for alcohol use,⁷ research on the associations that cannabis use across the lifespan has with subclinical disease will elucidate pathways to chronic illness. Prospective community studies with comprehensive measurement of confounding factors and regular measurement of lifespan cannabis use and outcomes would inform the literature.

In the present study, the association of cannabis use with physical health and psychosocial outcomes for men in the Oregon Youth Study (OYS) was examined from adolescence to midadulthood. These men were at risk for externalizing behaviors and related problems due to the neighborhoods in which they lived in childhood. To strengthen temporal inferences



regarding the associations, cannabis use was examined across 2 different developmental periods as predictors of health and psychosocial outcomes across the subsequent developmental period—namely, from cannabis use in adolescence (ages 13–20 years), to adjustment outcomes in early adulthood (ages 20–30 years), and then from early adulthood cannabis use to early midlife outcomes (ages 30–38 years). Although examination of changes in cannabis use across the lifespan is important, a first step is to estimate how average exposure to cannabis over a significant developmental period relates to adjustment in the next period.

The role of substance use in declining health at midlife

Rates of both cannabis use and cannabis use disorder in the U.S. approximately doubled from 2002 to 2013, and both have increased in nearly all demographic groups.⁸ Concurrently, there have been rises to epidemic levels in rates of obesity, CVD, and diabetes in the U.S.⁹ In particular, midlife White non-Hispanic individuals with less than a 4-year college education (which represents 76% of the current sample) are showing alarming increases in mortality (eg, an increase in deaths of 134 per 100 000 from 1999 to 2014), compared to continued declines for midlife White adults in other countries.¹⁰ Commentators Meara and Skinner¹¹ stated that “It is difficult to find modern settings with survival losses of this magnitude.” The increases were particularly in the areas of drug-related poisoning, suicide, chronic liver disease, and diabetes mortality. Thus, it is important to assess health outcomes and behavioral risk factors, especially those pertaining to substance use, in this subpopulation.

Whereas alcohol, tobacco, and other drug use are known to predict health and psychosocial problems,^{12–15} less is known about the role of cannabis use in adult health and adjustment. Furthermore, although use of 2 or more substances is common^{16,17} and alcohol use affects psychosocial outcomes,¹³ prospective data on the effects of cannabis use controlling for alcohol use are scant. In recent decades, rates of dual cannabis–alcohol use and exclusive cannabis use have climbed across the U.S., whereas the prevalence of exclusive alcohol use has declined.¹⁸ Given the changing legal status of cannabis in the U.S.¹⁹ and associated declines in the perceived harmfulness of regular cannabis use, there is a great need to understand the associations cannabis use may have with health outcomes.

A theoretical model of substance use and lifespan health and adjustment

The present study applies the *dynamic developmental systems* (DDS)^{20,21} theoretical framework, which builds on developmental-contextual and lifespan approaches that emphasize the interaction between the individual’s prior dispositions and learning and the environments in which s/he is placed or selects.^{22–24} The DDS model emphasizes both the interdependencies of systems

central to the development of the individual (ie, cannabis use, health, psychosocial functioning) with attention to the developmental period(s) when the substance use behaviors occurred. In prior work on cannabis use,²⁵ we extended the DDS approach to distinguish *outcome-specific risks* related to cannabis use from *general pathway risk* associated with childhood socioeconomic status (SES), problem behaviors, and indicators of health problems. However, this study primarily concerned adolescent predictors of heterogeneity in patterns of cannabis use and the association of the latter to a limited set of outcomes at age 36 years only.

Cannabis use in adolescence, relative to later stages, is likely to impact substance use patterns, brain development, cognitive function, and educational and occupational achievement,⁵ and thus later psychosocial functioning, physical health, and mortality risk. In their 20s, some individuals desist from use whereas others persist and become chronic users,²⁵ and early adulthood may be a key period of transition to long-term, patterned, or chronic use, and a lifestyle compatible with such use. Arria et al²⁶ identified 6 trajectories of cannabis use by students during college years and the association with physical and mental health outcomes at age 27 years. With the exception of days impaired by injury and distress outcomes, chronic cannabis users tended to have the worst outcomes across multiple domains, including more mental health visits, physician visits for physical health problems, days impaired by illness or emotion/mental health issues, and lower levels of life satisfaction.

Cannabis use in early adulthood may have adverse effects on both psychosocial and disease risk outcomes during the 30s and 40s. Cannabis use may be incompatible with normative developmental tasks during this period, such as child rearing and occupational achievement, and physiological systems may show some decline,²⁷ including less resilience to harmful exposures. Testing prediction from cannabis use in adolescence to functioning across the 20s, and from cannabis use in the 20s to functioning across the 30s, may shed light on the how cannabis use across these 2 key early-life periods relates to functioning in the next period. In the tobacco field, data on major reversals in health risks following tobacco cessation²⁸ and the weaker long-term quit success among smokers with adolescent onset²⁹ indicate the importance of development in the timing of interventions. The present study will open similar lines of inquiry and implications for cannabis.

Associations of cannabis use with physical health and disease risk

Some of the most significant threats to physical health that become apparent by midlife include accidents and injuries, indicators of CVD risk, and obesity. Cannabis use has been found to be related to driving accidents³⁰ and workplace injuries³¹ among adults and with elevated blood pressure³² (a CVD risk indicator) as well as stroke.³³ Regarding obesity, studies either do not support an association with body mass index

(BMI) or indicate that other substance use explains apparent linkages.^{26,34} Overall, study findings on longer-term physical health outcomes of cannabis use are mixed and rather limited. Given the importance of these 3 areas of health, further examination of these issues that uses long-term prospective data and adjusts for early health risk indicators is warranted.

