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Intergenerational Marijuana Use: A Life Course Examination of the Relationship between Parental Trajectories of Marijuana Use and the Onset of Marijuana Use by Offspring

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Abstract

Prior research documents intergenerational (IG) continuity in marijuana use, with most work adopting a life course perspective. Incorporating a methodology that allows for the measurement of "patterns of behavior" instead of singular aspects of parent marijuana use (e.g., age of onset or frequency at any one age or ages), we investigated the simultaneous effects of parental age of onset, frequency, and duration of marijuana use across three periods of the life course (i.e., adolescence, emerging adulthood, and adulthood) on the timing of first marijuana use among offspring. Using prospective data from two companion studies, the Rochester Youth Development Study and the Rochester Intergenerational Study, we used group-based trajectory models to estimate trajectories (or patterns) of parental marijuana use spanning ages 14 to 31 among a birth cohort of 462 parents. We then examined the relationship between parental trajectories of marijuana use and the timing of the onset of marijuana use through age 25 among firstborn offspring. Both late-onset persistent use by parents and increasing chronic use spanning adolescence to adulthood by parents were associated with an increased likelihood of onset of marijuana use among offspring. The results underscore the importance of patterns of marijuana use for IG continuity in contrast to singular measures (e.g., age of onset among parents), which can obfuscate important IG patterns of continuity. Prevention and intervention programs should

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consider the entire history of parent use in order to better identify children most at risk for the onset of marijuana use in adolescence and emerging adulthood.

Keywords

Marijuana use; Intergenerational continuity in substance use; Group-based trajectory models; Age of onset; Life course

Programs, practices, and policies designed to successfully delay the onset of marijuana use to the adult years are likely to have a profound impact on the positive development and health of young people. Adolescent marijuana use, particularly the early onset of use (age<15), as well as use in emerging adulthood, is associated with numerous harmful consequences including cognitive impairment, psychosocial maladjustment, mental illness, risky sexual behavior, and offending (Price et al., 2015; Volkow et al., 2014; Washburn & Capaldi, 2015). Though the drivers of marijuana use are vast, parent behaviors are one of the most proximal influences, including the patterns of marijuana use displayed by parents in both the past and present. As an ever-growing number of states legalize adult marijuana use, the potential impact of parental use on the timing of marijuana use initiation by offspring requires careful consideration.

In this study, we characterize parents' use of marijuana from age 14 to 31 and examine the extent to which a parent's pattern of use is associated with the onset of marijuana use in the first-born child. In doing so, we seek to gain a better sense of how the timing of a child's onset of marijuana use differs as a function of a parent's pattern of use, including age of onset, frequency, and duration. Our study not only informs epidemiological evidence regarding the prevalence of intergenerational continuity in marijuana use but may also have important implications for identifying children most at risk for early onset of marijuana use.

Intergenerational Continuity in Marijuana Use

The life course perspective takes an age-graded approach and explains the development of a behavior based on empirical observations from prospective, longitudinal studies (McGee & Farrington, 2019). Research grounded in the life course perspective (or life course theories of behavior; i.e., Moffitt, 1993; Thornberry & Krohn, 2005) frequently draws upon the seminal works of Glen Elder (e.g., 1998) and the principles of the life course – historical time and place, timing in lives, linked lives and human agency – to study behavior. Key among these principles is the notion of "linked lives" whereby "lives are lived interdependently" (Elder, 1998, p. 4) and "[e]ach generation is bound to fateful decisions and events in the other's life course" (Elder, 1985, p. 40). In accordance with this principle of the life course, a growing body of work examines intergenerational (IG) continuity in behavior, investigating how the behavior of a parent (or grandparent) relates to homotypic or heterotypic continuity in behavior among offspring, including marijuana use.

Examining the link in marijuana use between generations, extant work has investigated the relationship between recent or concurrent parental marijuana use and marijuana use among offspring (during adolescence). Research using parent-child dyads from the Seattle Social

Development Project (SSDP) and its longitudinal extension, The Intergenerational Project (TIP), indicated that current parental marijuana use predicted offspring marijuana use in adolescence (Bailey et al., 2016). Similarly, analyses from a sample of mother-child dyads from the British Cohort Study indicated that mothers' recent marijuana use predicted offspring marijuana use (between the ages of 12 and 15; Patrick, Maggs, Greene, Morgan & Schulenberg, 2014). Other research using a sample of parent-child dyads from Canada demonstrated that parental marijuana use in grade 6 predicted the onset of marijuana use by a child by high school (grade 11; O'Loughlin et al., 2019). Interestingly, there were no significant differences in the effect between maternal use and paternal use. Finally, analyses using a sample of mother-child dyads from the National Longitudinal Survey of Youth 1979 revealed that recent maternal marijuana use was associated with an earlier first age of marijuana use among offspring (Sokol et al., 2014).

Another principle of the life course states that the developmental impact of a life event is contingent upon when it occurs in the person's life (Elder, 1998). As such, additional research on IG continuity in marijuana use focuses on continuity in use across similar developmental periods. Analyses conducted by Kerr, Tiberio, and Capaldi (2015) using a sample of father-child dyads from the Oregon Youth Study (OYS) found evidence for indirect IG continuity in marijuana use during adolescence between father and child via the social and family environment in which the child lived, including parent use during the life of the child and associations with deviant peers. Other research has also examined IG continuity in marijuana use across the same developmental period and focused on the age of onset of marijuana use. For instance, research conducted by Henry and Augustyn (2017) using a sample of parent-child dyads from the Rochester Youth Development Study (RYDS) and the Rochester Intergenerational Study (RIGS) indicated that the early onset of marijuana use (by age 15) by a father was related to the early onset of marijuana use among offspring (by age 15). Moreover, this relationship was mediated by a paternal history of a marijuana use disorder, which is a documented consequence of early-onset marijuana use. Alternatively, early onset of marijuana use among mothers was unrelated to the early onset of marijuana use among her offspring.

In line with the research by Henry and Augustyn (2017), other studies have also documented a relationship between a parental marijuana use/marijuana use disorder and offspring marijuana use (e.g., Cho, 2018; Henry, 2017; Kirisci et al., 2013; Merikangas et al., 2009). It is worth noting that a marijuana use disorder consists of elevated, hazardous use as well as neglected roles, social/interpersonal problems, withdrawal symptoms, inability to quit or control use, reduced activities as a result of use, and physical or psychological problems (DSM-V; Hasin et al., 2013). In fact, using data from the SSDP and TIP, analyses conducted by Hill and colleagues (2018) demonstrated that paternal marijuana use that included a marijuana use disorder was associated with offspring marijuana use in adolescence, but a parental history of marijuana use without a marijuana use disorder was unrelated to offspring marijuana use, suggesting that IG continuity in marijuana use is dependent upon elevated, problematic use.

