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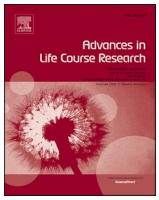

Can drug policies modify cannabis use starting choice? Insights from criminalisation in Italy

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ABSTRACT

A key question in the ongoing drug policy debate is whether legalising cannabis leads to an increase in cannabis use. In Europe although no country has yet moved to legalisation, many have decriminalised personal possession. However, some jurisdictions are still discussing increased sanctions or have further strengthened penalties for the possession of illicit substances in order to deter widespread cannabis use. This is the case in Italy, where a law introduced in 2006 and repealed in 2014 de facto criminalised personal drug possession, and a potential increase in penalties is currently being debated as a policy option. Despite the intense public debate surrounding the legal status of cannabis, limited empirical research has been conducted in Europe to assess the population-level effects of drug policy reforms, mainly due to data availability constraints. In this study, we analyse the effect of criminalisation on the age of onset of cannabis use using an unique dataset that combines seven waves (2001–2017) of the nationally representative Italian Population Survey on Alcohol and other Drugs with relevant socio-economic data. The final dataset comprises 77,650 observations. Leveraging the rare opportunity to examine the effects of a policy that remained in force for a limited period, our empirical investigation employs a Complementary Log-Log model to analyse the starting rate, that is, the transition rate from non-use to use. To do so, we use self-reported data on the age of first cannabis use. Our results suggest that the implementation of stricter punishments has a significant effect in reducing the likelihood of early cannabis use initiation. The observed impact of criminalisation is limited in younger ages and diminished as adulthood approaches. This paper also discusses other considerations related to the social costs of criminalisation, which should also be taken into account in the ongoing policy debate.

1. Introduction

According to UNODC (2022), about 4% of the global population aged 15–64 used cannabis in 2020, namely 209 million people, and there are signals that the prevalence will continue to increase. In Europe, approximately 16% of individuals aged 15–34 used cannabis in the past year. This prevalence increases to 19% when focusing solely on the 15- to 24-year-old age group (EMCDDA, 2022).

Against this backdrop, a growing amount of literature is seeking to empirically determine the causal nature of the relationship that runs from policy to cannabis use and between this and its potential consequences.

With respect to the first relationship, empirically investigating the impact of removing or increasing sanctions for cannabis possession on the extensive and intensive margins of cannabis use has been a fertile topic for research in recent times, but the evidence produced is mixed (EMCDDA, 2020; Hammond et al., 2020; Smart & Pacula, 2019).

Despite a substantial quantity of epidemiological and econometric studies, no robust evidence has been provided about the negative health effects of cannabis use. In particular, the review of Van Ours and Williams (2015) indicates that there do not appear to be serious health effects for moderate cannabis use, also in terms of mental health and

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well-being. An important feature in assessing the impact of policies on the dynamics of cannabis use is the age of onset. For cannabis, initiation typically occurs during adolescence (Van Ours and Williams, 2007), and if so it is associated with a longer duration of use (Richmond-Rakerd et al., 2017).

Although in recent years some countries have legalised cannabis, jurisdictions which take a "soft" approach are an exception to the rule and, to a large extent, those who decide to start using cannabis do so under the threat of administrative or criminal prosecution. In fact, governments have traditionally adopted a punitive stance towards cannabis policy, under the assumption that use should decline as punishment increases.

Within the conceptual framework of the rational-choice paradigm, where actors rationally select actions that maximise their expected utility, punitive drug policies inspired by modern deterrence theory (Becker, 1968) are believed to, at least in theory, discourage the initiation of cannabis use by increasing the risks, and therefore the costs, of engaging in such behaviour. Consequently, policies driven by this approach are designed to deter use both constraining supply in order to make the drug difficult to obtain and expensive, and providing disincentives to demand by setting strict and certain consequences of arrest (Room et al., 2010). The implication is that if perceived certainty and severity of legal sanctions were reduced, the expected utility of drug consumption would increase and so the prevalence of cannabis use (MacCoun, 1993).

Critics of this policy contend that its principal component, namely the enforcement of prohibition, has weak evidence of effectively reducing drug use and that more liberal cannabis policies do not necessarily translate into a higher incidence of cannabis use (Smart and Pacula, 2019). On the contrary, continued criminalisation in the face of high or growing demand is associated with many negative unintended consequences, such as increased financial costs of law enforcement and criminal justice system, including overcrowded prisons, large black markets, stigma of criminal or prison records, social stigma on cannabis users, barriers to treatment seeking, prevention of quality control over consumed substances, and restrictions on medicinal uses of cannabis (Reuter, 2009).

Therefore, comprehending the extent to which policies can effectively influence the age at which people first get into contact with cannabis is of paramount importance. Indeed, most cannabis users do not experience adverse consequences from its use, but others will become long-term heavy users (Van Ours, 2006), and the likelihood of experiencing adverse consequences is greater among those who start early (Hall, 2009).

However, information regarding when an individual initially faced the decision to use a specific drug is most often unavailable. This paucity of good data justifies the scarcity of research on the dynamics of cannabis use (Van Ours and Williams, 2015). The limited number of studies examining the impact of changes in cannabis policies on the initiation of cannabis use primarily concentrate on decriminalisation (Palali & Van Ours, 2015; Williams & Bretteville-Jensen, 2014; Červený et al., 2017). Červený et al. (2017) found that the decriminalisation implemented in Czechia in 2010 did not affect the age of onset of cannabis use, while Williams and Bretteville-Jensen (2014) found a small net increase in early uptake after decriminalisation in Australia, with a significance limited to the first five years following the policy change.

This paper has a twofold objective. First, it aims at extending previous research about the effects of drug policy reforms on the age at which cannabis is first used. While previous studies have focused on decriminalisation, this paper aims at investigating the effect of criminalisation, i.e. an increase of sanctions for cannabis use and possession. The second is to do it in the Italian context where, despite the relevant drug policy reforms implemented, very little studies have been performed to understand their population-level effects (Carrieri et al., 2019, 2020).

Our empirical analysis employs a Complementary Log-Log regression model to study the transition rate from non-use to cannabis use. In order to identify the effect of criminalisation on this transition, we exploit the reform that in the period 2006–2014 increased the penalties attached to cannabis possession. For this, we use a unique dataset pooling seven waves of the Italian Population Survey on Alcohol and other Drugs (IPSAD). Our results suggest that the introduction of higher punishments for cannabis possession has a significant, but limited, effect in reducing the uptake of cannabis.

2. Institutional setting

The first legislation concerning illicit drugs in Italy dates back to 1923, repressing drug trafficking and considering the use of any drugs as a mental disease to be treated with compulsory hospitalisation. Through a reform that was implemented in 1975, for the first time a distinction was made between drugs and between dealers and consumers.

In 1990, a reform commonly referred to as Jervolino-Vassalli (Presidential Decree 309/90) defined the possession of drugs for personal use as an administrative offence, thus distinguishing it from trafficking (i.e. penal offence). Furthermore, based on its lower health and social risks, cannabis was identified as a 'soft' drug, resulting in lighter sanctions for possessors than 'hard' drugs.

In 2006, a new law (n.49/2006) that is customarily called Fini-Giovanardi introduced several changes. The underlying rationale of this reform was that both drugs and drug users are dangerous, the former being harmful independently from their nature (D'Egidio, 2019). Consequently, the distinction between 'soft' and 'hard' drugs was removed. Possession for personal use was defined on the basis of the quantity of the psychoactive component of the drug seized. Both the administrative sanctions for the possession for personal use and the criminal penalties for dealing and trafficking were raised. Table 1 provides a description of the main changes.

In brief, the law substantially increased the sanctions for both personal cannabis possession and dealing, increasing the likelihood for users to fall in the latter crime.

Over the course of the eight years when the new policy was in force, a heated national debate emerged. Opponents argued that the quantity limits were excessively low, and for users, it was difficult, if not impossible, to determine the quantity of psychoactive substance present in the carried drug. This is especially due to the great variability of the potency of substances available in the market in recent years (EMCDDA, 2019). Furthermore, the reform was criticised for disproportionately elevating the societal costs of drug use. This was evidenced by a substantial rise in the number of complaints related to drug supply and the ensuing legal consequences. Additionally, the percentage of individuals incarcerated for minor drug-related offenses also escalated (Scandurra, 2009). Fig. 1 depicts the trend in the number of individuals receiving complaints for drug supply-related offenses, as well as the trend in the number of prisoners, spanning the period from 1992 to 2017. For the latter indicator, the share of those receiving a complaint for cannabis supply-related and for the former the portion of the individuals in jail for drug-related offences are provided. Concerning both the amount of drug and cannabis supply-related offenders an increasing trend can be observed as of 2006, the year in which the Fini-Giovanardi law was implemented, which reached the peak of 39,340 individuals charged in 2010. In 2014, the share of the total drug-supply complaints due to cannabis reached 49%. Although not reported, the application of the Chow structural break test (Chow, 1960) shows a non-significant effect of a time trend before 2006 and a significant and positive one from that year on. The same applies to 2014. Observing the total prison population, we note an increasing trend until 2005, followed by a sudden drop in 2006. This is because in the same year, due to the overcrowding of prisons and the inability to guarantee the respect of human rights in jail, a pardon was approved which reduced the prison population by 34.5%. Interestingly, only two years after the approval of the Fini-Giovanardi

Table 1
Penalties for the possession of cannabis (1990–2019).

