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Minimum Legal Drinking Age and Educational Outcomes

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Abstract

Over the past decades, many European countries have raised the minimum legal drinking age (MLDA) from 16 to 18 years. This study provides novel evidence of the impact of this policy on educational outcomes by exploiting the staggered timing of MLDA changes across Spanish regions. Raising the MLDA decreased alcohol consumption among adolescents aged 14–17 by 8 to 18% and improved their exam performance by 4% of a standard deviation. This effect appears driven by alcohol's direct impact on cognitive ability, as we find no significant changes in potential mediators like use of other substances or time spent on leisure activities, including socialising, sports, gaming, or internet use. We also observe a decrease in tranquilliser and sleeping pill use, suggesting improved mental health. Our findings indicate that reducing teenage alcohol consumption represents a significant opportunity to improve educational outcomes in Europe, where youth drinking rates remain notably high.

Keywords: alcohol, adolescence, minimum legal drinking age, PISA

JEL codes: I18, I12, I21

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1 Introduction

Despite a decreasing trend, alcohol consumption among European teenagers remains notably high compared to other regions of the world. Nearly half (47%) of European adolescents aged 15–16 report having consumed alcohol within the last 30 days, with 30% engaging in at least one binge drinking episode during the same period (ESPAD 2019). In contrast, in the U.S. only 12% of teenagers aged 14–17 report drinking alcohol and 6% binge drinking in the past month (SAMHSA 2020). Alcohol consumption rates among adolescents are generally even lower in the rest of the world (see Figure 1).

Over the past few decades, European countries have implemented a range of policies to reduce alcohol consumption among adolescents, including increasing alcohol taxes, restricting advertising and tightening regulations on alcohol licensing. A key policy shift has been the widespread increase in the minimum legal drinking age (MLDA). At the turn of the millennium, in most European countries the MLDA was 16, in stark contrast to the United States' limit of 21. During the past two decades, many European nations have raised their MLDA to 18. The increase in the MLDA has generally decreased alcohol consumption, although at times only moderately, with decreases ranging from 7% to 39%, presumably reflecting differences in enforcement (Dehos & Mensen 2022, Ahammer et al. 2022, Carpenter & Dobkin 2011, Yörük & Yörük 2011).[1]

There are compelling reasons to expect that decreases in alcohol consumption might impact academic performance and human capital accumulation. Extensive medical research indicates that the adolescent brain is particularly vulnerable to alcohol consumption. Alcohol-consuming youths exhibit lower grey matter volumes and reduced white matter integrity compared to their non-consuming peers (Luciana et al. 2013, Daviet et al. 2022, Ewing et al. 2014, Jacobus & Tapert 2013, Guerri & Pascual 2010, Morris et al. 2019, Robert et al. 2020). Furthermore, alcohol has been linked to problematic and risk-taking behaviours which could impede human capital accumulation, including traffic accidents, emergency department visits and crimes (Bindler et al. 2024, Carpenter & Dobkin 2009, 2017, Chalfin et al. 2022, Datta Gupta

[1]For instance, in Germany when individuals turn 16 – the legal drinking age for softer types of alcohol – their alcohol consumption increases by 20% (Dehos & Mensen 2022). In Austria, the effects are even more pronounced, with a 39% increase in alcohol consumption at the MLDA age of 16 (Ahammer et al. 2022)). In the United States, alcohol consumption increases by 7–21% when individuals reach the legal drinking age of 21 (Carpenter & Dobkin 2011, Yörük & Yörük 2011).

& Nilsson 2020, Dee & Evans 2001, Dehos & Mensen 2022, Hingson et al. 2006, Kamalow & Siedler 2019, Luukkonen et al. 2023, McCarty et al. 2004, O'Malley & Wagenaar 1991). Alcohol consumption may also reduce time and energy available for academic pursuits. Several studies have also documented that adolescents who consume alcohol tend to have worse mental health (Skogen et al. 2014, Holtes et al. 2015). On the other hand, drinking could also have potential benefits. Alcohol-consuming teenagers report having larger social networks, increased social time and greater peer trust (WHO 2019, Hoel et al. 2004), perhaps suggesting that alcohol may help some adolescents develop social skills that may be valuable in the labour market (Deming 2017). The impact of alcohol consumption may also depend on whether it complements or substitutes other substance use, which may itself harm educational performance (Marie & Zölitz 2017).

Despite the relevance of this question, the existing empirical evidence on the causal impact of MLDA laws on educational outcomes is relatively scarce and, to the best of our knowledge, limited to the US context. Findings are mixed, ranging between no effects, and some moderate declines in performance when alcohol consumption becomes legal (Koch & Ribar 2001, Dee & Evans 2003, Renna 2008, Balsa et al. 2011, Carrell et al. 2011, Lindo et al. 2013).[2] The effect of MLDA changes on educational outcomes might differ in the European context. The neurological impact of alcohol is likely more severe at 16 than at 18 or 21. There are also potentially important differences in social and cultural environments, legal enforcement and the availability of alternative leisure activities.

This paper provides novel evidence on the impact of raising the MLDA from 16 to 18 years on educational performance by exploiting its staggered implementation across Spanish regions. Before 1991, the MLDA was 16 years throughout Spain. From 1991 to 2019, regions began progressively increasing the MLDA to 18 years. Our analysis focuses on 2003 to 2022, due to data constraints. During this period, four regions implemented the MLDA increase: Castile and Leon, Galicia, Asturias, and the Balearic Islands.

[2]Evidence from regression discontinuity designs at age 21 shows that college students' GPA tends to decrease when they are allowed to drink legally. Lindo et al. (2013) observe a decrease of 0.03 standard deviations at the University of Oregon and Carrell et al. (2011) a decrease of 0.09 standard deviations at the US Air Force Academy. However, contrasting these findings, some studies that have exploited the increase in the MLDA from 18 to 21 across US states in the early 1980s do not find a significant impact on educational performance (Dee & Evans 2003). Similarly, Koch & Ribar (2001) argue that the actual effects of youthful drinking on education are likely to be small, based on between-siblings comparisons. Balsa et al. (2011) arrive at a similar conclusion using individual fixed-effects models with data from the National Longitudinal Study of Adolescent Health.