While a growing body of research documents the conditions under which IG continuity in marijuana use is evident, only a few of the aforementioned studies had the capacity to

answer questions of IG continuity using prospective data collected from adjacent generations (see Thornberry et al., 2012; e.g., OYS, SSDP/TIP, RYDS/RIGS). Additional research is needed utilizing prospective data sources across generations to further dissect the contexts under which IG continuity in marijuana use does and does not occur.

Current Study

Inherent to the life course perspective is the notion of "lives in motion" (Elder, 1998, p. 7). As such, two key aspects within the life course perspective are "trajectories" and "transitions". Trajectories are patterns of behavior marked by transitions. These transitions often serve as turning points, representing the initiation into a behavioral trajectory (onset), change in the behavior over time (i.e., the escalation in behavior or the reduced frequency of a behavior), or cessation and ultimate desistance from a behavior. The notion of trajectories has previously been applied to the study of marijuana use in order to identify different patterns of marijuana use in adolescence (e.g., Caldeira, O'Grady, Vincent, & Arria, 2012; Loughran, Larroulet, & Thornberry, 2018), adolescence and emerging adulthood (e.g. Ellickson, Martino & Collins, 2004; Homel, Thompson & Leadbeater, 2014; Passaroti, Crane, Hedeker, & Mermelstein, 2015; Windle & Weisner, 2004), and adolescence to adulthood (e.g., Brook, Lee, Finch, Seltzer, & Brook, 2013; Epstein et al., 2015). Notably, if observed for a long enough period (i.e., early adolescence to adulthood), the trajectory approach has the capacity to characterize the course of marijuana use across developmental periods, including the age of onset, the frequency of use, the intermittency or persistence of use, and desistance from marijuana use (or at least enduring cessation). For instance, Epstein and colleagues (2015) observed patterns of marijuana use spanning ages 14 to 30 and identified four patterns of marijuana use: nonuse, adolescent-limited use, late-onset use, and chronic use.

Unfortunately, the notions of trajectories and transitions have largely been ignored in prior research examining IG continuity in behavior, including IG continuity in marijuana use. Recognizing the developmental impact of trajectories or patterns of behavior, Loughran and colleagues (2018) argued that the study of IG continuity is augmented by the consideration of trajectories because there is so much heterogeneity in use *within*- and *between*-individuals that a singular measure likely obfuscates the true relationship between a parental behavior and offspring behavior:

> In behavior, the age of onset can vary widely across the life span, as can the duration of the behavior, patterns of involvement such as persistency versus intermittency, and whether and when individuals desist from the behavior (p. 1626).

Importantly, these patterns of behavior vary in their functional and social consequences for the individual (Brook et al., 2011; Brook et al., 2013; Caldeira et al., 2012; Epstein et al., 2015) as well as the likelihood that the parent will serve as a model for marijuana use for one's offspring. As such, they are likely to impact the patterns of behavior among the next generation.

Recognizing the importance of parental patterns of marijuana use for the study of IG continuity in marijuana use, we investigate the relationship between parental trajectories of

marijuana use across an extended period of time (parent's age 14 to 31) and the timing of first use of marijuana among offspring (i.e., onset). The study of onset is important because it denotes the beginning of one's trajectory of marijuana use, and it is also associated with numerous consequences if it occurs during adolescence and emerging adulthood (e.g., Arria, Caldeira, Bugbee, Vincent, & O'Gradey, 2015; Brook, Richter, Whiteman, & Cohen, 1999; Jacobus, Bava, Cohen-Zion, Mahmood, & Tapert, 2009; Jackson et al., 2016). Based on prior IG studies of continuity in marijuana use, we hypothesize that patterns of parental marijuana use characterized by early onset or persistent elevated use across multiple developmental periods will be related to an earlier age of onset of marijuana use among offspring.

Data and Methods

The data are drawn from the Rochester Youth Development Study (RYDS), a multiwave panel study designed to examine the development of delinquency and drug use in a high-risk sample of adolescents (n=1,000), and its intergenerational extension, the Rochester Intergenerational Study (RIGS). The RYDS data is comprised of a birth cohort of 1,000 adolescents who are representative of the 7th and 8th grade public school population in Rochester, New York in 1988. Notably, males (ratio of 3:1) and adolescents living in census tracts with a higher resident arrest rate based on police records from 1987 were oversampled to produce a sample at higher risk for delinquency and substance use. Data collection began in 1988 when adolescents were in seventh or eighth grade (average age 13.6 years, 73% were male, 68% were Black, 17% were Hispanic, and 15% were non-Hispanic White). A total of 14 waves of data were collected in three phases from the focal participants (Generation 2/G2). During Phase 1, which began in 1988 and covered adolescence, participants were interviewed semi-annually nine times (average ages 14–18; waves 1–9). Phase 2 began in 1994 after a 2.5 year-gap in data collection. Respondents were interviewed at three annual intervals (average ages 21–23 [1994–1995, 1995–1996, 1996–1997]; waves 10–12). After another gap in data collection, participants were interviewed twice in Phase 3, at approximate ages of 29 and 31 (waves 13 [2003] and 14 [2005]). Data were also collected from the focal participants' primary caregivers (Generation 1/G1) in Phase 1 and Phase 2, and official data were collected from schools, the police, and social services through Phase 3. A figure representing the research design of RYDS and retention rates at each wave of data collection is available in the Appendix. Krohn and Thornberry (1999) compared those retained to those not retained through wave 12 (1999) and failed to find any statistically significant differences ($p<.05$) across multiple dimensions, including sex, social class, family structure, drug use, delinquency, and criminal behavior measures.

RIGS began in 1999 (during the gap years between Phase 2 and Phase 3 of RYDS). The focal participant of RIGS is the oldest biological child of the RYDS participant (Generation 3/G3; average child age among the G3s was 6 in Year 1 of RIGS). Each subsequent year, new firstborns of RYDS participants were added as they turned 2. Interviews were collected annually from G2 participants through child age 17. If G2 was male, interviews were also collected annually from the other primary caregiver (OCG). Offspring completed annual interviews beginning at age 8. Beginning in Year 19, offspring only completed interviews up to the age of 25. Over the course of RIGS, data have been collected on 539 parent-child

dyads. Unlike in RYDS, where all G2 participants were of similar age, there is a large amount of heterogeneity in the age of RIGS G3 children at any given year of the study. Therefore, analysis with the RIGS data is typically oriented around G3's age rather than the study year.

This analysis uses data through the RIGS Year 20 (2018). Sample sizes for each birth year and for each child age in RIGS can be found in the Appendix. Additional details about the study are reported by Thornberry, Henry, Krohn, Lizotte, and Nadel (2018), including attrition analyses, which revealed that RIGS participants adequately represented the initial population of 7th and 8th graders in Rochester public schools in 1988. Furthermore, 92% of G3s who enrolled in RIGS were retained through Year 17 (Thornberry et al., 2018, p. 228). Analyses performed by Thornberry and colleagues (2018) indicated that across a variety of G2 demographic, family and behavioral characteristics, only three statistically significant differences ($p<.05$) between the original RYDS participants (G2s) and those G2s whose children were retained through Year 17 of RIGS were observed. G2s whose children participated in RIGS through Year 17 were more likely to have lived independently from one's parents during adolescence, were more likely to have had a parent (G1) who used marijuana, and were more likely to be in 8th grade at the start of RYDS.