	1990–2005 and from 2014 onwards	2006–2014
Possession for personal use		
Quantity threshold	No threshold defined. "Small quantity" defined by judicial court case by case on the basis of quantity of psychoactive component and specific circumstances of the offence, excluding distribution and supply.	For cannabis, 500 milligrams of psychoactive component.
Penalty	Administrative sanctions for a maximum of three months. First time offence: policy warning. Repeated offences: suspension of driving license and/or passport. Deferral to addiction treatment services foreseen as an alternative to punishment. For minor citizens: police warning and possible information to family.	Administrative sanctions for a maximum of one year. For first time offence: suspension of driving license, prohibition of leaving home in fixed hours, order to appear in police station two times per week. Deferral to addiction treatment services compulsory in addition to punishment. For minor citizens: police warning, information to family and referral to addiction treatment services.
Possession with intent to distribute or supply		
Quantity threshold	No threshold defined. Possession for quantities "greater than small".	Above 500 milligrams of psychoactive component.
Penalty	For cannabis, from two to six years incarceration and a fine from €25.822 a €258.228. Penalties reduced to one third in case of minor offences.	For all substances comprising cannabis, from 6 to 20 years incarceration and a fine from €26.000 to €260.000 for all other offences. Penalties reduced to 1–6 years incarceration and a fine from €3.000 to €26.000 for minor offences.

Source: Authors' elaboration based on information from the Italian Ministry of Justice

law the prison population had again reached the level of 2005, and its maximum in 2010 (67,961 individuals). Also the share of individuals in prison for drug-related offences reached the maximum of 40% in the years 2009–2011.

In 2014, a ruling by the Constitutional Court deemed the 2006 law illegitimate and subsequently repealed it ([4]The law was repealed not due to its contents, but because of the adoption procedure, which was included within a broader legislative initiative focused primarily on funding for the upcoming Olympic games. Constitutional Court, Judgment No. 32 of 2014, available at: https://www.cortecostituzionale.it/documenti/download/doc/recent_judgments/32-2014_en.pdf). Shortly thereafter, the legislative framework was reverted to the provisions of the Jervolino-Vassalli law.

3. Data

This research uses individual level data from the IPSAD study, a cross-sectional survey conducted by the Italian National Research Council (CNR-IFC). IPSAD is the only survey providing nationally representative data on substance use and risk behaviours in the population aged 15–74. Data are collected through postal self-administered and anonymous paper-and-pencil questionnaires from a proportional stratified randomised sample. A detailed description of the survey methodology is provided elsewhere (DPA, 2014).

For this study the 2001, 2003, 2005, 2008, 2011, 2014 and 2017 waves were pooled (77,650 observations). Cannabis first use is self-reported retrospectively by responses to the question "What age were you when you first used cannabis?".

3.1. Descriptive analysis

We initially had a sample of individuals born between 1955 and 1996. Figs. 2 and 3 display the reported first use of cannabis within the at-risk age range of 10–20 years and the average reported age of first cannabis use among individuals aged 20 or older, respectively.

Utilising reported data on the age of first cannabis use, individual histories were formed by assuming that sample members are at risk of uptake from the age of 10 until the age of 20. To ensure our sample covered the time span from 1980 to 2017 – encompassing the enactment of the Jervolino-Vassalli law in 1990 (i.e., decriminalisation), as well as the period from 2006 to 2014 during which the Fini-Giovanardi law was in effect – we right-cut our sample to the birth cohort of 1980.

On this basis, in order for our sample to span the calendar time period 1980–2017, covering the passing of Jervolino-Vassalli law in 1990, i.e. decriminalisation, and the period 2006–2014 during which the Fini-Giovanardi law was into force, we right-cut our sample to the birth cohort of 1980, who entered their at-risk period of life in 1990. In our calculations, individuals who had not initiated cannabis use at the time of the survey were considered to have a right-censored duration of non-use. Following Cêrvený et al. (2017), to address potential age heaping, individuals indicating a start of cannabis use at age 9 were assumed to have started at age 10. Individuals reporting a younger age of first use were excluded from the analysis due to possible misreporting. The final sample consists of 24,020 individuals aged 15–37 at the time of the survey, for whom cannabis initiation histories were reconstructed from the age of 10 to 20 years. Williams and Bretteville-Jensen (2014) highlight how the relatively young age of the sample allows to minimise potential issues of censoring and recall errors in relation to age at first use.

It has to be noted that, for the purpose of our estimation, the dataset has been developed so that individual observations are structured not as vectors, but as sub-matrices. In this framework, each vector corresponds to one year of life of the individual during her period at risk (10−20) within our specified observation period (1990–2017).

Sample means for the data used in our analysis are detailed in Table 2. For the sake of providing a more comprehensive understanding of the sample composition, for purely descriptive purposes, we present this information not only for the entire sample but also for subgroups based on whether respondents were exposed to the criminalisation period during their at-risk years for cannabis initiation (ages 10–20): the first group was never exposed (born between 1980 and 1985), the second group was partially exposed (less than four years of exposure - born between 1986 and 1989 or between 2000 and 2002) and the third group was consistently or fully exposed (at least four years of exposure - born between 1990 and 1999).

A comparison between the three groups reveals that they differ in terms of lifetime prevalence of cannabis use, with 41% of those in the first group having ever used cannabis compared with 32% of those in the second group and 29% of those in the third group. Regarding the age of first cannabis use, the first group exhibits a slightly higher age (17.23) compared to the other two groups (16.43 and 16.41 respectively).

Fig. 4 shows the hazard and the survival functions for initiating cannabis use during the at-risk period of ages 10–20 for the aforementioned three groups separately. The hazard rate represents the transition rate from non-use to use for each specific age within the considered at-risk period (10–20 years), conditioned on not having used up until that age. In calculating age-specific initiation rates, for individuals who have never used cannabis during their at-risk period, we assume that the duration until cannabis use is right-censored at their survey age. It can be noted that the hazard of starting cannabis use for all three groups exhibits peaks around the age of 16. Additionally, the 'Not exposed' and 'Consistently or fully exposed' groups each display an additional peak around the age of 18. Moreover, uptake declines substantially after the age of 18 in each group.

Fig. 4 also graphs a non-parametric estimation of the survival

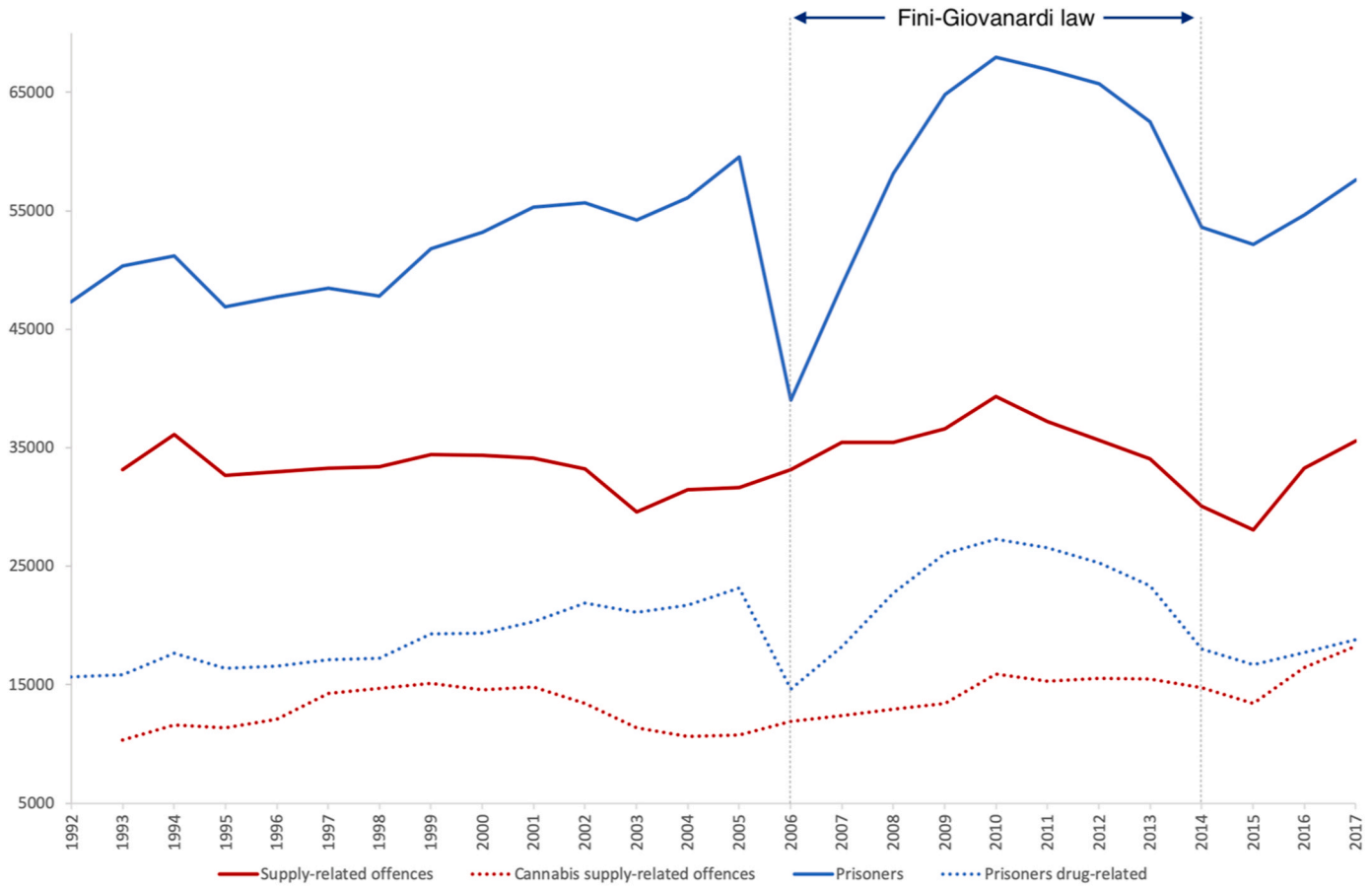

Fig. 1. Number of drug supply-related offenders and prison population (1992–2017),
Source: Authors' elaboration based on data from the Italian Ministry of Interior - DCSA and Italian Ministry of Justice - DAP.