We measure teenage consumption of alcohol and other substances using the information provided by the *Survey on Drug Use in Secondary Education in Spain*, a large-scale survey conducted every two years on a representative sample of high school students. Our analysis covers the period 2004–2021, including information for approximately 250,000 students. These surveys are conducted in classrooms and are anonymous, which may help reduce misreporting concerns. During our study period, alcohol consumption was prevalent among Spanish teenagers: 60% of those aged 14–17 reported consuming alcohol at least once in the preceding month, with 34% binge drinking and 24% experiencing intoxication. A concerning 19% reported experiencing memory loss of the previous day's events at least once in the past year, 15% reported difficulty focusing at school after drinking, and 33% experienced hangovers. The survey also provides information on the use of other substances and, in recent waves, on leisure activities.

Information on educational performance comes from two sources. We use data from the Programme for International Student Assessment (PISA). The OECD conducts this survey every three years on a representative sample of children born sixteen years earlier. An important advantage of PISA is that it measures students' performance using a standardised test which is comparable across regions. PISA also collects data on educational inputs such as student-teacher ratios, instruction time, and school resources, enabling us to rule out confounding effects from contemporaneous educational policy changes. We use data for the years 2003 to 2022, covering approximately 180,000 students. Furthermore, we measure educational attainment using the 2021 census. We focus on individuals born between 1987 and 2002, with a sample of around 600,000 individuals. Close to 78% of them had completed secondary education and 42% were attending or had completed college.

We estimate the effect of increasing the MLDA using a difference-in-differences strategy. To account for the limited number of regions, we employ wild bootstrap methods to compute standard errors. We start by analysing the extent of compliance with the law. When the MLDA is increased to 18, underage individuals acknowledge that it has become more difficult to access alcohol (0.12 standard deviations, p-value=0.00), but the modest magnitude of the effect reflects adolescents' adaptive behaviours in response to the policy change, altering how they acquire and consume

alcohol. While alcohol purchases in bars declined by 6 percentage points (11%, p-value=0.03) and teenagers were 9 percentage points (23%, p-value=0.07) less likely to report purchasing alcohol themselves, purchasing through someone above the age of 18 increased by 7 percentage points (29%, p-value=0.10). Overall, the probability of having consumed alcohol in the last 30 days decreased by around 5 percentage points (8%, p-value=0.04). We also observe a 5 percentage point (18%, p-value=0.03) decline in the probability of getting drunk and a 6 percentage point (16%, p-value=0.02) decrease in the probability of binge drinking. The effect on adolescents who were already below the previous MLDA (i.e., aged 14 and 15) is similar in magnitude to the effects on those aged 16 and 17, presumably reflecting that it became more difficult for them to circumvent the law. The effects were more pronounced among teenagers with parents with higher educational attainment but did not differ across gender or region of residence.

The MLDA reforms had significant positive effects on educational outcomes, improving average student performance in PISA exams by 4% standard deviations (p-value=0.03). The effect is stronger for children of more educated parents, consistent with this group experiencing a larger decrease in alcohol consumption. These results are not driven by contemporaneous changes in other educational inputs measured in PISA, such as instructional hours, class size, or school resources. Finally, we investigate whether these effects on educational performance at age 15–16 persist in time using information on young adults' education attainment from the census. We do not observe any impact of MLDA on the probability of completing mandatory secondary education (β=-0.01, p-value=0.49, baseline 79%), but there is some suggestive evidence of positive effects on college attendance (β=0.02, p-value=0.09, baseline 42%).

These effects appear to be driven by alcohol's direct impact on cognitive ability, as we find no significant changes in potential mediators like the use of other substances or leisure activities. After the reforms, smoking declined by 1.5 percentage points (from a baseline of 23%) and cannabis use increased by 0.4 percentage points (baseline 12%), but neither estimate is statistically significant. The decrease in alcohol consumption did not affect adolescents' socialisation or their engagement with other leisure activities. We do not observe substantial changes in their prevalence of going out, time spent on the internet, playing video games, or practising sports. If anything, the decrease in alcohol

consumption might have improved teen mental health, since we find a significant decrease in the use of tranquillisers and sleeping pills. The proportion reporting consumption in the previous month decreased by 0.6 percentage points (9%, p-value=0.04), and the proportion reporting consumption over the last year decreased by 1.2 percentage points (11%, p-value=0.04).

Our paper contributes to several strands of the health and education economics literature. First, we contribute to works examining the efficacy of MLDA policies in reducing alcohol consumption. Our results, which are based on evidence from Spain for the period 2004 to 2020, align with Brachowicz & Vall Castello (2019), who found that increases in the MLDA across Spanish regions between 1994 and 2002 reduced adolescent alcohol consumption by approximately 20%. The magnitude of the effect is consistent with estimates from other countries, where impacts range from 7% to 39%.[3] Our analysis also shows that the moderate magnitude of the effect can be attributed to adolescents' ability to circumvent the prohibition by accessing alcohol through older peers.

Second, we contribute to the literature on the relationship between the consumption of alcohol and other drugs, which is characterised by mixed results. Some studies have found that stricter alcohol laws lead to increased marijuana use (DiNardo & Lemieux 2001), while others have found a null effect (Yörük & Yörük 2011) or concluded that higher alcohol consumption increases hard drug use (Deza 2015). In the context of Spain, we do not find that the MLDA significantly affected the consumption of cannabis, the main alternative drug.

Third, we also contribute to the literature on the impact of alcohol consumption during adolescence on mental health. Most of the existing evidence is correlational, showing a strong association between higher alcohol consumption and poorer mental health (e.g. Skogen et al. (2014), Holtes et al. (2015)). By exploiting exogenous variation in alcohol consumption induced by changes in MLDA, our analysis shows that there is a causal impact on the use of tranquillisers among adolescents, consistent with an improvement in psychological well-being. This finding complements previous research documenting a causal link between MLDA and youth suicide (e.g. Birckmayer & Hemenway (1999)).

[3]See footnote 1.

Finally but most importantly, we contribute to the literature on the factors affecting adolescents' cognitive ability. To the best of our knowledge, our work provides the first causal estimate for the impact of alcohol consumption at age 16 on educational performance. Our findings show that stricter alcohol regulation can improve teenagers' educational performance. The evidence suggests that alcohol affects educational performance primarily through direct impacts on cognitive ability and potentially through its effects on mental health, rather than through changes in time use.