Measures

Parental (G2) marijuana use.—In waves two through nine of RYDS, participants self-reported whether or not they used marijuana since the date of the last interview (approximately six months), and if so, how many times. Beginning in wave 10 (through wave 14), participants self-reported whether or not they had used marijuana in the past year, and if so, how many times they had used marijuana in the past year. In RIGS yearly interviews, participants also self-reported whether or not they had used marijuana since the date of the last interview (or past year if the previous interview was not completed), and if so, how many times. To address the variation in length of the reference period across data collection, an ordinal measure approximating the rate of marijuana use was created, where 0 represents no marijuana use, 1 represents less than monthly marijuana use in the recall period, 2 represents a minimum of monthly marijuana use but not weekly use in the recall period, 3 represents a minimum of weekly marijuana use but no more than three times a week, and 4 represents marijuana use more than three days a week.

Offspring (G3) onset of marijuana use.—In the RIGS age 8 interview, offspring (G3) were asked whether they had used marijuana in the past year and at what age they had first smoked marijuana. In each subsequent yearly interview, children were asked whether they had smoked marijuana since the date of the last interview (or in the past year if the previous interview was not completed). The measure of the onset of marijuana use is the age of first reported use of marijuana.

Additional covariates.—In addition to dummy variables representing parent sex (female is the reference group) and child sex (female is the reference group), we included a set of binary variables representing the child's race/ethnicity (Black, Hispanic, Mixed/other; White serves as the reference group), a binary measure representing whether the focal parent (G2)

had any supervisory contact (on a monthly basis) with their child between the child ages of seven and 10,[1] a continuous measure of parent age at child's birth, and the community arrest rate of the parent (a sampling parameter for RYDS).

Analysis

To account for heterogeneity in marijuana use over ages 14 to 31 among RYDS participants, we employed group-based trajectory modeling (GBTM; Nagin 2005), a statistical model which allows for the identification of clusters of individuals who display similar individual-level trajectories or patterns of marijuana use. Given a sample of individuals, a traditional latent growth model estimates a single set of average growth parameters to describe change in a construct over time (e.g., a single estimate of the average intercept, average initial slope, and average rate of change in marijuana use over the course of adolescence and young adulthood). For each of these fixed effects, a random effect also may be estimated – allowing for interindividual variability around these average estimates of the growth parameters. Rather than assuming that a single estimate of the average growth parameters characterizes change in the sample, group-based trajectory modeling (GBTM), also referred to as latent class growth analysis (LCGA), seeks to identify subgroups of individuals who demonstrate a similar trajectory of change, and each of these subgroups is defined by their own average growth parameters. The GBTM model also assumes that once the optimal number of subgroups are identified, there is no remaining within group variation in the growth parameters (i.e., no random effects for the growth parameters within subgroup). That is, conditional on group membership, all variability is described by the group-specific growth trajectory parameters. This differs from Muthén & Muthén's growth mixture model (GMM), which allows for the estimation of random effects within each group (i.e., class). In our analysis, a GBTM approach is also advantageous because our yearly indicators of marijuana use are categorical, and modeling random effects for growth models of categorical variables can be tenuous (Bauer & Curran 2003). Ram and Grimm (2007) also note that the GBTM solution can have the advantage of being more interpretable.[2]

Patterns of marijuana use from ages 14 to 31 were observed for 868 RYDS participants (G2s) who participated in at least 70% of RYDS interviews (10 waves of data collection). When available, data from RIGS was used to account for marijuana use during gaps of data collection in RYDS (using years one to four [1999–2002] and year six [2004] of RIGS data) in order to maximize the amount of relevant data used for the identification of the trajectories and to improve model accuracy. Final model selection was based on a combination of factors, including optimization of the Bayesian Information Criterion (BIC) and the significance of higher order parameters (Nagin, 2005). We also evaluated our trajectory solutions using additional parameters recommended by Nagin (2005), favoring a solution where 1) the mixture probabilities ($\hat{\pi}$) were reasonably close to the percentage of the sample assigned (through hard classification) to each group ($\hat{p}$); 2) the 95% confidence

[1]Additional analyses were performed using a binary indicator representing whether or not the child lived with the focal parent (G2) at any point between child ages of 7 and 10. The results were the same in direction and significance.

[2]In practice, a GBTM approach will typically require more classes than a GMM to characterize variability in the growth trajectories. Most notably, when two curves have similar shapes but different intercepts GBTM will tend to treat these as distinct groups whereas GMM will not. In our example, more classes, provided they are meaningful, is likely advantageous as we are attempting to identify and describe different patterns of marijuana use that individuals display and a focus on parsimony may be less important.

intervals for the mixture probabilities were reasonably narrow; 3) the mean posterior probability of classification for each group, which indicates the likelihood that each individual belongs to the assigned group, exceeded .7; 4) the odds of correct classification for each group exceeded 5. Based on the individual data Y_i, each individual is assigned a posterior probability of group membership $P(J|\mathbf{y_i})$ for each group J. Roeder, Lynch and Nagin (1999) argued that when the mean posterior probabilities exceed .7, individuals can be reasonably analyzed as being 'hard-classified' into the group with the highest posterior probability for the purposes of post-estimation analyses because classification uncertainty is minimal. Because the average posterior probability of each trajectory group in our solutions was 0.88 or higher, indicating high classification accuracy, we hard classified RYDS participants into patterns of substance use based on the highest posterior probability of group membership.

Our analytic sample to examine the relationship between parental patterns of marijuana use and offspring onset of marijuana use consists of 462 parent (G2)-child (G3) dyads. Notably, this sample differs from the full RIGS sample of 539 dyads because 1) G3s who were not at least 12 years of age at the last wave of data collection (n=63) were excluded from this analysis and 2) some families had missing data on G2 contact with G3 between the child ages of seven and 10 (n=14), which is one of the control variables in our study.

To model G3 onset of marijuana use through age 25, we employed discrete-time survival analysis (DTSA). In this framework, we modeled the relationship between parents' membership in a particular marijuana use trajectory and the onset of marijuana use among offspring. DTSA models are a type of survival analysis that model the timing of an event when the event is measured in discrete-time or group intervals (Masyn, 2014; Singer & Willett, 2003). A DTSA is the appropriate model given that we do not know the precise moment that G3 began using marijuana, but rather that onset took place within a certain interval (e.g., between their age 13 and age 14 interviews). DTSA also appropriately handles right censored data, which occurs if a respondent did not begin using marijuana by their last point of observation (this is particularly important in our study because many G3s were less than 25 years old at the last point of observation). To further verify the appropriateness of the DTSA model, we investigated the proportional hazards assumption (i.e., that the effect of the predictors is constant across time). Results indicated that it was not violated for any predictors included in the model (i.e., we failed to reject the null hypothesis of a violation of the proportional hazards assumption, Wald χ^2=4.08, df=4, p=0.40). All analyses were generated using SAS software Version 9.4 (SAS Institute, 2017).