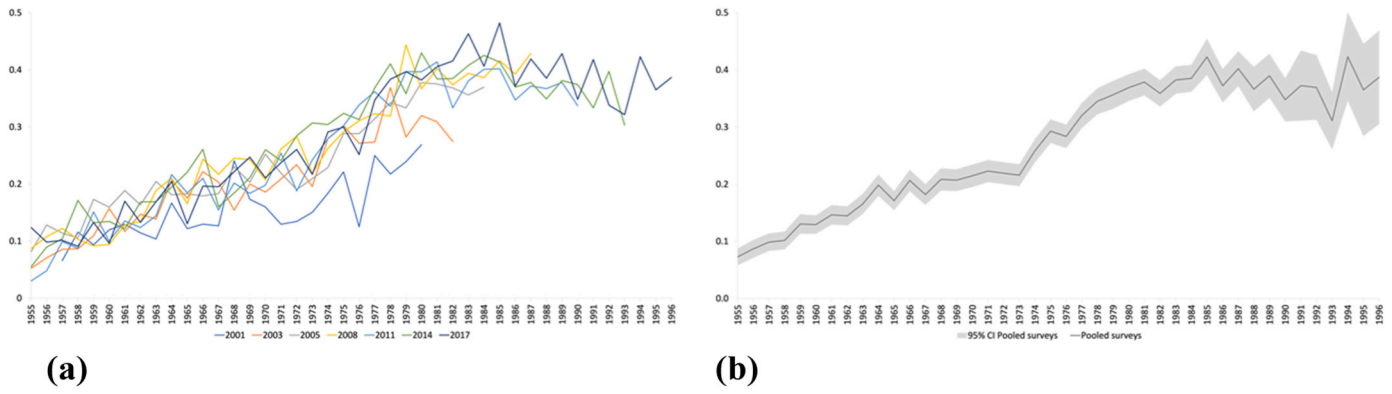

Fig. 2. Proportion of cannabis first use at age less or equal to 20 among older than 20 years, by birth cohort (1955–1996), **(a)** By survey (2001 - 2017), **(b)** Pooled surveys (2001 - 2017).
Source: Authors' elaboration on the IPSAD data. Note: In (a) each line represents a survey wave. In (b) the grey line represents the pooled surveys' trend and the light grey band represents the 95% confidence interval of the pooled surveys' trend.

function for the three groups, that is the probability of not using cannabis until at least age T. This graph shows that the probability of not using cannabis declines starting from age 13 across all groups. Furthermore it reveals that the three groups do not differ consistently in terms of survival probability over the analysed at risk-period.

While the distinction among the three groups is not utilised in the analysis, this description has been useful in revealing the presence of some differences between individuals who experienced partial or full exposure to criminalisation during their at-risk years and those who did not. Thanks to the longitudinal structure of our dataset, we can make it possible for individuals having been partially exposed to the policy to be affected by the policy itself from the exact same year when the policy was implemented until its withdrawal. Hence, within our research framework, all individuals aged 10–20 in the time frame 2006–2014 can be considered as the set of treated units only for the years in this time interval.

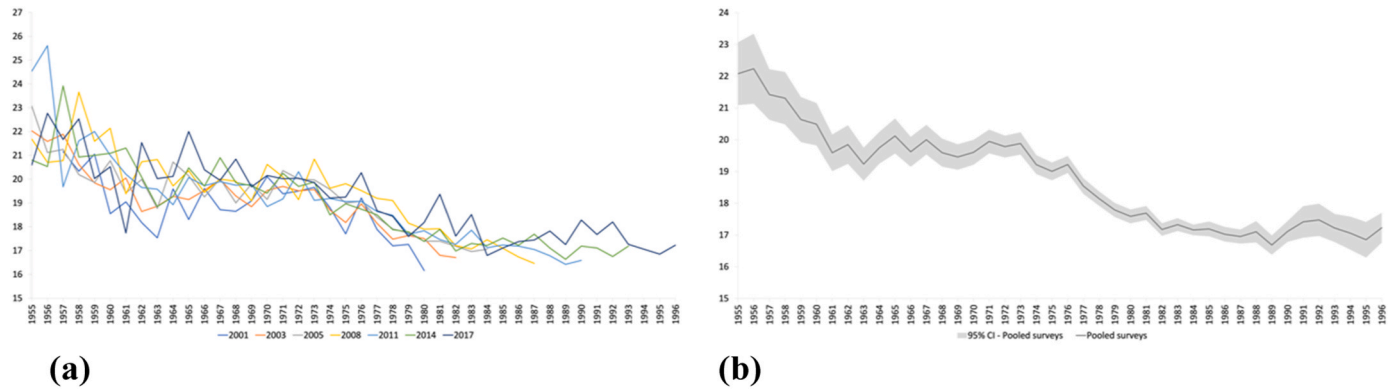

Fig. 3. Average age of cannabis first use among older than 20 years, by birth year (1955–1996), **(a)** By survey (2001 - 2017), **(b)** Pooled surveys (2001 - 2017). Source: Authors' elaboration on the IPSAD data. Note: In (a) each line represents a survey wave. In (b) the grey line represents the pooled surveys' trend and the light grey band represents the 95% confidence interval of the pooled surveys' trend.

Table 2
Sample means.

	Full sample	Never exposed	Partially exposed	Consistently/fully exposed
Age of cannabis first use	**16.85**	**17.23**	**16.43**	**16.41**
Female	0.56	0.57	0.56	0.54
Age at survey	22.22	24.78	20.68	19.24
North-West	0.29	0.27	0.31	0.32
Nort-East	0.26	0.26	0.26	0.26
Centre	0.18	0.18	0.18	0.19
South	0.16	0.17	0.16	0.16
Islands	0.10	0.11	0.09	0.07
Low education	0.27	0.12	0.35	0.47
Ever use cannabis	0.36	0.41	0.32	0.29
Ever use tobacco	0.66	0.75	0.66	0.51
Age of tobacco first use	15.52	15.73	15.25	15.36
Survey year 2001	0.03	0.05	0.01	0.00
Survey year 2003	0.08	0.11	0.10	0.00
Survey year 2005	0.30	0.39	0.35	0.05
Survey year 2008	0.20	0.19	0.18	0.23
Survey year 2011	0.17	0.10	0.19	0.29
Survey year 2014	0.09	0.07	0.06	0.17
Survey year 2017	0.14	0.09	0.12	0.26
Obs.	*24020*	*11010*	*7186*	*5824*

Note: the Never exposed group consist of individuals born between 1980 and 1985; the Partially exposed group consist of individuals born between 1986 and 1989 or between 2000 and 2002; the Consistently or fully exposed group consist of individuals born between 1990 and 1999.
Data coming from the 2014 and 2017 surveys are weighted.

4. Empirical model

With the aim of estimating the effect of criminalisation on cannabis uptake, we exploit the timing of the introduction of the policy. We pool cross-section population surveys and employ a retrospective question to reconstruct personal histories about spells in the state of interest, i.e. non-use of cannabis.

The framing of the survey question enables us to reconstruct year by year the life of the subjects in an event history form. Naturally, considering events within yearly intervals requires to rely on discrete-time events with interval-censoring, time-varying and time invariant covariates. Besides the fact that Flinn and Heckman (1982) highlight how time-varying covariates can generate the unintentional endogenisation of exogenous effects in the presence of a strong time trend, in a logarithmic model this shortcoming can be mitigated through the use of a dichotomous variable (Allison, 1982). This is precisely the case of the inclusion of a dummy indicating the presence of the policy reform during a given year.

The Complementary Log-Log regression model is widely used to treat survey or treatment data that have been transformed into an event-history format (Richardson, 2010; Southey et al., 2003), since it results in a closed-form marginal likelihood (Have, 1996). Furthemore, Prentice and Gloeckler (1978) highlight how, if the Cox (1972) proportional hazard model solved the problem of dealing with censored survival data with covariates, the current class of models goes forward by solving the issue of tied events stemming from simultaneous multiple failures.