Associations of cannabis use with psychosocial outcomes

Indicators of psychosocial adjustment in adulthood examined in the current study include general life adjustment (income, housing insecurity), cognition (intelligence), psychopathology including symptoms of depression or psychosis, hostile/aggressive behavior, social problems, and attention problems. A number of studies suggest cannabis use increases risk for maladjustment across these domains. Specifically, cannabis use in adolescence is linked with later socioeconomic status (SES), in particular, in both U.S.^{35,36} and New Zealand¹ samples. Additionally, early, frequent, and heavy adolescent cannabis exposure has been associated with poor cognitive outcomes such as memory and learning problems in adulthood.³⁷

Regarding symptoms of psychopathology, Brook et al³⁸ found that chronic/heavy users of cannabis from adolescence through midlife were more likely to be higher in antisocial behaviors and emotional dysregulation at midlife. However, there have been few long-term studies of cannabis use in relation to later externalizing behaviors. Whereas there are indications of an association of cannabis use with later depressive symptoms, both predicting from adolescence³⁹ and across adulthood,⁴⁰ findings are somewhat mixed.^{41,42} Further examination of these issues using measurement of both cannabis use and depressive symptoms over time, with controls for baseline symptoms and confounding factors, is needed.

A number of reviews indicate cannabis use, particularly frequent use, increases risk for later psychosis symptoms,⁴³ and a recent meta-analysis by Kiburi et al⁴⁴ of 18 studies supported that adolescent cannabis use increased risk for psychosis and predicted earlier onset of psychosis. Few studies, however, have extended from childhood to midlife, with controls for childhood predispositions and for use of alcohol.⁴⁵ Finally, effects of cannabis use on social and attention problems have been little examined but warrant examination as key indicators of psychosocial adjustment.

The present study

Limitations shared across the literature justifying a focus on midlife health and adjustment and cannabis use include (a) a focus on adolescent developmental outcomes; (b) reliance on cross-sectional or short-term longitudinal designs and almost none spanning from childhood to midlife; (c) that the requisite longitudinal studies have occurred primarily outside the U.S.; and (d) inadequate consideration of predispositions or

co-occurring risk factors that prospective designs using regular and extensive measurement permit.

Presently, we examine the associations between use of cannabis and midlife health and adjustment problems; specifically, accidental injury, injury-related problems, BMI, CVD risk, self-reported health and pain, general psychosocial adjustment indicators, and symptoms of psychopathology. Importantly, study models distinguish risks attributable to cannabis use from those presented by general pathway risk factors including family of origin SES and childhood externalizing behavior. Likewise, by accounting for use of alcohol in the same developmental period as cannabis use, we can identify independent associations of the latter. Furthermore, controlling for a childhood (age 9 years) measure or proxy of the outcome variable will account for early specific risk for each outcome that predated participants' cannabis use.

To capture effects of longer-term cannabis use during a specific developmental period prior yet proximal to the period in which the outcomes were assessed, we used the average level of cannabis use as modeled across the adolescent period to predict to the average level of health and psychosocial outcomes across early adulthood. We used the same approach to predict from cannabis use across early adulthood to outcomes in midadulthood.

Methods

Participants

The OYS started in 1984 and ended in 2013. All families with fourth-grade boys in schools in higher-delinquency neighborhoods (determined by density of adolescent offenders residing in the area) in a medium-sized metropolitan area in the Pacific Northwest were eligible to participate, except 31 families were ineligible as they could not speak English or were planning to move out of state within 6 months. Families were recruited via an initial letter from the school asking them to withdraw their names if they did not want to be contacted by study staff (very few families withdrew their names). Families then received a letter announcing the study, a phone call to schedule a home visit, and a home visit to explain the study participation and answer questions. The recruitment rate of eligible families was 74% (N = 206).⁴⁶ The study involved 25 assessment waves that were yearly from ages 9 to 10 to 31 to 32 years—except for no assessment at ages 26 to 27 years (22 assessments)—with 3 further assessments at ages 33 to 34, 35 to 36, and 37 to 38 years (participation was 98% at ages 20–21 years and 88% of living men at ages 37–38 years). Note that as assessments occurred by school year throughout the study, there was some overlap of ages by wave (eg, a boy could be ages 9 or 10 years in Wave 1 and ages 10 or 11 years in Wave 2).

Participants were primarily White (90%) and from lower- and working-class families (75%).⁴⁷ In the first year of the study, 33% of the families received welfare or food stamps. Regarding family structure, 40% of the families involved

2 biological parents, 25% were 2 parent including a stepparent, 30% were single-mother families, and 5% were single-father families. Regarding education, 17% of fathers and 8% of mothers were college graduates.

Procedures

OYS parents and boys/men completed in-person interviews and questionnaires. Adults provided written informed consent and all procedures were approved by the Institutional Review Board of the Oregon Social Learning Center. Participants were compensated for their time. The parent(s) and their sons were interviewed separately, with each interview lasting 45 minutes to 1 hour. The interviewers completed a ratings checklist after each interview.

Measures

Measures are described briefly below and in more detail in the Supplemental Appendix where the number of items per scale, sample items, and reliability information are provided. Measures were used from all available waves within each of the 3 developmental periods (namely adolescence, early adulthood, and midadulthood) to provide the strongest available measurement of the variables. Two types of criteria were used as a general guide to construct development.⁴⁸ Except in a few cases involving face-valid items, scales needed to exhibit internal consistency with a Cronbach's alpha of .6 and item-total correlations of .2 or greater and also congruence with other indicators by having a factor loading greater than .3 on a single-factor solution.

Cannabis use was assessed in adolescence from ages 13 to 14 to 19 to 20 years (7 measurements) and in early adulthood from ages 20 to 21 to 29 to 30 years (9 measurements). The constructs assessing adult outcomes were assessed from ages 20 to 21 to 29 to 30 years (early adult; up to 10 measurements) and from ages 30 to 31 to 37 to 38 years (midadult; up to 5 measurements); not all items were assessed at each wave (see Supplemental Appendix). In the measures descriptions below, the number of waves given are for early adulthood first with the number for midadulthood in parentheses following.