Results

Figure 1 displays the optimal solution for the marijuana use trajectories for the full RYDS sample (see Appendix for model diagnostics) of G2 participants, and it reveals five patterns or trajectories of marijuana use spanning ages 14 to age 31. These groups differ in terms of the age of onset, the frequency of marijuana use, and the maintenance/cessation of marijuana use spanning adolescence through adulthood. Comprising nearly 50%, the modal group was the *abstainer* group, who by and large refrained from marijuana use for the duration of the investigated period (age 14 to 31). At 11%, the *early-onset desistor* group displayed a low

frequency of use, which peaked at the end of adolescence, decreased through emerging adulthood, and ceased in adulthood. The *late-onset persistor* group, which is comprised of approximately 24% of the RYDS sample, initiated marijuana use around the age of 18 and then exhibited near monthly marijuana use through adulthood. A little over six percent were classified as *early-onset persistors*, who demonstrated elevated (approximately monthly) marijuana use early in adolescence that continued through adulthood. Finally, 8% of RYDS participants were classified in the *increasing chronic* group, which displayed a lower initial level of marijuana use in contrast to the early-onset persistors, but whose use steadily increased through emerging adulthood (age 25), which was characterized by an average of at least weekly use.

Only a subset of the full RYDS sample became parents, joined RIGS, and had sufficient data to be considered in the analytic sample of parent-child dyads considered in the current analyses. For this subsample (462 G2s), the modal trajectory of parent marijuana use was also the abstainer group (46%). Approximately 15% of parents were classified in the early-onset desistor group, 6% of parents were classified in the early-onset persistor group, and 21% of parents were classified in the late-onset persistor group. Finally, 9% of parents were classified as increasing chronic users. Descriptive statistics for all variables used in the subsequent analyses are presented in Table 1 by parent trajectory of marijuana use.[3]

The next step of our analysis examined whether parental patterns of marijuana use spanning G2 ages 14–31 were related to the age of first marijuana use among offspring (G3s). Figure 2 presents the raw survival probabilities, that is, the probability of surviving (i.e., not initiating marijuana use) through each respective age. We model onset through age 25. Consider first the offspring of the parent abstainer group. The parents by and large abstained from any marijuana use from age 14 to 31, and their offspring had a very high probability (>.90) of surviving through age 15 (the age commonly associated with early onset; Odgers et al., 2008), followed by a steady decline in the survival probability through adolescence and into emerging adulthood. By age 25, their survival probability was about .38 — meaning that about 62% had tried marijuana by the end of the observation period. Notably, the offspring of the early-onset desistors, the late-onset persistors, and the chronic users had a lower survival probability through age 15 (about .80), with a relatively consistent drop in the survival probability through age 25. Moreover, the offspring of chronic users and late-onset persistors demonstrated the lowest survival probability throughout most of the observation period. A comparison of the offspring of abstainers and early-onset desistors yields an interesting observation: the probability of marijuana use onset by age 15 was noticeably higher for the offspring of the latter group; however, the survival probabilities were quite similar for the two groups post adolescence. Finally, we note that the survival curve for offspring of the early-onset persistors is not what we expected. Throughout almost the entire observation period (with the exception of age 25), these children demonstrated the highest

[3]As an additional validation check for our trajectory solutions, we examined DSM-IV diagnoses of marijuana abuse or marijuana dependence, which were completed by RYDS participants during interviews in Phase 3. Among the abstainers, 0% met the criteria for marijuana abuse/dependence, and in the early-onset desistor group, 4.4% met the criteria for marijuana abuse/dependence. Among the early-onset persistor group, 3.4% met the diagnostic criteria for marijuana abuse/dependence. Among the late onset persistor group and the increasing chronic group, 8.0% and 21.4% met the diagnostic criteria for marijuana abuse/dependence, respectively.

probability of surviving of all groups, including what we predicted to be the lowest-risk group, the children of the abstainers.

Table 2 presents the results of the DTSA model to examine the relationship between parental patterns of marijuana use and age of first marijuana use among offspring, net of controls. The abstainer group served as the reference category in the presented results. Notably, there were no significant differences in the age of first marijuana use among children whose parents were classified as abstainers and either children of parents who were classified as early-onset desistors or early-onset persistors. Alternatively, among children of parents who were classified as late-onset persistors, the odds of onset, in any time period, is 1.7 times larger than the odds of onset among children of parents who were classified as abstainers, and the odds of onset are almost two times larger for children of parents whose parents were classified as increasing chronic users compared to those whose parents were classified as abstainers.

We subsequently rotated the reference group for the analyses presented in Table 2 in order to allow for the assessment of additional differences in the age of onset across parental patterns of marijuana use. For brevity, we do not report all of the differences between parental marijuana use trajectory groups; rather, we focus on comparisons directly related to our hypothesis (i.e., parental early age of onset and frequency of use in adulthood will be related to increased risk of marijuana use onset among offspring). Notably, there were no significant differences in the odds of onset between offspring of the parents classified as early-onset persistors and early-onset desistors. However, the odds of onset were 2.1 (95% CI = 1.15, 3.81) times larger among children whose parents were classified as late-onset persistors compared to children of parents who were classified as early-onset persistors, which suggests that it is not simply use of marijuana in adulthood that is related to the risk of onset of marijuana use among offspring. Additionally, the odds of onset were 2.5 (95% CI = 1.51, 13.37) times larger among children of parents who were classified as increasing chronic users compared to children whose parents were classified as early-onset persistors, implicating the importance of level of use by a parent in adulthood. Interestingly, no significant differences in the age of first use between children of parents classified as early-onset desistors, late-onset persistors, and increasing chronic marijuana users emerged.

Figure 3 summarizes the results from the DTSA model and presents the estimated survival probabilities for first marijuana use as a function of parental marijuana use, holding all control variables at the mean. Children whose parents were classified as increasing chronic marijuana users had the lowest survival probabilities from ages 12 to 25, followed by the children of the late-onset persistent marijuana users and the children of parents classified as early-onset desistors. Notably, children of parents who were classified as early-onset persistors had the highest survival probabilities of first marijuana use from age 12 to 25, followed by children of those parents who abstained from marijuana use.