Below, a generalized linear model for Complementary Log-Log regression (Penman and Johnson, 2009):

$$\log[-\log(1-\pi_i)] = \mathbf{X}^{\mathbf{T}}\beta$$
$$= \beta_0 + \beta_1 \text{period} - \text{at} - \text{risk}_i + \sum_{h=1}^{H} \gamma_h z_{i,h} + \sum_{g=1}^{G} \delta_g w_{i,g} + \psi d_i$$

where

$$\pi_i = h_i$$
$$= 1 - \exp(-\exp(\beta_0 + \beta_1 \text{period} - \text{at} - \text{risk}_i + \sum_{h=1}^{H} \gamma_h z_{i,h} + \sum_{g=1}^{G} \delta_g w_{i,g} + \psi d_i))$$

represents the predicted probabilities over a linearised range between $[-\infty; +\infty]$, and it can be interpreted as the specific value over the hazard function h. Consistent with Williams and Bretteville-Jensen (2014), the baseline hazard is discretely represented by the age of each individual, tracking them during the at-risk period which spans from 10–20 years old. Hence, the coefficient β_1 captures the effect of a linear age increase within the specified range in conditioning the probability of initiating cannabis usage. Additionally, z_h identifies the set of the h individual characteristics. The set of covariates related to other controls is represented by w_g, and d is a binary indicator equal to one for ages when the respondent was exposed to the new policy reform, all composing the matrix $\mathbf{X}$ that collects the variable values for each individual at each age within their at-risk period, comprised in the observation time window considered for the analysis (1990–2017).

In summary, the individual characteristics included comprise gender and an indicator equal to one if an individual discontinues schooling at the lower-secondary level. This latter indicator should be interpreted as a proxy for individual background, as it is plausible that those who drop out of school at an early stage also originate from socio-economically disadvantaged environments. In fact, Odoardi et al. (2021) found that a 1% increase in GDP at the provincial level was associated with a more than 10% reduction in secondary education dropout rates. This relationship was even stronger in the Central-Northern regions, constituting

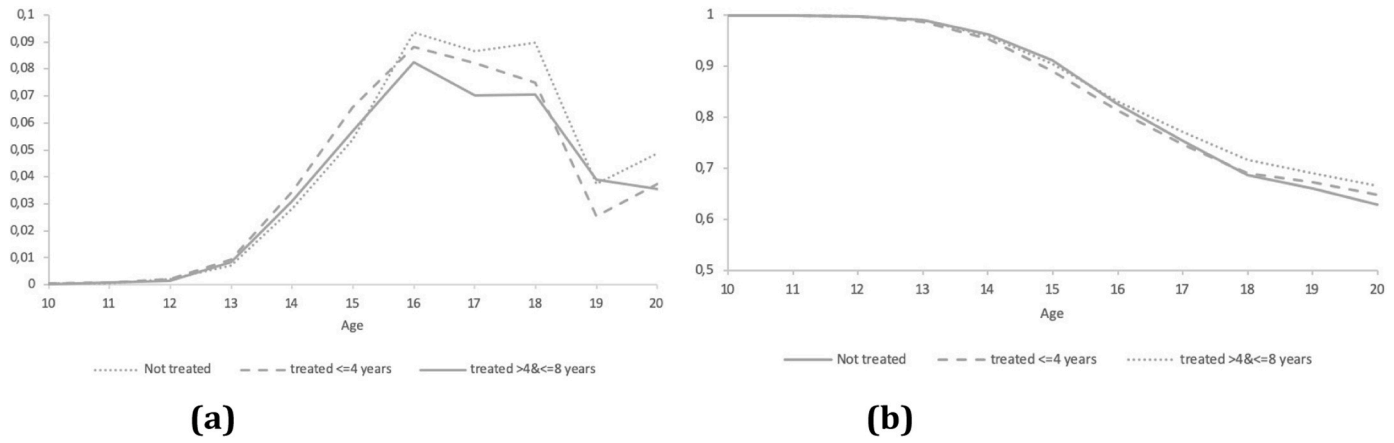

Fig. 4. Hazard and Survival functions for the uptake of cannabis, **(a)** Hazard function, **(b)** Survival function.

over 70% of our sample. At the micro-level, a comprehensive study conducted by O'Higgins et al. (2007) in Italy revealed robust and consistent evidence linking school dropout to factors such as low parental education (particularly when combined with failing grades), a lack of durable household assets, presence of at least one non-working parent, and non-attendance at a lyceum, which is known to be associated with lower levels of economic, social, and cultural status (as noted by Giancola and Salmieri, 2020). This indicator will be also interacted with the policy, aimed at exploring potential significant differences in the behavior of low-educated individuals at the confluence of the reform. Furthermore, the set of other time invariant indicators encompasses the macro-region of residence (to account for unobserved, time-invariant regional factors influencing cannabis initiation, potentially correlated with regional level cannabis availability), the surveyed year (to account for possible survey-specific effects) and birth year fixed effects (to control for common shocks potentially influencing cannabis initiation). The dummy variables for the macro regions of residence, defined according to the NUTS 1 geographical classification, cluster the 20 Italian regions into North West, North East, Centre, South, and Islands.

Although we decided not to include any region-level time-varying variables to proxy for the socio-economic characteristics of the environment of individuals, owing to the issues highlighted by Flinn and Heckman (1982) and discussed previously concerning the inclusion of time-varying variables, it has to be noted that there exists a strong correlation between Italian macro regions, moving from North to South, and per capita GDP (−49% in our sample) and unemployment rate (80% in our sample). While the former indicator could have functioned as a proxy for income levels, the latter could have proxied for the opportunity cost of time.

At this point, it is necessary to identify the functional form of the baseline hazard for the specified at-risk period.

Following Jenkins (2008), we employed the non-parametric function as a benchmark and conducted a comparison of logarithmic, quadratic, and cubic hazard functions. Comparing these three models based on the pseudo log-likelihood and the information criteria, we opted for the cubic functional form in our final estimation as it yields the higher pseudo log-likelihood and the lowest value in the information criteria (not shown here for conciseness) (Fig. 5):

$$\log[-\log(1-\pi_i)] = \mathbf{X}^{\mathrm{T}}\beta = \beta_0 + \sum_{c=1}^{3}\beta_c period - at - risk_i^c + \sum_{h=1}^{H}\gamma_h z_{i,h} + \sum_{g=1}^{G}\delta_g w_{i,g} + \psi d_i$$

Where c represents a value from 1 to 3 used for exponentiating the at-risk period, so to reach a cubic functional form.

Finally, we undertake three checks to assess the robustness of our

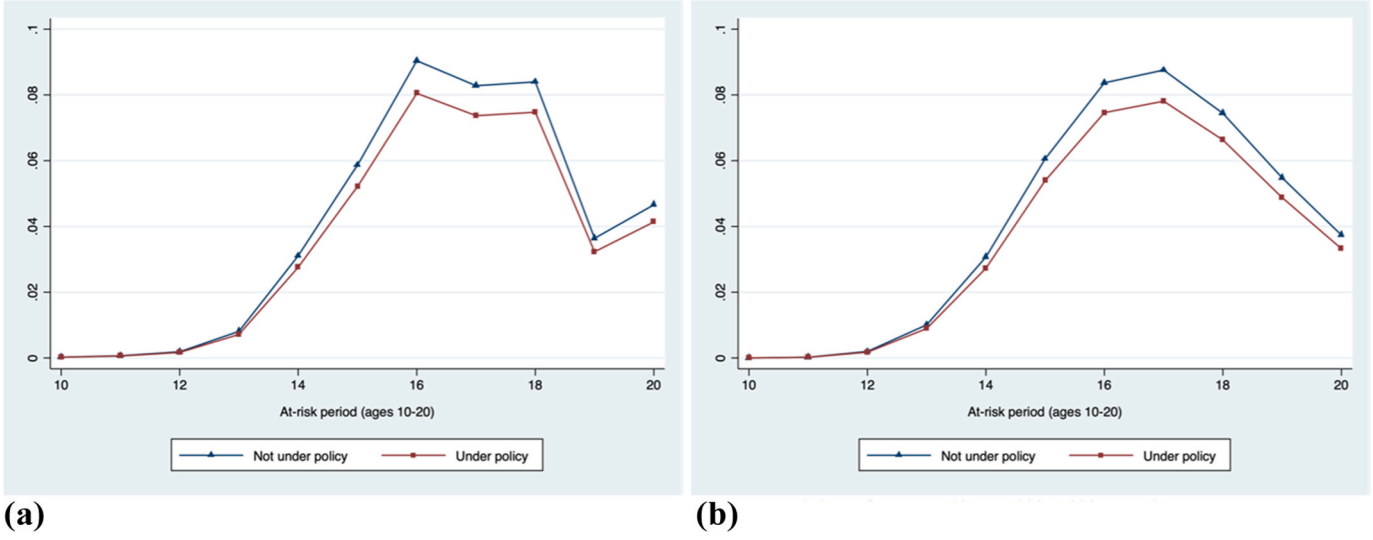

Fig. 5. Baseline hazard functions for the uptake of cannabis, **(a)** Non-parametric form (log-likelihood: -29316.248; BIC: 58644.5; AIC: 58706.29), **(b)** Cubic form (log-likelihood: -29413.094; BIC: 58836.19; AIC: 58887.6)