Cannabis use in adolescence and early adulthood. Participants were queried regarding their use of a range of cannabis products commonly used at the time of the assessment (product types were mentioned but they were not shown pictures of products). The cannabis use score per assessment was the product of self-reported frequency of use (capped at 365 times in the past year) and the number of units (in grams) used on a typical occasion (estimated as the number of grams), giving an estimate of volume or quantity of use.²⁵ Prior to combination, these values were log transformed to reduce skew. At the beginning of the adolescent (and young adult) periods, 89.1% (49.8%) reported not using cannabis while at the end of the

periods 53.3% (67.5%) reported no use. See the descriptives tables for statistics on the raw number of grams used over the periods.

Physical health outcomes

Accidental injuries. In the interviews, the men reported on traumatic injuries and consequences of the worst accident in the previous year. Regarding the former, across young adulthood (and midadulthood) 7 (3) waves, the men were asked whether they had experienced 7 different types of trauma events and resulting injuries. The number of injuries were summed and the outcome was represented by the maximum reported value across the time period. Across 6 (3) waves, the men describe the worst (single) accident during the previous year and 7 potential consequences from the accident (eg, *did you visit a doctor?* and *were you cut or bleeding?*). Their responses were summed and then the maximum number of consequences were used for each time period. The final score was the mean of the 2 standardized indicators (early adulthood $r = .30, P < .001$; midadulthood $r = .42, P < .001$).

Problems from prior injury. During interviews across 8 (3) waves, the men were asked if they had ongoing problems as a result of prior injury (no = 0/yes = 1). The maximum value was taken so that the final outcome represented whether they had ever reported ongoing problems during the time period.

Body mass index. At 2 waves (ages 20-21 and 23-24 years) and at 3 waves during midadulthood, the men's height and weight were measured by the interviewer and body mass calculated. The mean of measurements was taken and were strongly associated for the 2 occasions in early adulthood ($r = .83, P < .001$) and the 3 occasions in midadulthood ($\alpha = .96$).

Self-reported health. During the interview across 8 (3) waves (α s = .84 and .81, respectively), the men were asked to describe their health with 4 categories ranging from poor to excellent. The final outcome was the mean of available measures.

Pain scale. A pain questionnaire⁴⁹ with items from the Brief Pain Inventory⁵⁰ was administered twice in midadulthood when the men were aged 35 to 36 ($\alpha = .79$) and 37 to 38 ($\alpha = .85$) years. These 2 indicators were each formed from 3 subscales, namely impact of worst pain (α 's .94 and .95), frequency of significant pain (α 's .94 and .96), and general pain impact (α 's .61 and .65). The 2 indicators were combined ($r = .41, P < .001$) for the final outcome.

Poor cardiovascular health. When the men were ages 37 to 38 years, their blood pressure (assessed using a blood pressure cuff or sphygmomanometer) and pulse were measured by the interviewer, which resulted in 3 indicators (systolic, diastolic,

and pulse rate; $\alpha = .703$), each the mean of 2 separate measurements. Blood pressure and pulse rate are known to be indicators of heart health.^{51,52} Measures of CVD risk along with BMI represent underlying physiological risk factors for a wide range of negative health outcomes.⁵³⁻⁵⁵ Blood pressure and obesity have been considered indicators of metabolic syndrome, a diagnostic measure of risk for both diabetes and CVD.⁵⁶

Psychosocial health outcomes

Note that in the descriptions below that items from the Young Adult Self-Report instrument^{57,58} was used in several measures. These measures involved raw scores (rather than age/gender adjusted t scores).

Income. As one indicator of general adjustment, yearly personal income was assessed across the full range (ie, whole amounts), 10 (4) waves (cross wave alphas = .87 and .96, respectively).

Housing insecurity. Another measure of general adjustment, this variable was assessed in the interview by living situation changes and homelessness. The number of changes in housing in the past year was assessed each year in early adulthood (midadulthood)—4 (4) waves—scored in each of the 2 periods as the mean of the reported values. Homelessness was assessed by one interview item at 4 (3) waves, scored as whether the man reported ever being homeless during the period with the final score the maximum value (ie, 1 vs 0). Note that the participant was asked if he had been homeless, without any further definition provided. However, participants were not considered homeless if they were in jail. The final score was the mean of the standardized indicators of changes in living situation and homeless, $r = .48$, $P < .001$ ($r = .46$, $P < .001$).

Cognitive ability. This included the vocabulary and block design scores from the Wechsler Adult Intelligence Scale⁵⁹ and was assessed once in early adulthood when the men were ages 20 to 21 years ($r = .44$, $P < .001$) and once in midadulthood when the men were ages 31 to 32 years ($r = .52$, $P < .001$).

Depressive symptoms. Depressive symptoms were assessed 9 times in early adulthood by the Center for Epidemiological Studies Depression Scale;⁶⁰ the depression scale from the Brief Symptom Inventory;⁶¹ and the depressed and anxious symptoms scale from the Young Adult Self-Report.^{57,58} Note that not all measures were available at each wave. These same 3 measures were administered at 3 to 5 waves spanning the mid-adult period (alphas = .93 and .90, respectively).

Hostility/aggression symptoms. This construct was assessed by the hostility scale from the Brief Symptom Inventory⁶¹ and the

aggressive behavior scale from the Young Adult Self-Report^{57,58} at 8 (3) waves. Cross wave scores of the 2 measures were significantly associated ($r = .75$; $r = .68$, $P < .001$) at the 2 periods, respectively.