Discussion

Intergenerational patterns of marijuana use are of keen interest to policy makers and practitioners alike as the use of marijuana in adolescence and emerging adulthood is known

to have serious consequences (i.e., increased risk of substance use disorder, impaired cognitive functioning and development, stymied educational and occupational attainment, Flory et al., 2004; Gruber et al., 2012; Horwood et al., 2010; NIDA, 2018; Osuch et al., 2016). As such, delaying onset is an important public health goal. Adopting a life course perspective, this study built upon extant research examining IG continuity in marijuana use and explored how parental trajectories of marijuana use, spanning three developmental periods, were related to the timing of marijuana use onset among offspring. Our results demonstrate important differences in the survival curves of offspring's onset of marijuana use as a function of parental patterns of marijuana use spanning ages 14 to 31. We now provide additional commentary regarding these findings.

Similar to prior research examining trajectories of marijuana use spanning adolescence to adulthood (e.g., Brook et al., 2011; Brown et al., 2004; Ellickson et al., 2004; Epstein et al., 2015; Schulenberg et al., 2005), we identified a group of parents who, by and large, refrained from marijuana use for the duration of adolescence through adulthood (abstainers) and a group of parents whose marijuana use was categorized by a steady increase in use through adolescence and chronic use in adulthood (increasing chronic users). We also identified a group of parents whose marijuana use began late in adolescence and continued through adulthood (late-onset persistors), and a group of parents who desisted from marijuana use after adolescence (early-onset desistors). Other research has identified similar patterns of use spanning adolescence to adulthood (e.g., Epstein et al., 2015). In addition, we identified a fifth group of marijuana users (see also Ellickson et al., 2004; for exceptions see Brook et al., 2011; Epstein et al., 2015) - parents who engaged in moderate marijuana use for the duration of adolescence through adulthood (early-onset persistors). Notably, each of these patterns are important because they can be distinguished by age of onset (early, or prior to age 15, and late), the frequency of marijuana use at any time, and the duration of marijuana use over three developmental periods.

As hypothesized, children of increasing chronic marijuana users were most likely to onset throughout the observation period. This finding is not surprising given that these parents displayed the highest levels of marijuana use from late adolescence through adulthood, and validation analyses revealed that nearly 21% of these parents also met the diagnostic criteria for marijuana abuse or dependence. As such, this finding is complementary to other work that finds a relationship between the frequency of parental marijuana use (including a marijuana use disorder), either in the parent's own adolescence or during their emerging adulthood, and offspring marijuana use (e.g., Bailey et al., 2016; Henry & Augustyn, 2017; Kerr et al., 2004; Knight et al., 2016). It is also consistent with research documenting that an elevated level of marijuana use by a parent during the life of the child is a key risk factor for marijuana use among offspring (e.g., Patrick et al., 2014; Riggs et al., 2009). As such, the mechanisms underlying this continuity in marijuana use may include modeling or imitation, the transmission of favorable attitudes towards marijuana use, availability of marijuana in the home, genetic risk, compromised parental functioning, or a negative family climate (Bailey, Hill, Oesterle & Hawkins, 2006; Thornberry, 2005). Future research should attempt to identify the mechanisms that link this pattern of marijuana use to the onset of marijuana use among offspring.

Contrary to hypotheses, children of parents who were classified as early-onset persistent marijuana users displayed the lowest likelihood of first marijuana use spanning adolescence and emerging adulthood. This is a group of parents who started semi-regular use quite early and continued this level of use through age 31. For utility purposes, we compare this group of parents to the late-onset persistent group as both sets of parents demonstrated moderate levels of marijuana use during adulthood. Children of the latter group had the second highest odds of initiating marijuana use at each age from 12 to 25. Given that the frequency of use in adulthood between late-onset persistors and early-onset persistors were similar, the differences in the likelihood of onset between children of these two patterns of parental marijuana use cannot be attributed to marijuana use during the life course of the child. Instead, it appears that parental age of onset may play a role in understanding marijuana use among the next generation. Perhaps the transition to marijuana use (onset of marijuana use) at the end of adolescence (~18) may be linked to hardships or strain during late adolescence. It also may directly or indirectly be related to future educational attainment, employment, strained interpersonal relationships (see Brook et al., 2011; 2013), and ultimately parenting. After all, Epstein et al. (2015) found that late-onset marijuana use was associated with compromised individual functioning prior to the cessation of use. Alternatively, those who begin using marijuana at an earlier age and continue to do so, although at a moderate level, may be better equipped genetically, socially, and contextually to achieve life's milestones (e.g., graduate high school, secure stable employment, etc.) and perform adult roles, including parenting, all while engaging in tempered marijuana use.

It is also possible that these two groups and their offspring differ in other important ways. The descriptive statistics presented in Table 1 as a function of G2 trajectory group lend some credence to this proposition. Compared to the late-onset persistors, a greater proportion of the early-onset persistors tended to have their child at a younger age. As such, secular or historical effects may differentiate between the children who were born to parents of early-onset persistors and children of late-onset persistors. For instance, the legalization of medical marijuana (i.e., 2014 in New York; Nahmias, 2014) and other state movements to legalize recreational marijuana use were more likely to occur during the adolescence and early adulthood of children born to late-onset persistors (as indicated by older age at birth). Moreover, adolescent perceptions of harm associated with marijuana use have declined from 2005–2016 (Miech, Johnston & O'Malley, 2017). Each of these factors are associated with an increased likelihood of marijuana use (Miech et al., 2017). Additionally, there may be differences between these two groups in terms of guardianship, which we were unable to address in the present research. For instance, the ill effects of early-onset persistent use by one's parent may only operate if a child resides with the parent (i.e., moderation). Due to the sample sizes in each trajectory group and concern for power, we opted not to perform this analysis and suggest it for future research.

It is worth noting that the previous finding related to the survival probabilities among children of parents classified as early-onset persistors appears to contradict the work by Kerr et al. (2016) and Henry and Augustyn (2017) who found that earlier parental onset of marijuana use increased the likelihood of early-onset of marijuana use among offspring. However, in both studies, parents who we classified as increasing chronic users were likely combined with parents we classified as early-onset persistors and early-onset desistors.

Thus, the findings of the aforementioned studies may have been driven by the former and weakened by the inclusion of the latter two groups. As such, our results speak to the added value of considering the full developmental trajectory of use, as what happens after the early debut seems to matter.

As with all longitudinal studies, attrition is a limitation. However, prior work suggests that the G2s who participated in RIGS adequately represented the initial population of interest (Thornberry et al., 2018). Still, RYDS participants who did not have contact with their firstborn child were significantly less likely to participate in RIGS, biasing the sample somewhat, compromising generalizability, and further limiting the available parent-child dyads for analysis. Furthermore, our limited sample did not allow for the exploration of potential moderating effects of IG continuity in marijuana use, including the relevance of parental level of contact with the focal child or the relevance of parent and child sex in patterns of IG continuity (see Kosty et al., 2015).