estimates. Given that the choice to focus on the age range 10–20 years as the period when individuals are at risk of initiating cannabis use might seem somewhat arbitrary, particularly when considering Fig. 4, we extend our at-risk period to encompass the age range of 10–25 years. Secondly, we conduct two falsification tests. Such tests can be performed by using alternative placebo outcomes that are expected not to be affected by the treatment. For these tests, we select two distinct outcomes. The first is the age of initiation into tobacco use. As proposed by the 'gateway' hypothesis (Kandel, 2002), the initiation of tobacco smoking might function as a stepping-stone for cannabis initiation. This hypothesis finds support in various intertemporal demand studies, which have found that prior tobacco use increases the likelihood of subsequent cannabis use (Beenstock & Rahav, 2002; Pacula, 1998; Van Ours and Williams, 2007). Since, differently from cannabis, tobacco is not stigmatised by society, we perform the second falsification test using the age of first alcohol consumption — a substance more exposed to less social desirability such as cannabis. Furthermore, previous research has highlighted that alcohol can act as a substitute for cannabis consumption (Crost & Guerrero, 2012). Unfortunately, data on alcohol initiation are available only starting from the 2008 survey, limiting the sample for this test to 14,306 subjects. The changes in the policy regime governing cannabis use should not directly influence the initiation of cigarette or alcohol use. The identification of a significant effect would suggest that our results may capture other changes that occurred around the same time as the introduction of criminalisation and that impacted not only on cannabis use but also on tobacco and alcohol consumption.

In other words, our estimates of the effect of criminalisation would be biased or at least spurious. As of the interpretation of coefficient estimates, following Williams and Bretteville-Jensen (2014) and Červený et al. (2017) ($(exp(\beta) - 1) * 100)$) — where β in this case can be any coefficient — can be read as the percentage change in the probability of cannabis uptake.

5. Results

Table 3 reports the coefficient estimates of three different specifications of our Complementary Log-Log regression model for the uptake of cannabis use. In addition to the control variables listed in the table, all specifications include a full set of calendar birth year dummies.

Table 3
Parameter estimates of hazard model for cannabis uptake (at-risk period: ages 10–20).

	(1)	(2)	(3)
Policy change	-0.154 *	-0.153 *	-0.169.
	(0.0701)	(0.0711)	(0.0863)
Individual characteristics			
Gender (ref. Male)	-0.274 * **	-0.276 * **	-0.276 * **
	(0.0500)	(0.0493)	(0.0494)
Education low	-0.0452 * *	-0.0520 * *	-0.0695 *
	(0.0172)	(0.0166)	(0.0339)
Education low*Policy change			0.0618
			(0.0929)
Other controls			
North east		-0.0151	-0.0149
		(0.0667)	(0.0665)
Centre		0.0657	0.0656
		(0.0709)	(0.0711)
South		-0.302 * **	-0.302 * **
		(0.0329)	(0.0328)
Islands		-0.250 * **	-0.249 * **
		(0.0621)	(0.0622)
Surveys	Yes	Yes	Yes

Notes: The table reports coefficient estimates and standard errors in parentheses. Standard errors are clustered at survey level.
= ". p < 0.1 * p < 0.05 * * p < 0.01 * ** p < 0.001". Although not reported, all models include birth year fixed effects. Data for the 2014 and 2017 surveys are weighted.

Specification 2 adds the macro-region of residence, specification 3 includes an interaction term between the policy change and the low-education indicator (representing the discontinuation of schooling at the lower-secondary level). The top row of the table shows the effect of the policy change on the initiation of cannabis use.

The estimates from the first specification (column 1) suggest that the increase in penalties for cannabis possession has a negative effect on cannabis uptake and that this effect is statistically significant at the 5% significance level. Based on these estimates, being exposed to the new policy during the at-risk period of life (10–20 years) is associated with a 14.27% ((exp(−0.154)− 1)* 100)) decrease in the rate of cannabis uptake compared to an otherwise similar individual not exposed to the new policy. The remainder of the table illustrates how individual characteristics affect the rate of cannabis uptake. Women have a lower starting rate than men by 23.97%. Dropping out of school at the lower-secondary level negatively affects the risk of initiating cannabis use, although the coefficient indicates a relatively small effect (−4.40%). All survey year dummies, which are included to control for possible survey-specific effects, show a positive effect on the rate of uptake of cannabis use compared to the 2001 survey, ranging from 15.84% to 58.72% for the 2005 and 2017 survey years respectively. This might also be an indication of the long term trends in cannabis use discussed in Section 3.1, revealing an increasing uptake by age 20 over time. Specification 2 also allows the region of residence to influence the rate of cannabis uptake. Being from the North Eastern or Central regions of Italy does not have a significant effect compared to North Western regions (baseline). Still, compared to being from North Western regions, residing in the Southern regions and Islands decreases the risk of uptake by 26.07% and 22.12%, respectively. The other coefficients show similar values to those in the first specification. In the third and final model, we account for the fact that not everyone exposed to the policy change might be affected in the same way. Specifically, we are interested in understanding whether having a low educational level somehow modifies the effect of having lived under the criminalisation period during the at risk-period of life. This seems to strengthen the effect of criminalisation (to obtain the hazard rate, we have to exponentiate the sum of the coefficients for the policy variable and for the interaction term and subtract one from this quantity, as shown by Cleves et al. (2016)), but not significantly. The coefficient for criminalisation remains negative and significant, albeit with a lower intensity (at the 5% significance level). As with specification 2, all other coefficients remain substantially similar.

To gain a deeper understanding of the estimated effect of criminalisation on cannabis uptake, we utilise the coefficient estimates reported in column 3 of Table 3 to predict hazard and survival functions for individuals who lived through their at-risk period of life under criminalisation and those who did not. Furthermore, we differentiate between individuals with a higher and a lower risk profile. Based on the coefficients in Table 3, we define a higher risk profile as being male, with an educational level higher than lower secondary school and living in a central region. Conversely, a lower risk profile is defined as being female, with a low educational level, and living in a southern region. The results are graphed in Fig. 6.

Since the survival function is based on the cumulative hazard function, it estimates distinct values for varying time-varying covariate values. For this reason, in order to illustrate the effects of different predictors on the survival function, we employ the method of plotting it for hypothetical individuals who serve as prototypical examples (Singer and Willett, 1993). We achieve this by defining prototypical higher-risk and lower-risk individuals, utilising the same characteristics as described in the context of the hazard function, but specifying their year of birth: 1981 for those unexposed to criminalisation and 1994 for those under the criminalisation policy. Due to the choice of plotting the survival function for two types of individuals as different as possible, we can note how in their case we can observe that the two survival functions — both under criminalisation and otherwise — do not tend to converge, similar to the pattern observed in the hazard function.

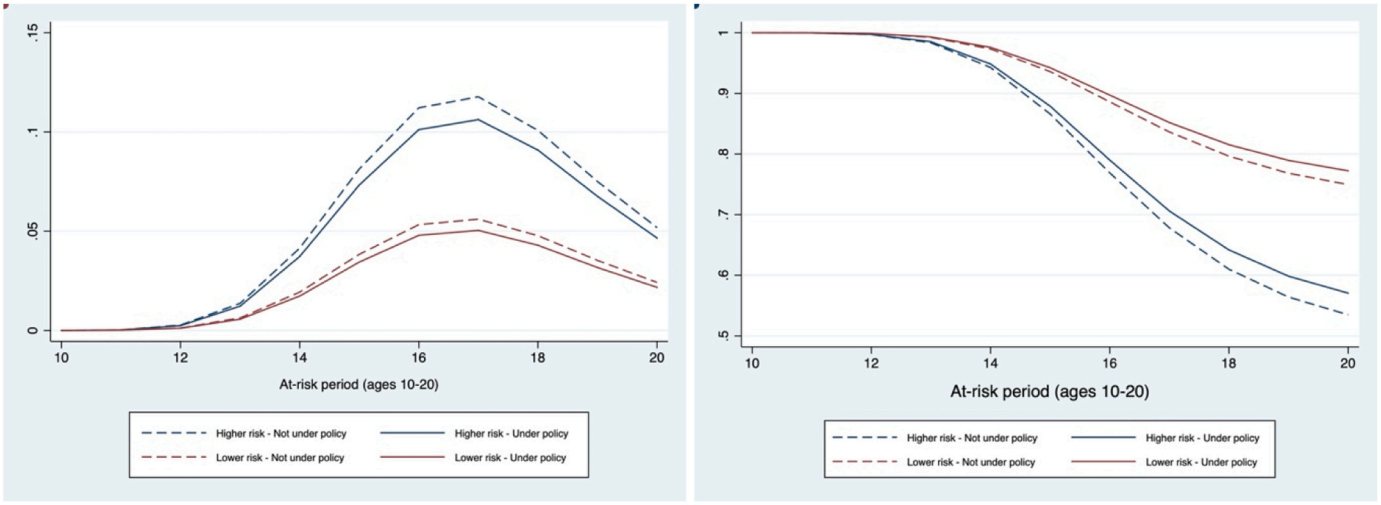

Fig. 6. Predicted hazard and survival functions for cannabis uptake for lower and higher risk individuals not under the policy and under the policy, **(a)** Predicted hazard functions, **(b)** Predicted survival functions.