The rest of the paper is structured as follows. Section 2 describes the context of the MLDA reforms in Spain. Section 3 presents the datasets used in the analysis. Section 4 outlines our identification strategy, results, and potential mechanisms. Section 5 discusses the robustness of our estimates to alternative assumptions and Section 6 concludes.

2 Institutional setup

Alcohol regulations in Spain are set by its 17 regions.[4] Until 1991, the minimum legal drinking age was 16 across all regions, with enforcement varying regionally. From 1991 to 2019, all regions raised the minimum drinking age to 18. A map of the timing of the reforms is available in Figure 2. These new regulations banned alcohol sales to minors, restricted their entry into venues like discotheques and in some cases banned consumption. Some regions introduced the ban in two phases, first restricting the sale of hard liquors to those under 18 and subsequently restricting the sale of all alcoholic drinks. Table A1 summarises all the reforms and describes some implementation details.[5]

Given data availability constraints, we focus on the more recent reforms. These were implemented in Castile and Leon in 2007, Galicia in 2011, Asturias in 2015 and the Balearic Islands in 2019. In Castile and Leon, the reform was a full ban on alcohol consumption for minors while before there was only a ban on hard liquors. In Galicia and Asturias, the MLDA increase was a full reform, banning consumption of all types of alcohol, when previously all consumption was permitted at 16. In the Balearic Islands, minors were not allowed to purchase alcohol before the age of 18 before 2019, but consumption was not explicitly prohibited.

[4]Each region may consist of one or more provinces, which are smaller administrative divisions of which there are 50. There are also two autonomous cities, Ceuta and Melilla.

[5]The table expands the content in Table C.1 in Brachowicz & Vall Castello (2019) with some amendments capturing the most recent reforms.

The factors driving the timing and stringency of MLDA implementation across regions are unclear. Political ideology does not predict MLDA reform adoption: seven regions increased the MLDA under Socialist Party (PSOE) governments and seven under People's Party (PP) governments.[6] GDP per capita also appears unrelated. As shown in Table 1, regions that raised the MLDA after 2006 ('Treatment' group) and regions where the MLDA was already 18 ('Control' group) had statistically similar levels of GDP per capita in both 2006 and 2020. The severity of adolescent drinking also fails to explain the timing differences. While we cannot observe drinking levels from the early 1990s when the MLDA was universally 16, we can examine this factor by comparing regions in 2020, after all had raised the MLDA to 18, assuming no dynamic effects. Although late adopter regions had significantly higher teenage drinking rates in 2006, treated and control areas had converged by 2020. The only factor correlated with adoption timing is PISA performance, with pupils in treated regions performing better in 2020. This gap suggests that regions with weaker academic performance may have adopted the higher MLDA earlier.

3 Data

We use several publicly available sources: the High School Survey on Drug Use, the Program for International Student Assessment (PISA) and the 2021 census. We describe the content of each database below.

3.1 High School Survey on Drug Use

The High School Survey on Drug Use (*Encuesta sobre uso de drogas en Enseñanzas Secundarias* in Spanish, also known by its acronym ESTUDES) is conducted every two years in a representative sample of Spanish high schools and mainly collects information on the consumption of alcohol and other drugs. We use information from the waves conducted between 2004 and 2020 and focus on students aged 14 to 17, with a total

[6]The MLDA was increased under PSOE governments in seven regions: Andalucia (1997), Aragon (2001), Asturias (2015), the Balearic Islands (2019), Castile-La Mancha (1995), Extremadura (1997), and Navarre (1991). The PP implemented similar reforms in Cantabria (1997), Castile and Leon (1994), Galicia (1996), La Rioja (2001), Madrid (2000), Murcia (1997), and the Valencian Community (1997). Regional parties were responsible for MLDA increases in three regions: the Canary Islands (1997), Catalonia (1991), and the Basque Country (1998).

sample size of about 255,000 students.[7] We describe the main variables of the database in Table A2 and we provide summary statistics in Table 2.

Similarly to other European countries, teenage alcohol consumption is prevalent in Spain (ESPAD 2019). Among adolescents aged 14 to 17, 60% report having drunk in the last 30 days, 34% had 5 drinks or more (binge drank) at least once in the last 30 days, and 24% got drunk in our sample. For a subset of years, the survey also provides detailed information on behaviours connected to alcohol intake. Around 33% report having experienced a hangover in the last year, 19% could not remember the events of the preceding night, 15% couldn't focus in school the day after having consumed alcohol and 13% had driven under alcohol influence.

Most teenagers consider that having access to alcohol is very easy (66%) or easy (25%). Around one third bought alcohol themselves and another third obtained alcohol through a friend who was 18 or older. Alcohol is consumed mostly in bars (41%) or at home and in parks (43%). The majority of teenagers (56%) acknowledge that heavy drinking (measured as 5 or more drinks each weekend) may be problematic.

The use of other substances, while lower, remains significant. Although Spanish law prohibits tobacco sales to minors, 24% of the sample report smoking in the last 30 days, with 10% smoking daily.[8] As for other drugs, 15% report using cannabis in the last 30 days. Other illegal drugs, such as cocaine, are very uncommon in the sample (<1%). Consistent with the findings of previous studies, we also observe that the consumption of these substances has been declining during the last two decades (Leal-López et al. 2019, 2020).

Around 5% of adolescents report having used tranquillisers or sleeping pills in the previous month (and 10% in the previous year).[9] Users report that their main motivations for consuming these drugs are to deal with anxiety (49%), to improve sleep (63%) and to feel better (14%). Only 4% report using them with other drugs.[10] Their use has increased

[7]The survey also includes information on pupils aged 18 who are typically repeat students. We do not consider them in our analysis. We also exclude 341 observations corresponding to students in treated regions who were already 17 when the MLDA was increased to 18.

[8]Law 28/2005, December 26, prohibits minors from purchasing tobacco or entering areas where smoking is permitted.