In addition to a limited sample size, which is inherent to most IG studies that collect prospective longitudinal data during the same developmental period among two or more generations, other limitations are worth noting. For instance, although relevant to offspring marijuana use, we were unable to include information regarding the history of marijuana use for the offspring's other parent. Moreover, it was argued that trajectories of marijuana use span the life course. However, data limitations only allowed us to examine marijuana use beginning at the parental age of 14, and we did not examine patterns of parental marijuana use further into adulthood due to concerns regarding temporal ordering between parent marijuana use and offspring onset of marijuana use. This is not to say that parental marijuana use prior to age 14 or parental use after the age of 31 are irrelevant to offspring patterns of marijuana use. In fact, both are likely to be related to (dis)continuity in patterns of marijuana use across generations. We also note that this research focused on a predominantly Black sample originating from one urban locale in the United States. While the patterns that emerged are informative, this analysis should be replicated among other samples where secular effects, prevalence rates, and frequency of marijuana use may be different. After all, it may be that the low frequency of use among early-onset persistent users identified among this sample of parents is unique (see Epstein et al., 2015). Finally, this research did not account for the comorbidity of other licit and illicit substances (e.g., binge drinking or hard drug use), both of which may compromise individual and family functioning and affect the onset of marijuana use by offspring. The comorbidity of substances may further explain the observed relationships and should be examined in future research.

Notwithstanding the aforementioned limitations, this work reinforces the importance of accounting for heterogeneous patterns of parent marijuana use (see also Loughran et al., 2018), which can speak to age of onset, frequency, and duration of use simultaneously as opposed to singular measures of each aspect of marijuana use. In line with this argument, prevention and intervention efforts should recognize parental patterns of marijuana use and tailor interventions to match the individual risk posed to offspring (Collins et al., 2004). Furthermore, prevention and intervention efforts would benefit from subsequent research that investigates why some individuals who experience an early onset of marijuana use

increase their use and display problematic patterns of marijuana through adulthood in contrast to others who only engage in moderate use through adulthood (e.g., genetics). This would certainly inform efforts that seek to limit the negative consequences of marijuana use (i.e., health and individual functioning as well as marijuana use disorders). Moreover, it may illuminate the mechanisms that can account for the finding that children of parents who experienced an early onset of marijuana use and engaged in moderated marijuana use in adulthood had offspring who were least likely to use marijuana during their own adolescence and emerging adulthood. Finally, future work should attempt to understand why some individuals begin to use marijuana at a later age and how this affects their future familial functioning. All of this is pertinent to public health efforts that seek to improve the general health and well-being of individuals as well as the health and well-being of the next generation who will be the employees, partners, and parents of tomorrow.

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The specific ideas and analyses presented in this research have not been presented elsewhere.

Points of view or opinions in this document are those of the authors and do not necessarily represent the official position or policies of the funding agencies.

Appendix

Appendix A.

Rochester Youth Development Study: Research Design

	Phase 1										Phase 2				Phase 3	
	(Spring 1988)								(Spring 1992)		(1994-1995)	(1995-1996)	(1996-1997)		(2003)	(2005)
Age:	14		15		16		17		18	//	21	22	23	//	29	31
Adolescent																
Interviews Number	x	x	x	x	X	x	x	x	x		x	x	x		x	x
Completed (n=1000)	956								881				846			803

Appendix B.

Rochester Intergenerational Study sample sizes at each child age.

	G3 Age												
	12	13	14	15	16	17	18	19	20	21	22	23	24	25
N	476	471	458	445	433	419	382	355	323	294	248	211	171	115

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Appendix C.

Trajectory model comparison for best-fitting group solutions representing marijuana use spanning age 14 to 31 among RYDS participants (G2s n=868)

Groups	Higher-order Parameters	AIC	BIC
2	2, 3	−9321.26	−9354.86
3	2, 3, 2	−9099.85	−9148.38
4	2, 3, 2, 2	−8884.98	−8948.44
5	2, 3, 3, 1, 2	−8820.57	−8898.96
6		No convergence	

Appendix D.

Trajectory solution diagnostics for marijuana use spanning age 14 to 31 among RYDS participants (G2s n=868)

		95% CI				
Group	Pi_hat	Lower	Upper	P_hat	Avg. PP	Odds CC
Abstainer	0.492	0.452	0.532	0.504	0.950	19.6
Early-onset Desistor	0.124	0.093	0.155	0.108	0.880	51.7
Late-onset Persistor	0.241	0.207	0.275	0.249	0.900	28.4
Early-onset Persistor	0.060	0.039	0.080	0.057	0.880	115.9
Increasing Chronic	0.084	0.061	0.106	0.083	0.900	98.8

Note: Trajectory solution passes all four key model adequacy diagnostics recommended by Nagin (2005)

Abbreviations. CI = Confidence interval; Pi_hat = Mixture probability of classification; P_hat=Hard classification; Avg. PP = Average posterior probability of classification; Odds CC = Odds of correct classification.

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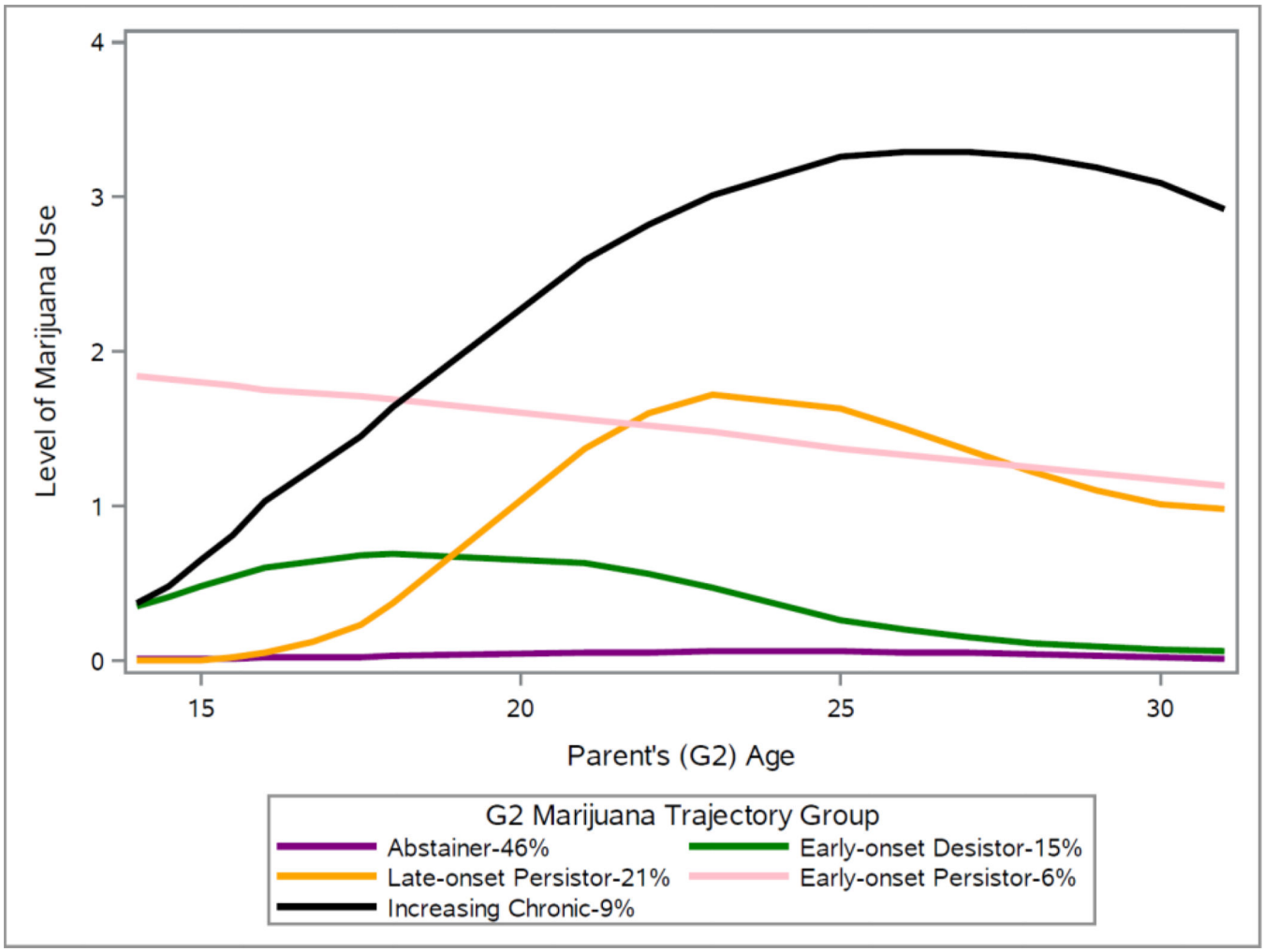