Psychosis symptoms. This construct was assessed by 2 scales from the Brief Symptom Inventory;⁶¹ namely, paranoid ideation and psychoticism and by the thought problems scale from the Young Adult Self-Report^{57,58} at 8 (3) waves. Cross wave scores of the 3 measures were significantly associated (alphas = .79 and .81 in early adulthood and midadulthood, respectively).

Social problems. This construct was assessed by a scale from the Young Adult Self Report.^{57,58} The 8 (3) cross wave scores were significantly associated in early adulthood (midadulthood), with alphas = .90 and .83, respectively.

Attention problems. This construct was assessed by a scale from the Young Adult Self-Report.^{57,58} The 8 (3) cross wave scores were significantly associated in early adulthood and midadulthood (alphas = .90 and .81, respectively).

Control variables. All the control variables were assessed at the first wave of the OYS (boys ages 9-10 years), except for BMI (assessed at ages 11-12 years) and alcohol use, which was assessed across both adolescence and early adulthood. SES of the family of origin was assessed by the Hollingshead index⁴⁷ of the parents' education and occupation. The sons' psychopathology (externalizing behavior, internalizing behavior, thought problems, social problems, and attention problems) were each assessed by both mother and father reports on the relevant scales on the Child Behavior Checklist.⁶² Physical health was measured by the parents rating of their son's general health in his the first 5 years from very poor to excellent.⁶³ Scale alphas ranged from .53 to .90 for mothers and fathers separately (all but one—father report of thought problems—were at .60 or higher), and mother and father reports showed significant correlations ($P < .001$) for all 5 constructs. Parental transitions prior to Wave 1 were assessed by parental reports (ranging from both biological parents as 0 transitions to 3 being transitions past first repartnering/stepparent). Finally, cognitive function was assessed by the Peabody Picture Vocabulary Test⁶⁴ and the Wide Range Achievement Test reading score.⁶⁵

Alcohol use in adolescence and early adulthood was assessed by yearly volume of use from ages 13 to 14 through 19 to 20 years (7 waves) and from ages 20 to 21 to 29 to 30 years (9 waves) using the interview of the OYS boy (man), and was the product of the number of times alcohol was used and the number of drinks per occasion (calibrated for alcohol content). Each wave's score was log transformed prior to combining. Cross wave alphas for early and midadulthood were strong (alphas = .73 and .88, respectively).

Analytic plan

Cannabis use across 2 different developmental periods was used to predict to health and psychosocial outcomes across the next developmental period. Namely, cannabis use from ages 13 to 20 years was used to predict to adjustment outcomes from ages 20 to 30 years, then cannabis use across ages 20 to 30 years was used to predict to outcomes across ages 30 to 38 years. Items were averaged across available years/indicators for most outcomes, though some indicators (homelessness, traumatic injuries, and problems from worst accident) and one outcome (problems from prior injury) were based on the maximum value.

Outcomes based on means had the final score z -transformed, and values greater than ± 2.58 standard deviations (sd) above or below the mean were winsorized while still maintaining rank order among the values. The outlying values were replaced with the next highest or lowest non-outlying value in .10 increments. For example, if the 3 most extreme values were 2.56, 2.79, and 3.02, the 2 outlying values would be replaced by 2.66 and 2.76; thus, final winsorized scores could exceed ± 2.58 sd units. One binary outcome (prior injury problems) was treated as categorical. Analyses were conducted in Mplus 8.5⁶⁶ and utilized 2-level modeling with cannabis use (log of estimated volume in grams multiplied by frequency of use) regressed on age (group-mean centered by individual) at the within level and adjustment outcomes regressed on the random intercept of cannabis use at the between level. Thus, effects of adolescent cannabis use on early adult adjustment and effects of early adult use on midadult adjustment were examined, respectively. Note that relating changes in cannabis use across the developmental period to changes in the health and psychosocial adjustment across the subsequent period were not the focus of the study. Rather, the study hypotheses related to average levels of exposure to cannabis during a developmental period and the effects on aspects of future adjustment (averaged across a later developmental period). Such aggregation we consider to provide strong measurement of both cannabis use and the outcomes, overall, rather than focusing on how changes in cannabis use during one period relate to adjustment in the next period.

Models included prediction from prior cannabis use to later adjustment for both physical and psychosocial outcomes in both early adulthood and midadulthood, in each case first with prior cannabis use alone as a predictor (Model I) and second with prediction models including a number of control variables (Model II). To address multiple comparisons, the Benjamini and Hochberg⁶⁷ procedure was used to adjust P -values in order to control the false discovery rate (ie, the expected proportion of false discoveries amongst the rejected hypotheses). Adjustments were made within 8 sets of models; 4 parameters each for Model I and Model II early adult physical health outcomes, 6 parameters each for the 2 midadulthood sets of physical health models, then 8 parameters each for the early adult

Models I and II and the midadult Models I and II psychosocial models. The magnitude of effects is provided, first, by presenting the correlation matrices and, second, by presenting standardized coefficients in the modeling analyses.

Results

Descriptive statistics

Shown in Tables 1 and 2 are the correlation matrices for the physical health outcomes and the psychosocial outcomes, in each case the matrix also includes the control variables. In each table, correlations for early adults are shown below the diagonal and for midadults above the diagonal. Means and standard deviations are shown for the unstandardized scores for cannabis use and the physical and psychosocial outcome variables (scores for the control variables were standardized). Except in the case of cannabis use in adolescence and self-reported health in early adulthood, the physical health variables were not significantly associated with cannabis use in the prior developmental period. For psychosocial adjustment, cannabis use in the prior developmental period showed significant associations with a number of the outcomes.