[9]The question on the use of tranquillisers and sleeping pills explicitly mentions several drugs: *hipnotics, benzos, trankimazin, rohipnol, tranxilium, diacepam, valium, barbitúricos, lexatin, orfidal, noctamid, benzodiacepinas, zolpidem* and *stilnox*. It does not include drugs that are commonly used to treat attention deficit hyperactivity disorder (ADHD) such as methylphenidate, sold under the brand names *Ritalin* and *Concerta*, among others.

[10]Source: High School Survey on Drug Use (ESTUDES), year 2004, question 46.

substantially during the period of our study, from 3.5% monthly users in 2006 to 7.3% in 2020. Similar to previous studies, we also observe a strong correlation between the consumption of these drugs and alcohol (Carrasco-Garrido et al. 2018).

Some waves of the survey also include information on leisure activities. Teenagers in Spain go out frequently with their friends. The average respondent meets their friends during the daytime 7 times monthly and goes out 4 times at night. The mean arrival time when going out at night is around 2 AM. They also spend substantial time on the internet and social media. For instance, in 2020, around 35% reported playing videogames more than two hours daily. Sports are also popular. Around 70% practice sports at least once a week and 18% almost every day.

3.2 Program for International Student Assessment (PISA)

To measure students' performance consistently, we use the information provided by the OECD's Program for International Student Assessment (PISA).[11] PISA assesses students' competencies in reading, mathematics, and science, and measures their ability to apply knowledge and skills to real-world problems (OECD 2024). As the test carries no explicit incentives, performance likely reflects both cognitive ability and motivation.

It is conducted every three years on a stratified random sample of schools and participants within each school are randomly selected among students born 16 years before the calendar year of the test. Exams usually take place between April and May. At the time of assessment, students are aged between 15 and 3 months and 16 years and 5 months. We use the seven PISA waves that were conducted between 2003 and 2022.[12]

The PISA sample size for Spain is exceptionally large, as most regions have opted to fund expanded samples to obtain statistically meaningful scores at the regional level.[13] Our sample includes information for approximately 143,000 students. We report the main summary statistics in Table 3 and detailed variable definitions in Table A3. The scores

[11] Unlike many other countries, Spain does not conduct national standardised assessments of student performance. To enter university, students are required to take the Spanish University Admission Tests (*Evaluación de Bachillerato para Acceso a la Universidad* or E.B.A.U.) but the content and the assessment of these exams vary across regions and over time.

[12] We did not use the first PISA wave, in the year 2000, as it does not include information on the region where students are based.

[13] PISA reports information on the region where the school is located only for these expanded samples. In the 2003 wave there is information on location for 3 regions, for 10 regions in 2006, 15 regions in 2009, 14 regions in 2012, 17 regions in 2015, and 18 regions in 2018 and 2022.

provided by PISA are standardised to have a mean of 500 points and a standard deviation of 100 points across OECD countries.[14] The average performance of Spanish students is 490, slightly below the OECD average. Around half of the students are women and 88% were born in Spain. Approximately one-third of parents have a college degree.

The OECD has raised concerns about the reliability of some of the assessments conducted in Spain in 2018 (OECD 2019). The problem appears to be related to unusual response patterns in the reading test. Some Spanish students responded in ways that were inconsistent with typical testing behaviours, most likely because some PISA exams were administered too close to high-stakes final exams. In our preferred specification, we exclude observations that may have been affected by this problem, which constitute around 2% of the overall sample.[15]

PISA also provides information on school characteristics. The average student in our sample attends a school with a student-to-teacher ratio of 12:1 and where there are two computers for every three students. Weekly instruction time per subject ranges between 3 and 4 hours, and students report spending approximately 9 hours per week on homework.

3.3 Census micro-data

We obtained information on educational attainment from the 2021 census.[16] We focus on the likelihood of completing upper secondary education and on the likelihood of attending university.

Since we study the reforms that took place between 2007 and 2020, we restrict our attention to individuals born between 1987 and 2002, which is the latest cohort for which there is information on college attendance. There are 610,207 individuals in the sample, with an average age of 26; 78% had completed upper secondary education and 42% were enrolled in college at the time of the census or had already graduated. Approximately 9% of individuals in the census live in a region different from their region of birth.

[14]The exam lasts for 2 hours and each student is assessed on a booklet (from a pool of 7). From the questions answered, the OECD estimates an underlying distribution of each student's ability. PISA reports 5 plausible values (10 plausible values in the more recent waves) for each pupil in each examination category. In our analysis, we take the average of all the available plausible values.

[15]Following OECD guidelines, we identify as potentially problematic those PISA exams administered during weeks 7–10 in regions with early high-stakes exams. We identified these observations using a separate dataset that was provided by the OECD (OECD 2019).

[16]Source: Spanish Statistical Office 2021, available at `www.ine.es`.

4 Empirical analysis

We estimate a two-way fixed-effects regression model, exploiting the staggered timing of MLDA changes across regions in a difference-in-differences framework. In the following equation:

$$Y_{i,r,c,t} = \alpha_r + \delta_c + \gamma_t + \beta MLDA18_{r,c,t} + X_{i,t}\boldsymbol{\theta} + \varepsilon_{i,r,c,t}, \quad (1)$$

$Y_{i,r,c,t}$ is an outcome for individual i, living in region r, born in cohort c, and observed at year t. We include fixed effects for the region of residence, birth cohort, and for year of survey or exam.[17] Our main variable of interest, *MLDA18*, takes value 1 when the MLDA to which an individual was exposed at age 16 is 18 years, and 0 if it is 16 years. We also control for individual characteristics in vector $X_{i,t}$, including parental education, month of birth, gender, age, country of birth and parental socio-economic status when available. We estimate equation (1) using Ordinary Least Squares (OLS) and employ weights to account for stratified sampling, provided in the survey. Given the small number of regions (N=17), we use clustered wild bootstrap to compute confidence intervals and p-values.

To validate the parallel trends assumption, we conduct an event study analysis comparing the evolution of the main outcome variables in the treatment and control groups. As shown below, the evidence supports the absence of pre-trends. Moreover, the consistency of our two-way fixed-effects estimates relies on two additional assumptions: homogeneous treatment effects across regions and the absence of dynamic effects over time (Roth et al. 2023). To test the first assumption, we estimate the impact of the policy separately for each region, finding similar results across regions. The second assumption might be violated if, for instance, MLDA enforcement improves gradually after implementation. As a robustness check, we restrict our comparison group to regions which had an MLDA of 18 for at least 5 years (see Section 5).