Fig. 7 allows for an examination of the marginal effects of age on the probability of cannabis uptake. It confirms that criminalisation does not seems to affect the probability of initiating cannabis use at younger ages (11–12 years). However, it begins to reduce the probability of uptake as age increases, particularly between 15 and 18 years. From the age of 19 onward, the effect of criminalisation in diminishing the probability of cannabis uptake becomes visibly less pronounced.

Observing the hazard functions, the initiation of cannabis use starts to rise around the age of 13, reaches its peak at 17, and subsequently declines. A comparison of the hazard functions reveals that introducing criminalisation leads to lower the hazard function for commencing cannabis use. On the other hand, starting from the age of 13 an individual not subjected to criminalisation faces a hazard that is nearly twice as high as that of an otherwise similar individual under criminalisation. This suggests that criminalisation seems to influence whether an individual ever engages in cannabis use, but it does not appear to lead to uptake at a later age than would otherwise occur under decriminalisation. Moreover, upon comparing the two profiles, it can be noted how an individual with a higher risk profile encounters a slightly higher hazard than an individual with lower risk profile under decriminalisation as opposed to criminalisation. Additionally, it can be observed that by the age of 20, the hazard functions for higher risk and lower risk profiles nearly converge both under criminalisation and decriminalisation. This seems to suggest that factors such as gender and socio-economic background, which play a role in determining the hazard of cannabis uptake at earlier ages, progressively weaken their effect as age advances.

6. Robustness checks

To investigate the robustness of our findings, we conduct two types of checks. Firstly, we extend the considered at-risk period to encompass the age range of 10–25 years. Secondly, we undertake a placebo test where we examine the impact of criminalisation on the initiation of tobacco smoking and alcohol consumption. The rationale behind our first robustness check stems from the potential for changes in uptake rates after the age of 20, which marks the commencement of adulthood and, for many individuals, corresponds to the onset of university life. Table 4 presents the estimates of the model specifications as reported in Table 3, now focusing on the at-risk period spanning ages 10–25 years. An initial observation is that no major deviations are evident when compared to the estimates based on the age window of 10–20. The coefficients for the criminalisation indicator slightly increase (−16.80% in the full model, column 3, compared to the corresponding −15.54% estimated within the age window of 10–20) together with their statistical significance (0.1%). The coefficient for gender is slightly smaller (−24.11% versus the corresponding −22.66% within the 10–20 age window) and the coefficient for low education level is slightly larger (−8.26% versus −6.71%).

The additional robustness checks consist of two falsification tests. Specifically, we examine the relationship between criminalisation and initiation into cigarette and alcohol use. As explained in Section 4, if we were to find significant evidence of an effect of criminalisation on the uptake of tobacco or alcohol use, it would suggest that our results are capturing other changes that occurred around the same time as the introduction of criminalisation, which affected both cigarette or alcohol consumption and cannabis use. Table 5 presents the results for age at initiation into cigarette use (columns 1, 2 and 3) and age at initiation into alcohol consumption (columns 4, 5 and 6), using the same specifications as shown in Table 3. As evident from Table 5, in both cases, the policy variables are not statistically significant. This suggests that our findings regarding the effect of criminalisation on cannabis uptake are robust. It is worth noting that, surprisingly, in the case of alcohol consumption, the coefficient of low education is negative. Nonetheless, this result is consistent with Kwok and Yuan (2016), who highlight that the majority of studies found no evidence of a relationship between parental socioeconomic status and alcohol consumption in adolescents and, when an association was found, it was positive. Additionally, the interaction term between low education and policy change has a positive and significant coefficient. This might indicate the presence of a underlying substitution effect between cannabis and alcohol (Crost & Guerrero, 2012) in the subpopulation of less educated individuals, who are presumably more likely to be impacted by the increased lifetime costs of a criminal sanction (Williams and Bretteville-Jensen, 2014).

7. Discussion and conclusions

In the EU, 27.2% of the population used cannabis in 2019 (EMCDDA, 2021) despite the threat of administrative or criminal prosecution. This raises concerns due to the economic and social costs associated with maintaining sanctions. In fact, a significant portion of policing resources is allocated to cannabis control, with three quarters of the 1.5 million drug use or possession offenses in 2019 being related to cannabis (EMCDDA, 2021). Over the last 20 years, these concerns have lead several countries to decriminalise or reduce sanctions related to

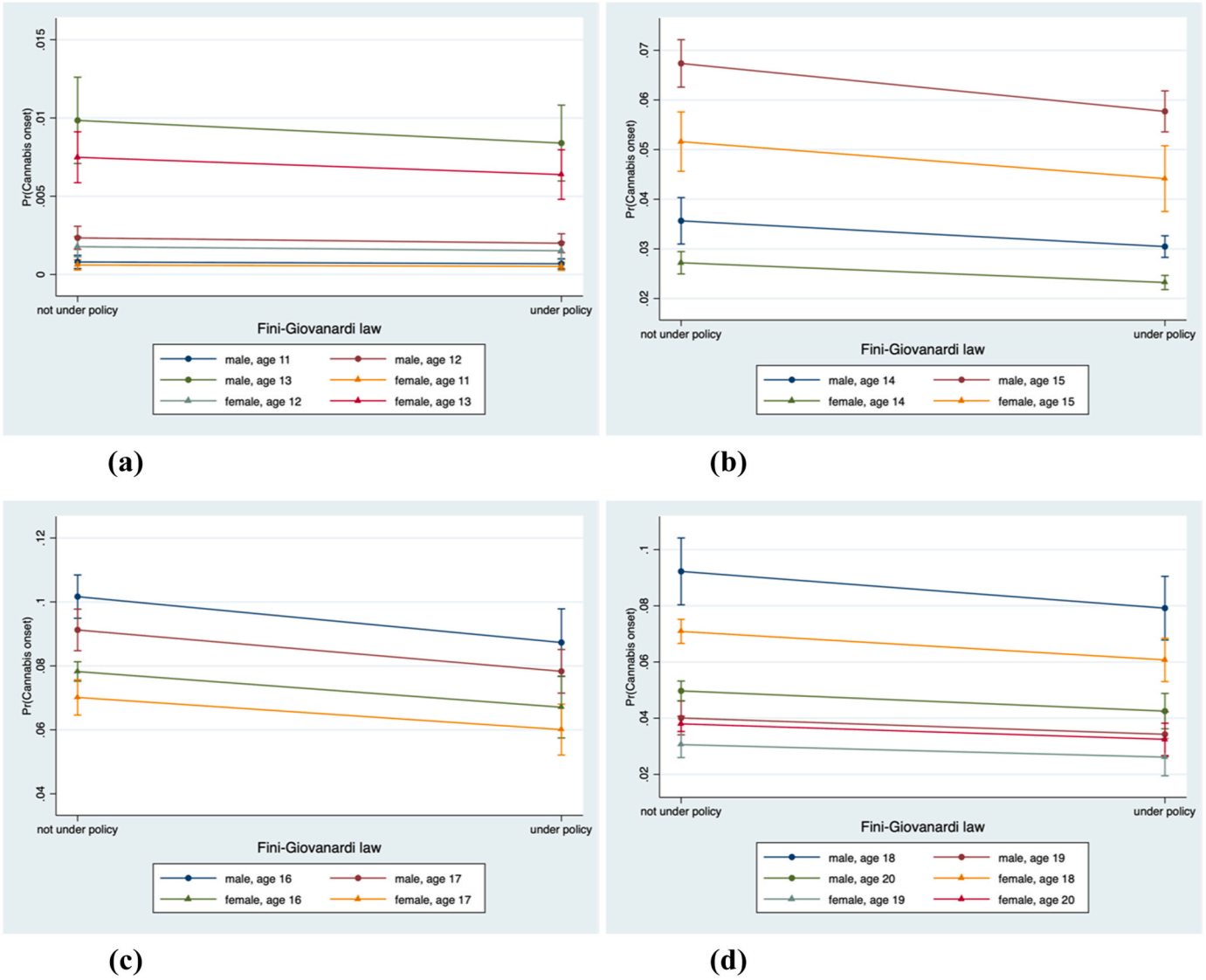

Fig. 7. Marginal effects of age on the probability of cannabis uptake, by policy regime and gender (95% CIs), **(a)** At-risk period: ages 11-13, **(b)** At-risk period: ages 14-15, **(c)** At-risk period: ages 16-17, **(d)** At-risk period: ages 18-20.

Table 4
Parameter estimates for the rate of uptake of cannabis (at-risk period: ages 10–25).