Physical health prediction models

Shown in Table 3 are findings of the modeling for physical health outcomes involving 2-level modeling, with cannabis use regressed on age at the within level (same estimates for all models) and physical health outcomes regressed on the random intercept of cannabis use at the between level, both alone (Model I) and with control variables (Model II; family-of-origin SES, the men's childhood externalizing behavior, and general health at age 9 years, as well as alcohol use in the prior developmental period). Note that age was significantly associated with cannabis use in both adolescence ($b[SE] = .375$ [.025], $P < .001$) and early adulthood ($b[SE] = -.135$ [.038], $P < .001$).

For the predictions to early adult (ages 20-30 years) health outcomes (Table 3, Model I), there were no significant effects for any of the 4 physical health outcomes in the model without control variables. In the model including controls (Model II), effects were only significant for BMI, such that adolescent cannabis use was associated with a lower BMI in young adulthood.

For the models involving prediction to health outcomes in midadulthood (ages 30-38 years), from cannabis use in early adulthood (Table 3), there were no findings of significant associations in models either with or without control variables (Models I and II).

Psychosocial adjustment prediction models

Shown in Table 4 are findings of the modeling for the psychosocial adjustment outcomes involving 2-level modeling, with cannabis use regressed on age at the within level and

Table 1. Correlations among physical health variable.

	1	2	3	4	5	6	7	8	9	10	11	12	MEAN (SD)
1. SES, ages 9-10	–	–.201**	.075	–.063	.120	.003	–.161*	–.047	–.032	.119	–.070	–.081	.000 (1.00)
2. Externalizing, ages 9-10	–.201**	–	–.059	–.011	–.004	.122	.225**	.118	–.041	–.150*	.145*	–.034	.000 (1.00)
3. Parent-report general health, ages 9-10	.075	–.059	–	.008	.057	.000	.013	–.042	.046	.133	–.017	–.043	.000 (1.00)
4. Body mass index, ages 9-10	–.063	–.011	.008	–	–.072	–.010	–.012	.120	.593**	–.213**	.078	.113	.000 (1.00)
5. Alcohol use, adolescent/early adult	–.082	.113	.010	–.013	–	.356**	–.011	.051	–.096	.012	.008	.044	.000 (1.00)
6. Cannabis use, adolescent/early adult	–.015	.118	–.020	–.002	.523**	–	–.007	.132	–.080	–.112	.130	.014	.537 (.665)
7. Accidental injuries	–.060	–.045	–.061	–.015	.269**	.051	–	.110	–.099	–.068	.224**	–.149	–.012 (.966)
8. Problems from prior injury	–.091	.208**	–.118	–.026	.093	.075	.047	–	.155*	–.219**	.429**	.098	.421 (.495)
9. Body mass index	–.031	.019	.055	.647**	.024	–.087	–.057	–.019	–	–.327**	.072	.411**	–.007 (.979)
10. Self-report health	–.011	–.046	.098	–.239**	–.107	–.168*	–.104	–.149*	–.179**	–	–.335**	–.210**	.004 (.990)
11. Pain	–	–	–	–	–	–	–	–	–	–	–	.090	–.006 (.982)
12. Heart risk	–	–	–	–	–	–	–	–	–	–	–	–	–.013 (.958)
Mean (SD)	.000 (1.00)	.000 (1.00)	.000 (1.00)	.000 (1.00)	.000 (1.00)	.363 (.521)	.005 (.070)	.693 (.463)	–.006 (.982)	.004 (.990)	–	–	–

Early adult below the diagonal, Middle adult above diagonal.
* $P \leq .05$. ** $P \leq .01$.

Table 2. Correlations among psychosocial health variables.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	MEAN (SD)
1. SES, Age 9-10	–	–.201**	–.131	.273**	–.110	–.132	–.197**	–.220**	.120	.003	.184**	–.094	.305**	–.060	–.207**	–.128	–.042	–.032	.000 (1.00)
2. Externalizing, age 9-10	–.201**	–	.157*	–.010	.665**	.400**	.633**	.644**	–.004	.122	–.220**	.329**	–.171*	.237**	.325**	.260**	.107	.217*	.000 (1.00)
3. Family transitions prior to age 9-10	–.131	.157*	–	–.096	.165*	.220**	.117	.238**	.167*	.125	–.137	.115	–.116	.083	.159*	.136	.141*	.046	.000 (1.00)
4. Vocabulary and reading, age 9-10	.273**	–.010	–.096	–	–.030	–.186**	–.119	–.185**	.087	.146*	.174*	.043	.611**	.019	.046	.002	–.022	.114	.000 (1.00)
5. Anxious/depressed, age 9-10	–.110	.665**	.165*	–.030	–	.517**	.587**	.628**	–.044	–.010	–.187**	.194**	–.128	.163*	.216**	.193**	.120	.140	.000 (1.00)
6. Thought problems, age 9-10	–.132	.400**	.220**	–.186**	.517**	–	.250**	.461**	.041	.176*	–.147*	.104	–.182*	.066	.049	.083	–.033	.004	.000 (1.00)
7. Social problems, age 9-10	–.197**	.633**	.117	–.119	.587**	.250**	–	.649**	–.055	.026	–.209**	.146**	–.063	.127	.286**	.119	.016	.210**	.000 (1.00)
8. Attention problems, age 9-10	–.220**	.644**	.238**	–.185**	.628**	.461**	.649**	–	.004	.022	–.236**	.219**	–.211**	.181*	.007	.217**	.057	.198**	.000 (1.00)
9. Alcohol use, mean across period	–.082	.113	.223**	–.018	.009	.172*	.010	–.008	–	.356**	–.112	.165*	.052	.009	.163*	–.001	–.045	.014	.000 (1.00)
10. Cannabis use, mean across period	–.015	.118	.186**	.038	.013	.142*	–.026	–.061	.523**	–	–.207**	.318**	.037	.222**	–.282**	.182*	.028	.188**	.537 (.665)
11. Income	.072	–.153*	–.053	.124	–.158 ^s	–.120	–.188**	–.157*	.037	–.147*	–	–.350**	.253**	–.364**	.313**	–.354**	–.256**	–.301**	–.009 (.971)
12. Housing insecurity	.017	.288**	.057	.044	.234**	.222**	.169*	.211**	.150*	.242**	–.207**	–	–.026	.354**	–.032	.383**	.148*	.215*	–.038 (.866)
13. Cognitive ability	.387**	–.127	–.126	.636**	–.078	–.174*	–.127	–.201**	–.104	–.030	.108	.087	–	.005	–.032	–.040	–.019	.086	.027 (.996)
14. Depressive symptoms	.040	.216**	–.009	–.006	.189**	.098	.159*	.211**	–.011	.172*	–.246**	.298**	–.005	–	.754**	.818**	.530**	.710**	–.015 (.951)
15. Hostility/aggression symptoms	–.088	.360**	.053	.002	.223**	.047	.201**	.249**	.128	.137	–.239**	.331**	–.078	.705**	–	.762**	.438**	.724**	–.028 (.887)
16. Psychotic symptoms	.015	.255**	.021	.055	.188**	.075	.168*	.194**	–.001	.161*	–.229**	.382**	.033	.835**	.731**	–	.507**	.681**	–.032 (.875)
17. Social problems	–.072	.084	.166*	–.123	.062	–.044	.088	.155*	–.064	.036	–.242**	.083	–.075	.503**	.513**	.500**	–	.358**	–.016 (.954)
18. Attention problems	.179	.212*	.040	.105	.189**	.068	.216**	.232**	–.076	.151*	–.275**	.322**	.159*	.698**	.554**	.624**	.341**	–	–.010 (.965)
Mean (SD)	.000 (1.00)	.000 (1.00)	.000 (1.00)	.000 (1.00)	.000 (1.00)	.000 (1.00)	.000 (1.00)	.000 (1.00)	.000 (1.00)	.363 (.521)	–.011 (.964)	–.018 (.942)	.004 (1.00)	–.015 (.951)	–.017 (.943)	–.032 (.867)	–.022 (.923)	–.011 (.963)	–