[17] The inclusion of a set of fixed effects for cohort and another for year of survey only plays a role when we analyse data from the High School Survey on Drug Use, which takes place biannually and includes information each year for four cohorts. Instead, these two sets of fixed effects are co-linear when we use PISA data, as there is only one cohort per year of survey, and when we use the Census, where we have data for multiple cohorts in one single year.

4.1 Impact of MLDA on access to alcohol

After the reforms, respondents were less likely to reply that accessing alcohol is easy (β=-12% st. dev., p-value=0.00), and became less likely to report purchasing or consuming alcohol at legal points of sale (see Table 4). Teenagers affected by the reforms were 6 percentage points (p.p.) less likely to buy or drink at a bar (a decline of 11% over the counterfactual mean, p-value=0.03), and 9 percentage points less likely to report buying alcohol themselves (23%, p-value=0.07). However, some teenagers found alternative ways to access alcohol, with a 7 p.p. increase in the proportion reporting buying alcohol through someone above 18 (29%, p-value=0.10). The proportion reporting obtaining alcohol at a private house or park is also positive, but the coefficients are not statistically significant. Importantly, the high MLDA might affect people's attitudes towards alcohol. Teenagers became 7% more likely to report that having 5 or more drinks on a weekend is a moderate to serious problem (p-value=0.05).

4.2 Impact of MLDA on alcohol consumption

Alongside changing the channels through which teenagers obtained alcohol, the MLDA also affected net consumption. The DID estimates, reported in Table 5, show that the impact of MLDA reforms on teenage alcohol consumption in Spain was modest but non-negligible. Among adolescents aged 14–17, the probability of drinking alcohol in the previous month decreased by 5 percentage points (8%, p-value=0.04). Similarly, the likelihood of getting drunk in the last month fell by 5 percentage points (18%, p-value=0.03), and binge drinking declined by 6 percentage points (16%, p-value=0.02). The reforms also affected the intensive margin of consumption: teenagers reported drinking on 0.39 fewer days per month (12% decrease, p-value=0.06), getting drunk on 0.13 fewer days (18% decrease, p-value=0.07), and binge drinking on 0.18 fewer days (16% decrease, p-value=0.02). The higher MLDA delayed both initial alcohol consumption and first intoxication: exposed adolescents reported starting to drink 1.3 months later (0.11 years, p-value=0.12) and experiencing their first intoxication 2 months later (0.17 years, p-value=0.03).

Event study plots support the validity of the difference-in-differences strategy in this context. As shown in Figure 3, there are no significant differences in the evolution of

drinking behaviour across treated and control regions before the policy changes.

4.2.1 Heterogeneity analysis

The change in the MLDA decreased the proportion of teenagers consuming alcohol – and particularly the proportion reporting high levels of consumption. Next, we explore whether there are any differences in the magnitude of the effects depending on adolescents' age, gender, and parental education. As shown in Table A4, there is already a significant impact at age 14, which becomes stronger at ages 15 and 16, and decreases slightly at age 17. For instance, the probability of drinking decreased by 3 percentage points at age 14, 5 percentage points at age 15, 8 percentage points at age 16, and 4 percentage points at age 17. The effects by age are qualitatively similar for other measures of alcohol consumption.

We do not find substantial differences by gender, but the effect varies with parental education gradient (Figure A1). Pupils whose parents graduated from university reduced their alcohol consumption the most when the MLDA increased, although they were drinking less at baseline.

4.3 Educational performance

4.3.1 Impact of MLDA on PISA scores

Next, we assess the effects of the MLDA on educational performance using the information provided by PISA. These exams are completed by individuals aged between 15 years and 3 months and 16 years and 5 months, a group that experienced a significant decrease in alcohol consumption when the MLDA increased (see Table A4, column 5).

The event study plots show that PISA grades had evolved similarly in treated and control regions before the policy change (see Figure 4). However, as shown in column 1 of Table 6, the overall score improved by around 4.6% standard deviations (st. dev.) (p-value=0.03) when the MLDA increased to 18 years. A key threat to the validity of our analysis would be simultaneous increases in educational resources at the regional level accompanying the change in the MLDA. Column 2 shows that our estimates are robust to controlling for changes in student-to-computer ratios, student-to-teacher ratios, and instructional hours. Finally, results are also unchanged when we exclude

observations from the 2018 wave that were flagged by the OECD as potentially unreliable due to atypical testing behaviour (around 2% of the overall sample). The estimate is this restricted sample is 4.4% st. dev. (p-value=0.03). Out of the three dimensions assessed in PISA, the impact is largest in Reading (7% st. dev., p-value=0.05) and Science (4% st. dev., p-value=0.03), and it is not statistically significant in Maths (1% st. dev., p-value=0.37), although none of these three estimates is significantly different from each other (see Table A5).

Given that the MLDA increase had a larger effect on drinking behaviour among children of more educated parents, we examine heterogeneity in educational impacts by parental education (see Table 6, columns 4 and 5). The effect is larger for children with at least one college-educated parent (β=0.09 st. dev., p-value=0.02) than for children of less educated parents (β=0.03 st. dev., p-value=0.05), although this difference is not statistically significant.

4.3.2 Impact of MLDA on educational attainment

Our PISA analysis shows improved performance among students aged 15–16. To examine whether this translates into longer-term educational attainment, we analyse data from the 2021 census using two measures: completion of upper secondary education and college enrolment.

The event studies support the validity of our difference-in-differences strategy (see Figure 5). There are no significant differences in educational attainment between treatment and control groups for individuals who were 18 or older when the reform was implemented. After the reforms, we do not find significant changes in the completion of upper secondary education. As shown in Table 7 (column 1), the estimate is close to zero and not significant. Instead, significant differences emerge in terms of college enrolment completion. We observe a 2.1 percentage point increase (5%, p-value=0.09) in university attendance (column 4).