Figure 1.
Parental marijuana use trajectory solutions, G2 ages 14–1 (N=462)

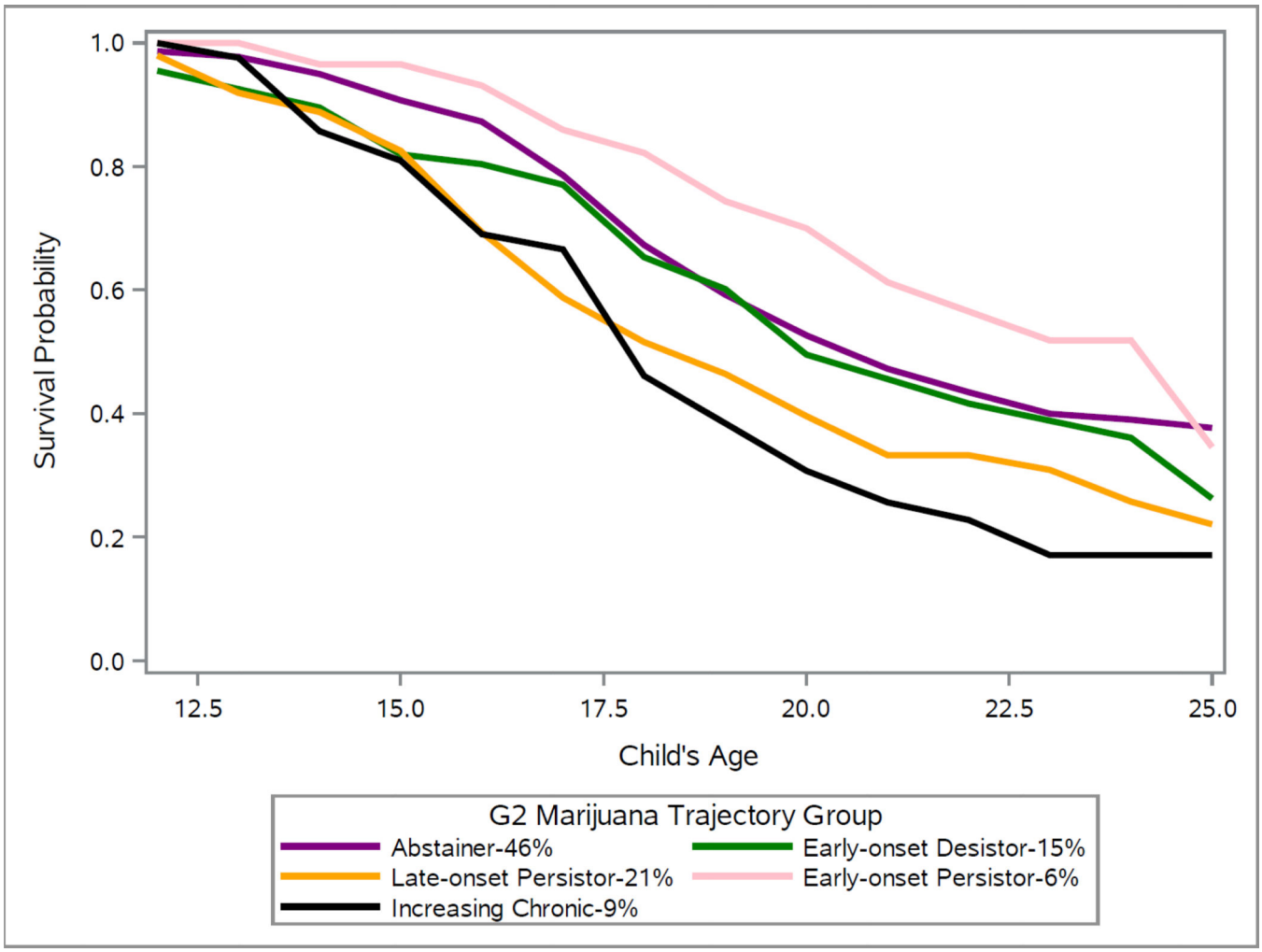

Figure 2.
Unadjusted survival probabilities for child onset of marijuana use by parent trajectory of marijuana use (N=462)