Early adult below the diagonal, Middle adult above diagonal.

* $P \leq .05$. ** $P \leq .01$.

Table 3. Cannabis use prediction to physical outcomes.

EARLY ADULT OUTCOME (AGES 20-30YEARS):	MODEL I		MODEL II			
	ADOLESCENT CANNABIS USE	ADOLESCENT CANNABIS USE	GENERAL HEALTH (AGE 9)/ BMI (AGE 11) ^a	CHILDHOOD SES (AGE 9)	CHILDHOOD EXTERNALIZING (AGE 9)	ADOLESCENT ALCOHOL USE
	BETA (SE)	BETA (SE)	BETA (SE)	BETA (SE)	BETA (SE)	BETA (SE)
Accidental injuries	.167 (.068) [†]	.052 (.094)	.072 (.065)	-.058 (.066)	.167 (.073)*	.167 (.100) [†]
Prior injuries	.189 (.174)	.045 (.189)	-.214 (.139)	-.062 (.132)	.397 (.142)**	.124 (.176)
BMI	-.101 (.083)	-.157 (.060)*	.643 (.056)***	.012 (.053)	.039 (.053)	.107 (.075)
Self-report health	-.185 (.084) [†]	-.174 (.100)	.088 (.071)	-.025 (.078)	-.023 (.072)	-.009 (.082)
MIDADULT OUTCOME (AGES 30-38YEARS):	EARLY ADULT CANNABIS USE	YOUNG ADULT CANNABIS USE	GENERAL HEALTH (AGE 9)/ BMI (AGE 11) ^a	CHILDHOOD SES (AGE 9)	CHILDHOOD EXTERNALIZING (AGE 9)	EARLY ADULT ALCOHOL USE
	BETA (SE)	BETA (SE)	BETA (SE)	BETA (SE)	BETA (SE)	BETA (SE)
	BETA (SE)	BETA (SE)	BETA (SE)	BETA (SE)	BETA (SE)	BETA (SE)
Accidental injuries	-.008 (.059)	-.047 (.063)	.036 (.070)	-.119 (.065) [†]	.206 (.070)**	.020 (.063)
Prior injuries	.266 (.135)	.230 (.149)	-.071 (.141)	-.055 (.152)	.177 (.138)	.027 (.143)
BMI	.083 (.074)	-.053 (.064)	.601 (.048)***	-.019 (.068)	-.023 (.059)	-.033 (.069)
Self-report health	-.115 (.074)	-.114 (.075)	.119 (.072) [†]	.087 (.079)	-.105 (.075)	.035 (.066)
Pain scale	.132 (.082)	.128 (.088)	-.005 (.069)	-.042 (.075)	.113 (.070)	-.033 (.079)
Heart risk indicator (systolic, diastolic, and pulse)	.015 (.092)	.006 (.107)	-.048 (.069)	-.095 (.079)	-.059 (.083)	.051 (.085)

Standardized coefficients: *P* values of main outcomes adjusted for multiple comparisons (controls are not).
[†]<.10. *<.05. **<.01. ***<.001. ^a=age 11 BMI for young adult BMI outcome.

psychosocial adjustment outcomes regressed on the random intercept of cannabis use at the between level, both alone and with control variables (family-of-origin SES, the men’s childhood externalizing behavior at age 9 years, an age-9-year proxy measure of the respective psychosocial outcomes, and alcohol use in the prior developmental period).

In prediction to psychosocial adjustment in early adulthood from adolescent cannabis use, significant effects were found for 6 of the 8 outcomes (Table 3, Model I) without including control variables. In the case of hostility/aggression, effects were no longer significant in the regression models including the control variables (Table 3, Model II). For effects of adolescent cannabis use on early adult income, housing insecurity, depressive symptoms, psychosis symptoms, and attention problems, findings were significant in models both with and without inclusion of the control variables.