We conduct two robustness exercises. In columns 2 and 5, we separately examine individuals affected by the MLDA increase before age 16 (*fully treated*) and those who were 16-17 when the reform was implemented (*partially treated*). As expected, the impact on college enrolment is larger for the fully treated group (2.4 vs. 1.4 percentage points), although these estimates are not statistically significant. In columns 3 and 6, we restrict

the sample to individuals who still reside in their birth region at census time (91% of the sample). The effect on college attendance is slightly larger in this restricted sample (3.4 percentage points, p-value=0.09). While this restriction is appropriate for individuals who moved before age 16, it could introduce bias if mobility occurred later and was influenced by improved educational outcomes.

4.3.3 Impact of alcohol consumption

The above estimates capture the impact of raising the MLDA. To calculate the impact of alcohol consumption itself using this policy-induced variation it would require making some additional assumptions. This calculation is complex, as the reform affects both whether teenagers drink (extensive margin) and how much they drink (intensive margin). For instance, if we consider our analysis using PISA data, the share of drinkers in the control group (see Table A4, column 5), around 35%, reflects the share of *never takers* under the assumption of monotonicity (i.e., no individuals would drink more due to an increase in the MLDA). These teenagers were unaffected by the policy, as they would not have drunk even if the MLDA was 16. The remaining 65% were affected by the policy to some degree. On the extensive margin, we observe a decrease of 6 percentage points in the share that would have drunk if the MLDA was 16. Moreover, for the remaining 59%, there was a decrease in their intensity of drinking, particularly in terms of getting intoxicated and binge drinking. If we assume that the impact of alcohol on educational performance was similar across the extensive and intensive margins, our previous results could be scaled up by dividing by 0.64 (i.e., the share of teenagers who changed their drinking behaviour due to the reform).

4.4 Mechanisms

We consider several possible ways in which alcohol consumption may have affected educational performance, beyond its direct impact on cognitive ability.

4.4.1 Other drugs

We examine whether the effects on academic performance might operate through alcohol's impact on the consumption of other substances.

As shown in Table 8 (columns 1–4), we observe a small reduction in cigarette use and a slight increase in cannabis consumption, though neither result is statistically significant. The share of smokers decreased by 1.5 percentage points (6%, p-value=0.19), while cannabis use increased by 0.4 percentage points (4%, p-value=0.62). However, we find a significant decrease in tranquilliser use. The share of users declined by 0.6 percentage points (9%, p-value=0.04) in the previous month and by 1.2 percentage points (11%, p-value=0.04) in the previous year. While these effects are modest in absolute terms, they may indicate an overall improvement in mental health.

4.4.2 Leisure

We assess whether the decrease in alcohol consumption affected teenagers' time use patterns. We observe no significant changes in leisure habits (Table 9). Contrary to expectations, the MLDA changes do not affect teenagers' nighttime activities: neither the frequency of going out (β=0.1 days, p-value=0.75) nor their return time (β=0.1 hours, p-value=0.46) changes significantly. Similarly, we find no significant effects on afternoon socialising (β=0.1 days, p-value=0.70), internet use (β=0.02 days, p-value=0.16), video game use (β=0.02 st. dev., p-value=0.46), or sports participation (β=-0.02 st. dev., p-value=0.52).

4.4.3 Student effort

Alcohol consumption might affect students' study time and effort. Using PISA data on weekly homework hours as a proxy for student effort, we find no substantial changes in the time allocated to studying in none of our specifications (see Table 10). This absence of effects on time allocation suggests that the observed negative impact on performance likely reflects alcohol's direct effect on cognitive ability rather than changes in study habits.

5 Robustness checks

Heterogeneous or dynamic effects over time

Recent methodological work on staggered difference-in-differences designs has shown that TWFE estimates may be biased when treatment effects vary across cohorts treated at different times or when effects are dynamic (Roth et al. 2023, Callaway & Sant'Anna 2021).

To validate the homogeneity assumption, we analyse the impact of the policy separately for each of the four regions that changed their MLDA during the period of our study. We find very similar estimates for the four treated regions, suggesting that treatment effects are likely to be homogeneous (see Table A6). However, the potential dynamics remain a reason for concern, particularly given that regions in the control group had the MLDA of 18 for several years and thus are *already treated*. If strictness in MLDA enforcement has changed over time our estimates could either overstate or understate the true effects.

To address these concerns, we repeat our analysis using only comparison regions where the MLDA had increased at least 5 years earlier. This approach relaxes the assumption of homogeneous effects over time, requiring only that MLDA impacts stabilize after 5 years. We implement this by creating *stacked databases* from our health survey and PISA data (Cengiz et al. 2019, Deshpande & Mueller-Smith 2022). Each *stack* pairs one of the four treated regions with regions where the MLDA change occurred more than 5 years before. For example, for Castile and Leon (treated in 2007), the comparison regions are those where the MLDA changed before 2002. For Asturias (treated in 2015), the control group includes all regions treated before 2010, and so forth. We include all controls from our main specification interacted by stack and compute standard errors using clustered wild bootstrap. These supplementary estimates show similar magnitudes to our main findings for both drinking and PISA outcomes (see Tables A7 and A8).

Non-linear models

We estimate additional models for our intensive margin drinking variables using non-linear methods to adapt to the count nature of the variables (number of days

drinking, getting drunk and binge drinking). In Table A9 we present the estimated effects using Poisson Quasi Maximum Likelihood Estimation (PQMLE). The specification can be expressed as follows, where all variable definitions are as in Section 4. We compute standard errors using clustered bootstrap.

$$log(Y_{i,r,t}) = \alpha_r + \alpha_t + \gamma D_{r,t} + \delta X_{i,t} + \varepsilon_{i,r,t} \tag{2}$$

The magnitudes estimated are similar to those in the linear case. For the number of days drinking we estimate a fall of 9% (previously 12%). For the days getting drunk we estimate a drop of 18% in our non-linear model (in our linear regression this was 18%), and for the number of days binge drinking we estimate a drop of 17% (before 14%). The estimate on the number of days drinking alcohol is not statistically significant at standard levels (with a p-value of 0.11), but coefficients on measures of heavy consumption are significant at the 6% level for getting drunk and at the 1% confidence level for binge drinking.