	(1)	(2)	(3)
Policy change	-0.172 * **	-0.173 * **	-0.184 * **
	(0.0483)	(0.0490)	(0.0510)
Individual characteristics			
Gender (ref. Male)	-0.255 * **	-0.257 * **	-0.257 * **
	(0.0438)	(0.0431)	(0.0431)
Education low	-0.0648 * **	-0.0713 * **	-0.0863 * *
	(0.0145)	(0.0145)	(0.0296)
Education low*Policy change			0.0518
			(0.0793)
Other controls			
Geographical Macro-Region	No	Yes	Yes
Surveys	Yes	Yes	Yes

Notes: The table reports coefficient estimates and standard errors in parentheses.
Standard errors are clustered at survey level.
= ". p < 0.1 * p < 0.05 * * p < 0.01 * ** p < 0.001".
Although not reported, all models include birth year fixed effects.
Data for the 2014 and 2017 surveys are weighted.

cannabis possession for personal use. Conversely, a few countries, including Italy, have increased penalties. Thus, the question of whether changes in cannabis policy are able to modify cannabis use remains a central topic in public discourse.

To contribute to this ongoing debate, the present study examines the policy's effect on a specific aspect, which is the initiation of cannabis use. To do so, we exploit the timing of a policy reform that, in the years 2006–2014, heightened sanctions for cannabis possession in Italy. Our empirical framework relies on a Complementary Log-Log model to study the policy's effect on the onset of cannabis use.

Our results suggest that the introduction of higher penalties has a significant, although limited, effect in reducing the early uptake of cannabis. Additionally, as we approach adult ages, the effect of criminalisation in reducing the probability of cannabis uptake seems to diminish. Our finidings align with Williams and Bretteville-Jensen (2014), Červený et al. (2017), and Greaves and Hemsing (2020), who indicate that women have lower chances of uptake than men, particularly at early ages. Low education negatively affects, albeit with a small effect, the risk of taking up cannabis use. The fact that those who have dropped out of schooling at the secondary education level have a lower risk of starting to use cannabis could appear to contradict previous findings highlighting a link between poor school performance and

Table 5
Robustness check: Parameter estimates for the rate of uptake of tobacco and alcohol (at-risk period: ages 10–20).

	Tobacco uptake			Alcohol uptake		
	(1)	(2)	(3)	(4)	(5)	(6)
Policy change	0.0360	0.0355	0.0397	0.025	0.026	-0.021
	(0.0548)	(0.0551)	(0.0555)	(0.037)	(0.039)	(0.058)
Individual characteristics						
Gender (ref. Male)	0.170 * **	0.169 * **	0.169 * **	-0.258 * **	-0.258 * **	-0.259 * **
	(0.0224)	(0.0231)	(0.0231)	(0.031)	(0.031)	(0.031)
Education low	0.217 * **	0.217 * **	0.221 * **	-0.132 * **	-0.144 * **	-0.250 * **
	(0.0455)	(0.0451)	(0.0521)	(0.046)	(0.042)	(0.031)
Education low*Policy change			-0.0156			0.197 *
			(0.0505)			(0.083)
Other controls						
Geographical Macro-Region	No	Yes	Yes	No	Yes	Yes
Surveys	Yes	Yes	Yes	Yes	Yes	Yes
Number of Observations		24,020			14,306	

Notes: The table reports coefficient estimates and standard errors in parentheses. Standard errors are clustered at survey level.
= ". p < 0.1 * p < 0.05 * * p < 0.01 * ** p < 0.001".
Although not reported, all models include birth year fixed effects.
Data for the 2014 and 2017 surveys are weighted.

cannabis use (Lynskey & Hall, 2000; Mokrysz et al., 2016). Our explanation is that those who interrupt schooling at such an early stage lose a significant part of their peer social network, likely having to start working and moving into the "adults' world" sooner, in line with Červený et al. (2017).

Finally, we also find that being from the South of Italy reduces the likelihood of cannabis uptake. This could indicate potential differences in cannabis availability across the national territory, as well as reflecting the well-known economic disparities in the country. In this light, we confirm previous studies indicating that youths from wealthier socio-economic backgrounds have a higher risk of cannabis experimentation (Bowes et al., 2013; Gerra et al., 2020; Legleye et al., 2012; Moor et al., 2015).

The main potential explanation for our findings is that criminalisation may have discouraged individuals from starting to use cannabis due to the higher expected lifetime costs associated with increased penalties. By setting a low threshold to differentiate possession as an administrative offense from a criminal one, individuals who would have previously faced administrative sanctions, could potentially have incurred a prison sentence under the new regime. Furthermore, while previously the judicial court had the discretion to define possession for dealing, considering various aggravating circumstances beyond the quantity carried, the new threshold eliminated this option. The policy reform also mandated harsher penalties for drug possession by minors, which may reflect into the findings of our study. However, we also show that the deterrence effect (Becker, 1968) of partially shifting from administrative to criminal penalties for possession of 'soft drugs' is relatively limited. This has significant policy implications. Since cannabis use typically starts by the age of 18, the policy's impact on early uptake is restricted, implying that the overall effect of the policy on public health is also limited. Considering the evidence that early cannabis initiation increases the risk of prolonged usage and dependence, a reduced effect on younger age groups could also indicate a limited influence on these public health consequences. Another potential explanation for our results is that potential consumers may have encountered increased difficulty in accessing cannabis compared to before. Regrettably, we are unable to verify the hypothesis of perceived changes in the illicit cannabis market based on our data. Additionally, the heightened punishments foreseen under criminalisation might have dissuaded "less motivated" individuals who would have simply tried the substance, but not those who would progress to frequent and consequently higher-risk consumption (Benedetti et al., 2021).

Furthermore, the effect on the initiation of cannabis use represents just one facet of the broader spectrum of intended and unintended consequences that must be taken into account when examining the outcomes of drug policies. Indeed, the benefits, like the one analysed in this work, must be weighed against the social costs of heightening penalties, affecting both individual users and the entire community. The official data presented in Section 2 of this paper show that under criminalisation, not only did cannabis-related complaints substantially increase, but also the population incarcerated for drug-related offenses significantly expanded. This against the backdrop of a pardon that was granted just a year prior to the policy reform due to the overcrowding of prisons.

7.1. Strengths, limitations and future directions

This paper has several strengths. It presents supporting data for our case drawn from drug-supply related offenses and prison data, as well as secular trends in cannabis use across multiple data sets. Particular attention was also given to investigating the hazard function in order to avoid making assumptions about a specific functional form over time. Additionally, the study examined the marginal effects, suggesting that the policy change's impact may have been most pronounced between the ages of 15 and 18. Regarding our findings, to our knowledge this is the first study providing evidence on criminalisation, while previous studies examined the effects of depenalising cannabis possession, thus providing useful evidence on both effectiveness and negative unintended, although foreseeable, consequences for countries exploring the opportunity of increasing punishments.

While we conducted several additional analyses to demonstrate the robustness of our findings, some limitations and caveats remain. The main limitation is the reliance on self-reported survey data. This introduces two potential sources of measurement error. Firstly, respondents may lack honesty in their responses to the questionnaire, although this is partially mitigated by the fact that the IPSAD survey is anonymous and self-administered. Secondly, the use of retrospective information increases the possibility of reporting errors. However, the young age range of our sample (15−37) partially mitigates the risk of recall bias. Most importantly, to establish the external validity of our findings, we do not have a clean counterfactual as in the case of other studies that focused on federal states and exploited variations in the timing of policy introduction across different jurisdictions. In our case, the policy reform occurred at the central level and was implemented simultaneously across the entire national territory. This introduces the risk of endogenising a time trend in our data. However, looking at the description in Section 3, two observations can be made: the proportion of cannabis first use at age 20 or younger has been increasing over time, and the average age of first use has significantly decreased. These indications do not support the hypothesis of endogenisation of the time

trend in our analysis.

Since over the last 20 years several European countries changed their drug policies, in future studies it would be interesting to compare our findings with other countries having implemented a similar policy.

Finally, although our empirical findings identify potential risk factors based on observable variables, they may underestimate the effect of criminalisation or violate the homogeneity assumptions underlying our models. Considering that cannabis use can be part of a larger subculture within the population at any given age, future studies investigating onset risk should focus on identifying specific population subgroups that are at higher risk or have a significantly reduced risk of cannabis use initiation.

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Declaration of Competing Interest

The authors have no conflict of interest to declare.

Data Availability

The data used in the manuscript are available upon request to the corresponding author.

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References

Allison, P. D. (1982). Discrete-time methods for the analysis of event histories. *Sociological Methodology, 13*, 61–98.

Becker, G. S. (1968). Crime and punishment: An economic approach. *Journal of Political Economy, 76*(2), 169–217.

Beenstock, M., & Rahav, G. (2002). Testing gateway theory: do cigarette prices affect illicit drug use? *Journal of Health Economics, 21*(4), 679–698.

Benedetti, E., Resce, G., Brunori, P., & Molinaro, S. (2021). Cannabis policy changes and adolescent cannabis use: Evidence from europe. *International Journal of Environmental Research and Public Health, 18*(10), 5174.

Bowes, L., Chollet, A., Fombonne, E., Galéra, C., & Melchior, M. (2013). Lifecourse sep and tobacco and cannabis use. *The European Journal of Public Health, 23*, 322–327.