Findings for prediction to psychosocial adjustment in midadulthood from cannabis use in early adulthood also indicated pervasive effects on adjustment, with significant effects found for 6 of the 8 outcomes (Table 4, Model I). Findings for Model II, including control variables, also indicated significant predictions to income and housing insecurity, and to depressive symptoms, psychosis symptoms, and attention problems. In the

case of prediction to hostility/aggression, findings were only significant in the univariate model (Model I).

Discussion

In the present study, associations between longer-term cannabis use during one developmental period and health and psychosocial outcomes in the next developmentally proximal period were examined, including prediction from adolescence to early adulthood and from early adulthood to midadulthood. Findings indicated that, whereas there was almost no prediction from prior cannabis use to the physical health outcomes in the subsequent period, there were comprehensive associations of prior cannabis use and psychosocial outcomes.

Findings regarding lack of an association of prior cannabis use with physical health outcomes, either in early adulthood or midadulthood, show similarities to prior studies that have been mixed regarding the association of cannabis use with later physical health outcomes. The present study had the benefit of being fully prospective and of involving measurement of both the predictor and outcomes over a number of years. Control variables in the study were relatively comprehensive, in the case of physical health models including childhood measures of family SES, which is known to be related to health,⁶⁸ externalizing behavior,

Table 4. Cannabis use prediction to psychosocial Outcomes.

EARLY ADULT OUTCOME (AGES 20-30YEARS):	MODEL I	MODEL II				
	ADOLESCENT CANNABIS USE	ADOLESCENT CANNABIS USE	CHILDHOOD PROXY	CHILDHOOD SES (AGE 9)	CHILDHOOD EXTERNALIZING (AGE 9)	ADOLESCENT ALCOHOL USE
	BETA (SE)	BETA (SE)	BETA (SE)	BETA (SE)	BETA (SE)	BETA (SE)
Income	-.158 (.061)*	-.258 (.079)**	NA	.059 (.072)	-.131 (.069) [†]	.203 (.084)*
Housing insecurity	.262 (.082)**	.234 (.103)*	-.025 (.066)	.065 (.071)	.275 (.079)***	-.003 (.101)
Intelligence	-.030 (.074)	-.002 (.061)	.581 (.047)***	.186 (.053)***	-.069 (.057)	-.063 (.054)
Depressive symptoms	.193 (.077)*	.272 (.101)*	.102 (.090)	.071 (.076)	.149 (.097)	-.177 (.097) [†]
Hostility/aggressive symptoms	.160 (.058)*	.089 (.091)	NA	-.021 (.066)	.340 (.071)***	.037 (.106)
Psychosis symptoms	.177 (.077)*	.235 (.102)*	-.035 (.080)	.049 (.069)	.266 (.090)**	-.154 (.100)
Social problems	.047 (.072)	.123 (.086)	.062 (.093)	-.073 (.073)	.029 (.090)	-.144 (.075) [†]
Attention problems	.167 (.065)*	.309 (.080)***	.237 (.090)**	.236 (.066)**	.096 (.090)	-.241 (.080)**
MIDADULT OUTCOME (AGES 30-38YEARS):	EARLY ADULT CANNABIS USE	YOUNG ADULT CANNABIS USE	CHILDHOOD PROXY	SES (AGE 9)	EXTERNALIZING (AGE 9)	EARLY ADULT ALCOHOL USE
	BETA (SE)	BETA (SE)	BETA (SE)	BETA (SE)	BETA (SE)	BETA (SE)
Income	-.215 (.057)***	-.164 (.067)*	NA	.161 (.073)*	-.161 (.067)*	-.073 (.068)
Housing insecurity	.330 (.072)***	.261 (.083)**	.021 (.073)	-.045 (.072)	.278 (.075)***	.073 (.082)
Intelligence	.038 (.068)	-.010 (.054)	.580 (.049)***	.135 (.051)**	-.134 (.056)*	-.014 (.062)
Depressive symptoms	.230 (.076)**	.232 (.082)*	.049 (.091)	-.014 (.078)	.167 (.104)	-.070 (.068)
Hostility/aggressive symptoms	.169 (.070)*	.137 (.076) [†]	NA	-.152 (.066)*	.269 (.079)**	-.022 (.072)
Psychosis symptoms	.189 (.071)*	.184 (.076)*	-.056 (.082)	-.084 (.064)	.235 (.090)**	-.053 (.069)
Social problems	.030 (.077)	.032 (.086)	-.089 (.086)	-.030 (.070)	.151 (.090) [†]	-.057 (.074)
Attention problems	.194 (.061)**	.198 (.065)**	.130 (.077) [†]	.030 (.071)	.112 (.089)	-.061 (.061)

Abbreviation: NA = nonapplicable.

Standardized coefficients: *P* values of main outcomes adjusted for multiple comparisons (controls are not).

[†]<.10. *<.05. **<.01. ***<.001.

and general health at age 9 years. In addition, alcohol use across the same period that cannabis use was measured was controlled for in the analyses, and alcohol use is known to have a number of detrimental physical health effects,⁶⁹ although in the present study alcohol use was not significantly associated with the physical health outcomes. However, it is also the case that prior to including the control variables in the models, cannabis use did not show significant prediction to the physical health outcomes in midadulthood, and only to BMI, with cannabis use being associated with a lower BMI in early adulthood, which was an unexpected finding. However, prior study findings are equivocal regarding cannabis use and risk for obesity, and either do not support an association with BMI or indicate that unhealthy

behaviors, including alcohol, tobacco, and other drug use that are associated with cannabis use explain apparent linkages (eg, Arria et al^{26,34}).