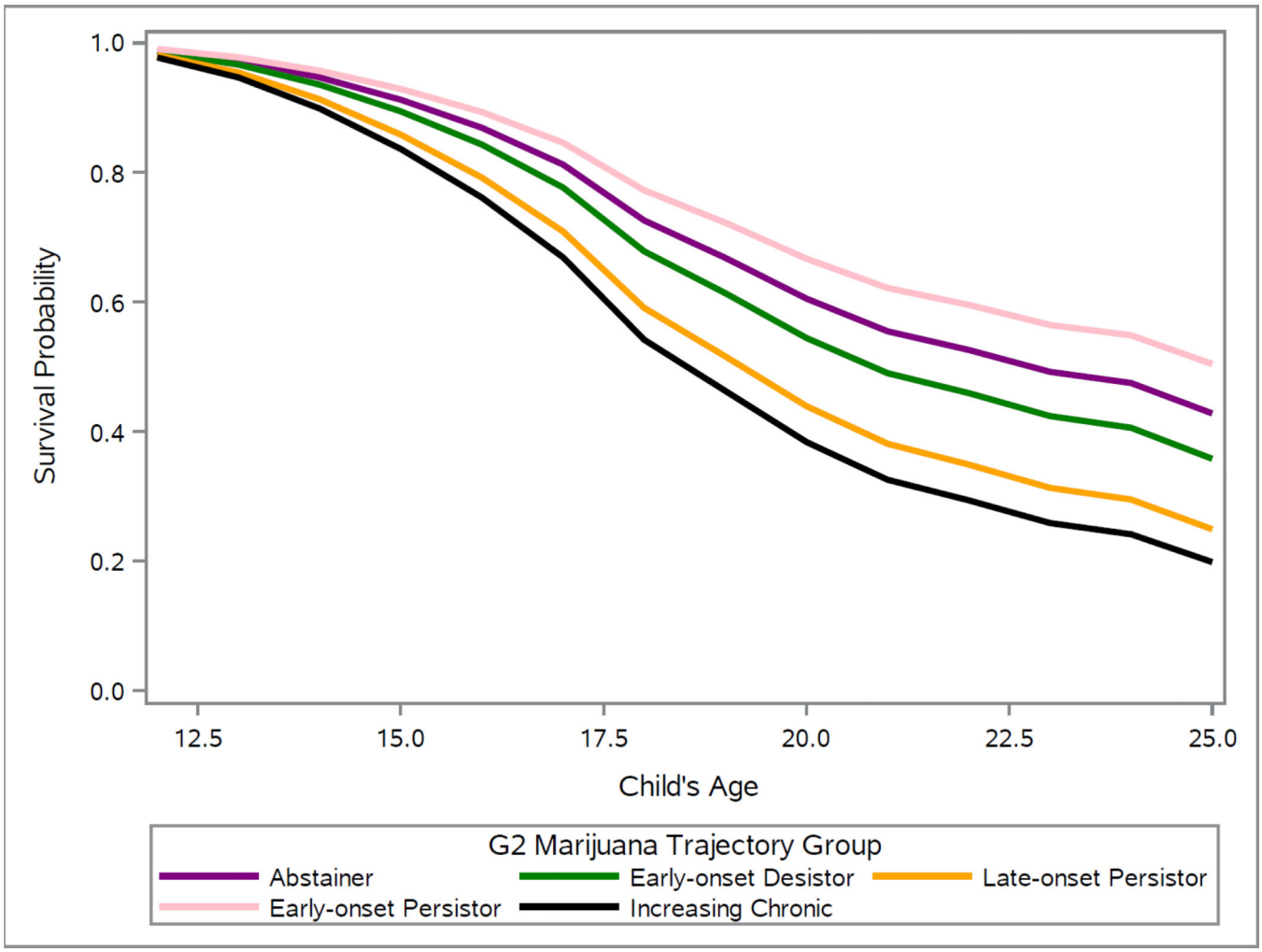

Figure 3.
Adjusted survival probabilities for the child's onset of marijuana use by parental trajectory of marijuana use (n=462) Note. All covariates are held at their mean.

Table 1.

Descriptive statistics for covariates in DTSA analysis by parent marijuana use trajectory group

		Full Sample (N=462)	Abstainer (N=225)		Early-onset Desistor (N=67)		Early-onset Persistor (N=29)		Late-onset Persistor (N=99)		Increasing Chronic (N=42)	
	Range	**Mean/ Proportion (SD)**	**N**	**Mean/ Proportion (SD)**	**N**	**Mean/ Proportion *(SD)***	**N**	**Mean/ Proportion *(SD)***	**N**	**Mean Proportion *(SD)***	**N**	**Mean/ Proportion *(SD)***
Child Onset of Marijuana Use (by last observation)	0,1	462	0.56	225	0.48	67	0.60	29	0.55	99	0.62	42	0.79**
Child Age of Onset	12–25	260	17.88 (3.30)	110	18.03 (3.03)	40	17.95 (4.06)	16	20.05 (3.63)	61	17.03 (3.12)	33	17.61** (2.73)
Child Last Age of Observation	12–25	462	21.87 (3.43)	225	21.47 (3.61)	67	22.42 (3.19)	29	(23.14 (2.82)	99	21.57 (3.51)	42	22.98 (2.48)
Parent Sex (G2)													
Male	0,1	462	0.64	225	0.57	67	0.54	29	0.59	99	0.82	42	0.79**
Female (reference)	0,1	462	0.36	225	0.43	67	0.46	29	0.41	99	0.18	42	0.21
Child Sex (G3)													
Male	0,1	462	0.50	225	0.55	67	0.45	29	0.45	99	0.45	42	0.40
Female (reference)	0,1	462	0.50	225	0.45	67	0.55	29	0.55	99	0.55	42	0.60
Child Race/ethnicity													
Black	0,1	462	0.65	225	0.64	67	0.78	29	0.69	99	0.62	42	0.50*
Hispanic	0,1	462	0.11	225	0.14	67	0.06	29	0.07	99	0.09	42	0.11
Mixed/Other	0,1	462	0.14	225	0.14	67	0.07	29	0.10	99	0.17	42	0.21
White (reference)	0,1	462	0.10	225	0.08	67	0.09	29	0.14	99	0.12	42	0.17*
Supervisory Contact	0,1	462	0.94	225	0.96	67	0.91	29	0.97	99	0.93	42	0.95
Parent Age at Child's Birth	14.10–32.50	462	21.09 (3.81)	225	21.51 (4.02)	67	20.69 (3.83)	29	19.32 (3.33)	99	21.34 (3.64)	42	20.06** (2.74)
Community Arrest Rate	0.12–7.87	462	4.36 (2.02)	225	4.46 (2.01)	67	4.39 (1.95)	29	4.27 (2.07)	99	4.33 (2.05)	42	3.90 (2.05)

Note. All control variables mean centered in analyses.

One-way anova tests were performed as an omnibus test to assess whether there are significant differences across the five G2 trajectory groups:

* p<.05,

** p<.01 (two-tailed test)

Abbreviation. SD=Standard deviation.

Table 2.

DTSA models examining the relationship between parental history of marijuana use and child age of onset of marijuana use

	OR	95% CI
Parental Trajectory Group		
Early-onset Desistor	1.22	(0.83–1.79)
Early-onset Persistor	0.80	(0.45–1.42)
Late-onset Persistor	1.68	(1.19–2.37)
Increasing Chronic	1.98	(1.28–3.04)
Male Parent	1.09	(0.80–1.47)
Male Child	1.36	(1.04–1.77)
Black	1.15	(0.69–1.92)
Hispanic	1.52	(0.82–2.80)
Mixed/Other Race	1.39	(0.78–2.50)
Supervisory Contact	0.79	(0.46–1.37)
Parent Age at Child's Birth	0.97	(0.92–1.02)
Community Arrest Rate	0.96	(0.90–1.03)

Note. The parent trajectory group "Abstainer" serves as the reference group. Parent age at birth and community arrest rate were centered at 0 prior to inclusion in the analysis.

Abbreviations: OR = Odds ratio; CI = Confidence interval.