Carrieri, V., Madio, L., & Principe, F. (2019). Light cannabis and organized crime: Evidence from (unintended) liberalization in Italy. *European Economic Review, 113* (C), 63–76.

Carrieri, V., Madio, L., & Principe, F. (2020). Do-it-yourself medicine? the impact of light cannabis liberalization on prescription drugs. *Journal of Health Economics, 74*, Article 102371.

Chow, G. C. (1960). Tests of equality between sets of coefficients in two linear regressions. *Econometrica, 28*, 591–605.

Cox, D. R. (1972). Regression models and life-tables. *Journal of the Royal Statistical Society Series B (Methodological), 34*(2), 187–220.

Crost, B., & Guerrero, S. (2012). The effect of alcohol availability on marijuana use: Evidence from the minimum legal drinking age. *Journal of Health Economics, 31*(1), 112–121.

DPA - Dipartimento Politiche Antidroga. (2014). *Relazione annuale al Parlamento, Technical report*. Presidenza del Consiglio dei Ministri (URL) ⟨https://www.politicheantidroga.gov.it/media/2987/relazione-annuale-al-parlamento-2015-dati-2014.pdf⟩.

D'Egidio, P. F. (2019). La legge 309/90: le proposte di federserd. *Mission - Italian Quarterly Journal of addiction, 52*, 1–5.

EMCDDA. (2019). *European Drug Report 2019: Trends and Developments*. Luxembourg: Publications Office of the European Union.

EMCDDA. (2020). *Monitoring and evaluating changes in cannabis policies: insights from the Americas* (Technical report). Luxembourg: Publications Office of the European Union,.

EMCDDA. (2021). *European Drug Report 2021: Trends and Developments*. Luxembourg: Publications Office of the European Union,.

EMCDDA. (2022). *European Drug Report 2022: Trends and Developments*. Luxembourg: Publications Office of the European Union,.

Flinn, C., & Heckman, J. (1982). *Models for the analysis of labor force dynamics*. NBER Working Papers 0857. National Bureau of Economic Research, Inc,. NBER Working Papers 0857 ⟨https://EconPapers.repec.org/RePEc:nbr:nberwo:0857⟩.

Gerra, G., Benedetti, E., Resce, G., Potente, R., Cutilli, A., & Molinaro, S. (2020). 'Socioeconomic status, parental education, school connectedness and individual socio-cultural resources in vulnerability for drug use among students'. *International Journal of Environmental Research and Public Health, 17*, 1306.

Giancola, O., Salmieri, L. et al. (2020), Family background, school-track and macro-area: The complex chains of education inequalities in italy, Technical report.

Greaves, L., & Hemsing, N. (2020). Sex and gender interactions on the use and impact of recreational cannabis. *International Journal of Environmental Research and Public Health, 17*.

Hall, W. (2009). The adverse health effects of cannabis use: What are they, and what are their implications for policy? *International Journal of Drug Policy, 20*, 458–466.

Hammond, D., Goodman, S., Wadsworth, E., Rynard, V., Boudreau, C., & Hall, W. (2020). Evaluating the impacts of cannabis legalization: The international cannabis policy study'. *International Journal of Drug Policy, 77*, Article 102698.

Have, T. R. T. (1996). 'A mixed effects model for multivariate ordinal response data including correlated discrete failure times with ordinal responses'. *Biometrics, 52*(2), 473–491.

Jenkins, S. (2008). *Survival analysis with stata, Module ec968, survival analysis course at university of essex summer school*. National Bureau of Economic Research, Inc, (URL:) ⟨https://www.iser.essex.ac.uk/resources/survival-analysis-with-stata⟩.

Kandel, D. B. (2002). *Stages and pathways of drug involvement: Examining the Gateway Hypothesis*. Cambridge University Press..

Kwok, K. H. R., & Yuan, S. N. V. (2016). 'Parental socioeconomic status and binge drinking in adolescents: A systematic review'. *The American Journal on Addictions, 25* (8), 610–619.

Legleye, S., François, B., Khlat, M., Peretti-Watel, P., & Chau, N. (2012). 'The influence of socioeconomic status on cannabis use among french adolescents'. *Journal of Adolescent Health, 50*, 395–402.

Lynskey, M., & Hall, W. (2000). 'The effects of adolescent cannabis use on educational attainment: a review'. *Addiction, 95*(11), 1621–1630.

MacCoun, R. J. (1993). 'Drugs and the law: a psychological analysis of drug prohibition'. *Psychological Bulletin, 113*(3), 497–512.

Mokrysz, C., Landy, R., Gage, S., Munafò, M., Roiser, J., & Curran, H. (2016). 'Are iq and educational outcomes in teenagers related to their cannabis use? a prospective cohort study'. *Journal of Psychopharmacology, 30*(2), 159–168.

Moor, I., Rathmann, K., Lenzi, M., Pförtner, T.-K., Nagelhout, G. E., de Looze, M., Bendtsen, P., Willemsen, M., Kannas, L., Kunst, A. E., & Richter, M. (2015). 'Socioeconomic inequalities in adolescent smoking across 35 countries: a multilevel analysis of the role of family, school and peers'. *European Journal of Public Health, 25* (3), 457–463.

Odoardi, I., Furia, D., & Cascioli, P. (2021). 'Can social support compensate for missing family support? an examination of dropout rates in italy'. *Regional Science Policy & Practice, 13*(1), 121–139.

O'Higgins, N., D'Amato, M., Caroleo, F. E., & Barone, A. (2007). 'Gone for good? determinants of school dropout in southern italy'. *Giornale degli Economisti e Annali di Economia*, 207–245.

Pacula, R. L. (1998). *Adolescent Alcohol and Marijuana Consumption: Is There Really a Gateway Effect?*. NBER Working Papers 6348. National Bureau of Economic Research, Inc,. NBER Working Papers 6348 ⟨https://ideas.repec.org/p/nbr/nberwo/6348.html⟩.

Palali, A., & Van Ours, J. C. (2015). 'Distance to cannabis shops and age of onset of cannabis use'. *Health Economics, 24*(11), 1483–1501.

Penman, A. D., & Johnson, W. D. (2009). 'Complementary log-log regression for the estimation of covariate-adjusted prevalence ratios in the analysis of data from cross-sectional studies'. *Biometrical Journal Biometrische Zeitschrift, 51*(3), 433–442.

Prentice, R. L., & Gloeckler, L. A. (1978). 'Regression analysis of grouped survival data with application to breast cancer data'. *Biometrics, 34*(1), 57–67.

Reuter. (2009). *The unintended consequences of drug policies*. RAND Corporation, (URL) ⟨https://www.rand.org/content/dam/rand/pubs/technicalreports/2009/RANDTR706.pdf⟩.

Richardson, D. B. (2010). 'Discrete time hazards models for occupational and environmental cohort analyses'. *Occupational and Environmental Medicine, 67*(1), 67–71.

Richmond-Rakerd, L., Slutske, W., & Wood, P. (2017). 'Age of initiation and substance use progression: A multivariate latent growth analysis'. *Psychology of Addictive Behaviors, 31*.

Room, R., Fischer, B., Hall, W., Lenton, S., & Reuter, P. (2010). *Cannabis Policy: Moving beyond stalemate*. Oxford University Press.,.

Scandurra, A. (2009), Libro bianco sulla legge fini giovanardi, Technical report, Associazione Antigone. URL: ⟨https://www.fuoriluogo.it/pubblicazioni/libro-bianco-droghe/.XgJmzC2ZOgQ⟩.

Singer, J. D., & Willett, J. B. (1993). 'It's about time: Using discrete-time survival analysis to study duration and the timing of events'. *Journal of Educational Statistics, 18*(2), 155–195.

Smart, R., & Pacula, R. L. (2019). 'Early evidence of the impact of cannabis legalization on cannabis use, cannabis use disorder, and the use of other substances: Findings

from state policy evaluations.'. *American Journal of Drug and Alcohol Abuse, 45*, 644–663.
Southey, B., Rodriguez-Zas, S., & Leymaster, K. (2003). 'Discrete time survival analysis of lamb mortality in a terminal sire composite population'. *Journal of Animal Science, 81*, 1399–1405.
United Nations - UNODC. (2022). *World Drug Report 2022*. New York: United Nations Publications Office,. ⟨https://www.unodc.org/res/wdr2022/MS/WDR22Booklet2.pdf⟩.
Van Ours, J. (2006). 'Dynamics in the use of drugs'. *Health Economics, 15*(12), 1283–1294.
Van Ours, J. C., & Williams, J. (2007). 'Cannabis prices and dynamics of cannabis use'. *Journal of Health Economics, 26*(3), 578–596.
Van Ours, J. C., & Williams, J. (2015). 'Cannabis use and its effects on health, education and labor market success'. *Journal of Economic Surveys, 29*(5), 993–1010.
Williams, J., & Bretteville-Jensen, A. L. (2014). 'Does liberalizing cannabis laws increase cannabis use?'. *Journal of Health Economics, 36*(C), 20–32.
Červený, J., Chomynova, P., Mravcík, V., & Van Ours, J. (2017). 'Cannabis decriminalization and the age of onset of cannabis use'. *International Journal of Drug Policy, 43*, 122–129.