6 Conclusion

Increasing the MLDA from 16 to 18 years in Spain was moderately effective in reducing teenage alcohol consumption and led to significant improvements in educational outcomes. The policy reduced alcohol consumption among adolescents aged 14–17 by 8–17% and improved their PISA exam performance by 0.04 standard deviations. This impact is substantial: the OECD estimates that it is equivalent to two months of additional schooling.[18] The magnitude is also comparable to the effect of approximately 1.5 additional instructional hours per week.[19] While the MLDA changes did not lead to measurable effects on secondary school completion, we find suggestive evidence of a 2 percentage point increase in college attendance probability. Interestingly, we find no significant impact of the MLDA on adolescents' leisure activities, time devoted to homework, or consumption of other substances. These results suggest that alcohol

[18] One standard deviation in our sample corresponds to approximately 80 PISA points. According to OECD calculations, 20 PISA points is equivalent to roughly one year of schooling (Schleicher 2023), implying that the observed increase of 0.04 standard deviations (or 3.2 PISA points).

[19] Several authors have estimated the returns to the number of instructional hours using PISA data and exploiting within-individual variation in the number of hours per subject. Estimates vary across waves, ranging from as low as 0.014 st. dev. in PISA 2018 up to 0.058 st. dev. in PISA 2006, with an average return of 0.028 st. dev. (Rivkin & Schiman 2015, Lavy 2015, Bietenbeck & Collins 2023).

affects cognitive ability directly rather than through changes in time use or other behaviours. We also observe a decrease in tranquilliser and sleeping pill use, suggesting improved mental health.

Our findings highlight that stricter alcohol regulation can lead to substantial improvements in educational performance, even in contexts with moderate compliance. These results have important policy implications for European countries: youth cognitive ability could be significantly improved if countries strengthen MLDA enforcement or raise the MLDA to 18 years in countries where it remains at 16 (e.g., Austria, Belgium, Denmark, Germany and Switzerland).

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Tables

Table 1: Comparison of treated and control regions, 2006 and 2020

	(1)	(2)	(3)	(4)	(5)	(6)
	Treated	Control	Diff	Treated	Control	Diff
		2006			2020	
Drink last 30 days	0.618	0.566	0.052	0.479	0.482	-0.002
			(0.033)			(0.041)
Get drunk last 30 days	0.302	0.246	0.056**	0.219	0.231	-0.012
			(0.022)			(0.031)
Binge drink 30 days	0.444	0.384	0.060**	0.251	0.278	-0.027
			(0.028)			(0.029)
GDP per capita	20,394	22,689	-2,295	22,043	23,609	-1,566
			(1,717)			(1,840)
PISA score	0.127	0.017	0.110	0.098	-0.102	0.199**
			(0.100)			(0.081)

Notes: Summary statistics for treated regions in 2006 in Column 1 (i.e. Castile and Leon, Galicia, Asturias and the Balearic Islands) and for treated regions in 2020 in column 4. Information for control regions in year 2006 is available in column 2 and for year 2020 in column 5. Columns 3 and 6 show the difference in means between the treatment and control group, and its standard error in parenthesis, allowing for clustering at the region level. Stars (*, **, ***) indicate significance at the 90%, 95% and 99% confidence levels, respectively. Teenage drinking variables come from the High School Survey on Drug Use and are binary indicators. PISA score shows the standardised test score across all topics assessed in PISA (Science, Maths and Reading). GDP figures are in euros in current (2024) prices from the Spanish Statistical Authority (INE).

Table 2: Summary statistics - High School Survey on Drug Use

	(1)	(2)	(3)	(4)	(5)
Variable	**Mean**	**SD**	**Min**	**Max**	**N**
Outcomes of interest					
Alcohol consumption					
Drink last 30 days (dummy)	0.60	0.49	0	1	240,803
Drink last 30 days (days)	3.09	4.80	0	24	240,803
Get drunk last 30 days (dummy)	0.24	0.43	0	1	242,416
Get drunk last 30 days (days)	0.66	2.03	0	24	242,416
Binge drink last 30 days (dummy)	0.34	0.48	0	1	214,376
Binge drink last 30 days (days)	1.20	3.01	0	24	214,376
Age first drank	13.80	1.31	10	17	176,458
Age first got drunk	14.52	1.20	10	17	103,070
Having 5 drinks each wkdn is a problem	0.56	0.50	0	1	221,797
Access to alcohol					
Very easy to access alcohol	0.66	0.47	0	1	147,893
Easy to access alcohol	0.25	0.43	0	1	147,893
Obtained alcohol at bar/shop	0.49	0.50	0	1	212,264
Obtained alcohol at house/park	0.20	0.40	0	1	188,394
Acquired alcohol themselves	0.33	0.47	0	1	189,445
Acquired alcohol through adult friend	0.30	0.46	0	1	189,444
Drink alcohol at bar/shop	0.41	0.49	0	1	237,830
Drink alcohol at house/park	0.43	0.49	0	1	237,830
Problems related to alcohol					
Hangover after consuming	0.33	0.47	0	1	122,640
Could not remember last night	0.19	0.39	0	1	121,692
Could not focus after consuming	0.15	0.35	0	1	121,643
Drove under influence	0.13	0.34	0	1	218,286
Other drugs					
Cigarettes last 30 days	0.24	0.43	0	1	250,422
Smokes daily	0.10	0.30	0	1	250,422
Cannabis last 30 days	0.15	0.36	0	1	247,780
Cannabis last 30 days (index)	1.13	4.11	0	24	247,780
Tranquillisers/sleeping pills last 30 days	0.05	0.23	0	1	228,806
Tranquillisers/sleeping pills last 12 months	0.10	0.30	0	1	229,058
Leisure					
Goes out at night (index)	4.53	4.95	0	20	238,356
Arrival time when going out at night	2.35	2.24	0	8	252,250
Goes out afternoon/evening	7.36	5.84	0	20	145,857
Videogames	1.73	1.30	0	4	164,947
Internet daily	0.85	0.36	0	1	147,376
Sport	2.55	1.28	0	4	170,601
Individual controls					
Age	15.49	1.06	14	17	255,752
Female	0.51	0.50	0	1	255,752
Born in Spain	0.82	0.38	0	1	255,752

Notes: Summary statistics for selected variables from the High School Survey on Drug Use 2004–2021. The sample includes pupils aged 14 to 17 at the time of the survey. A detailed description of each variable is available in Table A2.