Although, the present study did not find evidence of associations between cannabis use in the prior period and subsequent physical health in either early adulthood or midadulthood, limitations of the study should be considered. Relatively limited measures of physical health were available on the study and—with the exception of BMI, heart rate, and blood pressure—were assessed by self-reports. Second, the men were followed to age 38 years, which while representing an examination of health outcomes at older ages than many prior studies, is still likely relatively early for some negative health effects to emerge.

Findings for associations from cannabis use in the prior developmental period with psychosocial adjustment showed a number of significant associations, both in early and midadulthood, even after accounting for a number of control variables. Findings indicated associations with a relatively broad range of factors ranging from housing insecurity to symptoms of psychopathology. Predictions showed robustness not just to the control factors but across developmental periods (ie, prediction from adolescent cannabis use to the outcome in early adulthood and prediction from cannabis use in early adulthood to the outcome in midadulthood), as the same 5 outcomes that were significant (accounting for control variables) in early adulthood were significant in midadulthood. These outcomes included 2 indicators of general adjustment (ie, income level and housing insecurity) and 3 indicators of psychopathology (ie, depressive symptoms, psychosis symptoms, and attention problems). The significant prediction of cannabis use to psychosis symptoms is in line with the findings of numerous prior studies (eg, Kiburi et al⁴⁴), and this effect was not attenuated by the significant association of childhood externalizing with psychosis symptoms in adulthood. The finding is of particular concern—given first, that higher levels of psychosis symptoms relate to poorer quality of life in adulthood;⁷⁰ second, that many cannabis products have become stronger in recent years;⁷¹ and third, that rates of both cannabis use and cannabis use disorder in the U.S. have each increased in nearly all demographic groups in recent years⁸—leading to concerns that the effect of use on psychosis symptoms may become more severe and affect more individuals in the future.

Cannabis also showed prediction to both depressive symptoms, as has been found in a number of prior studies,³⁹ and to attention problems, which have been less studied as an adult outcome of prior cannabis use.¹ Along with the prediction to psychosis symptoms, this indicates that cannabis use may be associated with impairment of a number of aspects of brain functioning in adulthood, which could result in difficulty functioning in several key areas that impact quality of life. It is also possible that the association of cannabis use with poorer attention in adulthood may relate to the negative association of prior cannabis use with income. In sum, the latter association may be due to poorer work performance and achievement due to the attention problems. Tests of mediational associations could clarify whether attention problems are a mechanism involved in this association.

It was notable that contrary to some prior studies,⁵ poorer cognitive ability was not associated with prior cannabis use at either developmental period. As might be expected, the age 9 to 10 years control measures of both family SES and cognitive function were significantly associated with cognitive function in adulthood. However, that did not seem to account for the lack of association, as it was not significant prior to adding controls in the model. The present measure of cognitive ability involved the vocabulary and block design tests from the Wechsler Adult Intelligence Scale,⁵⁹ and it is possible that a

broader measure of ability may show association with prior cannabis use.

There are a number of key prevention implications of the present study. First, the findings of prediction from levels of cannabis use both across adolescence and across the decade of the 20s to poorer levels of functioning across a broad range of outcomes, including general adjustment as well as symptoms of psychopathology in the decades of the 20s and 30s, indicates that cannabis use in early life is associated with poorer later functioning. Information regarding long-term associations between cannabis use and psychosocial adjustment needs to be widely disseminated from national health spokespersons. In addition, prevention programs for adolescents need to communicate this information. A second key prevention issue concerns the findings of associations between cannabis use in the 20s and future maladjustment in midadulthood. This indicates that associations exist not only for adolescents, who are still in a phase of growth and brain development,⁷² but also for individuals who use cannabis during early adulthood.

The present study had a number of strengths, notably prospective data spanning adolescence through midadulthood, availability of control measures from childhood, and measurement of a range of indicators of physical and psychosocial health in adulthood for a demographic subgroup known to be vulnerable to poor physical health in adulthood (ie, 76% of the current sample of men were White and had less than a 4-year college education¹⁰). However, the lack of diversity is also a study limitation, and tests of the models for women and for individuals from other racial and ethnic backgrounds is needed. A second limitation was that the measures used were relatively heavily reliant on the men's self-reports, particularly from the Young Adult Self Report instrument, and would have benefited from additional modes of assessment, particularly for assessment of physical health. Note also regarding measurement of cannabis, that participants were not shown pictures of cannabis products but common forms of use at that time were stated by the interviewer. Finally, the study hypotheses related to levels of cannabis use during a developmental period and the effects on aspects of future adjustment (averaged across a later developmental period). However, the study did not address how changes in cannabis use in one period related to changes in adjustment in the subsequent period, and future studies would contribute by addressing these issues.

Findings of the present study indicate that whereas levels of use of cannabis in adolescence and early adulthood had little association through midlife with the physical health indicators assessed, they had comprehensive associations with psychosocial adjustment, ranging from indicators of general adjustment to symptoms of psychopathology. These findings are further bolstered by the inclusion of a number of other known risk factors for poorer psychosocial adjustment, including early indications of family risk and childhood maladjustment that predominantly predated cannabis use.

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Author Contributions

Dr. Capaldi led the conceptualization of the study, in consultation with the co-authors, wrote the first draft of the manuscript, and was the Principal Investigator of the study from which the data was used. Dr. Tiberio was the lead methodologist on the study and oversaw the data analyses as well as contributing to drafts of the manuscript. Dr. Kerr consulted on the study design at all stages and made substantial contributions to manuscript drafts. Lee Owen conducted the data analyses, and prepared tables and descriptions of measures. He checked manuscript drafts to answer queries from other authors and for correctness of the data.

ORCID iD

Deborah M Capaldi  <https://orcid.org/0000-0002-8057-5976>

Supplemental Material

Supplemental material for this article is available online.

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