Table 3: Summary statistics - PISA and census

	(1)	(2)	(3)	(4)	(5)
Variable	**Mean**	**SD**	**Min**	**Max**	**N**
PISA					
Outcomes of interest					
Average score	491.92	80.01	27	849	180,668
Math score	491.77	82.71	21	870	180,668
Reading score	488.37	86.47	1	847	180,668
Science score	495.90	84.07	-175	913	180,668
Homework time	9.25	9.06	0	90	98,571
Individual controls					
Age	15.85	0.29	15.25	16.42	180,668
Female	0.50	0.50	0	1	180,667
Born in Spain	0.88	0.33	0	1	180,668
Father has college degree	0.31	0.46	0	1	170,531
Mother has college degree	0.35	0.48	0	1	174,141
PISA during finals period	0.02	0.14	0	1	180,668
School controls					
Student to teacher ratio	11.93	5.07	1	139	164,027
Computer to student ratio	0.66	0.59	0	7	166,082
Instruction time Math	3.56	1.38	0	72	156,692
Instruction time Science	3.25	2.00	0	66	112,957
Instruction time Reading	3.51	1.18	0	80	116,998
Census					
Higher secondary education	0.78	0.41	0	1	610,207
College	0.42	0.49	0	1	610,207
Age	26.57	4.69	19	34	610,207
Female	0.49	0.50	0	1	610,207
Mover	0.09	0.29	0	1	610,207

Notes: Summary statistics for selected variables from PISA 2003–2022, and the 2021 Census. The PISA sample includes all pupils in the assessment. The Census sample includes people born between 1987 and 2002. A detailed description of each variable is available in Table A3.

Table 4: Impact on alcohol access

	(1)	(2)	(3)	(4)
	Having 5 drinks each	Easy to access	Obtained alcohol at:	
	wknd is a problem	alcohol	Bar/Shop	House/Park
MLDA 18	0.042	-0.122	-0.063	0.015
	[0.00,0.09]	[-0.20,-0.10]	[-0.13,-0.01]	[-0.04,0.08]
Magnitude (%)	7.09		-11.48	8.55
Mean	0.59	0.14	0.55	0.17
p-value	0.05	0.00	0.03	0.35
N	220,929	221,998	211,258	187,388
	(5)	(6)	(7)	(8)
	Acquired alcohol:		Drank at:	
	Themselves	through adult friend	Bar	House/Park
MLDA 18	-0.095	0.067	-0.064	-0.016
	[-0.35,0.01]	[-0.02,0.15]	[-0.19,0.00]	[-0.08,0.10]
Magnitude (%)	-22.67	29.27	-13.01	-4.05
Mean	0.42	0.23	0.49	0.41
p-value	0.07	0.10	0.05	0.57
N	188,437	188,436	236,818	236,818

Notes: The dummy variable *MLDA 18* takes value one when 18 is the minimum legal drinking age in the region at the time of the exam. Each column reports the estimated impact of increasing the MLDA on a number of alcohol access measures, for individuals aged 14 to 17 in the High School Survey on Drug Use, years 2004–2021. A detailed definition of each variable is available in Table A2. Easy to access alcohol is a standardised index variable. The remaining dependent variables are binary indicators. Controls include age, father's education, mother's education, gender, month of birth, country of birth and month of survey. Weights applied. 95% confidence intervals (in brackets) and p-values have been calculated using wild bootstrap. *Mean* includes the counterfactual mean, calculated as the observed mean in treated regions after accounting for the estimated effect of the MLDA.

Table 5: Impact on alcohol consumption

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Drinking alcohol last 30 days		Getting drunk last 30 days		Binge drinking last 30 days		Age first	
	dummy	days	dummy	days	dummy	days	drank	got drunk
MLDA 18	-0.051	-0.389	-0.049	-0.129	-0.060	-0.178	0.111	0.170
	[-0.11,-0.01]	[-1.67,0.22]	[-0.09,-0.01]	[-0.38,0.01]	[-0.13,-0.02]	[-0.85,0.00]	[-0.00,0.22]	[0.09,0.25]
Magnitude (%)	-7.86	-12.19	-18.02	-17.51	-16.14	-14.38		
Mean	0.64	3.19	0.27	0.74	0.37	1.24	13.73	14.51
p-value	0.04	0.06	0.03	0.07	0.02	0.06	0.12	0.03
N	239,766	239,766	241,410	241,410	213,335	213,335	238,524	220,190

Notes: Estimates of the MLDA increase in Castile and Leon, Galicia, Asturias and the Balearic Islands on self-reported drinking measures last month for individuals aged 14 to 17 from the High School Survey on Drug Use. Columns 1 to 6 show different drinking measures, are estimated with OLS and the confidence interval is calculated using wild bootstrap. Columns 7 and 8 show effects on age at first drinking and are estimated using Tobit to account for right-censoring in the variable and the confidence interval is calculated using bootstrap. Controls include age, father's education, mother's education, gender, month of birth, country of birth and month of survey. Weights applied. 95% confidence intervals (in brackets) and p-values have been calculated using wild bootstrap. *Mean* includes the counterfactual mean, calculated as the observed mean in treated regions after accounting for the estimated effect of the MLDA.

Table 6: Impact on educational performance (PISA)

	(1)	(2)	(3)	(4)	(5)
	PISA score (standardised)				
MLDA 18	0.064	0.064	0.061	0.114	0.050
	[-0.03,0.31]	[-0.03,0.27]	[-0.03,0.27]	[0.08,0.15]	[-0.03,0.23]
Sample	Full	Full	Restricted	College	Less educated
Indiv. controls	Yes	Yes	Yes	Yes	Yes
School controls	No	Yes	No	No	No
p-value	0.11	0.10	0.12	0.02	0.13
N	180,668	140,927	176,886	74,072	102,814

Notes: The outcome variable *PISA score* is the average across all plausible values provided in the data for an individual's performance in Maths, Reading and Science, standardised to mean 0 and standard deviation 1. All columns include controls for individual-level attributes (age in months, father's education, mother's education, gender, month of birth, immigrant status and socioeconomic status). Column 2 also includes school-level attributes (class size, computers per student, number of lectures per week). In column 1 the sample includes all students who participated in PISA exams in Spain between 2003 and 2022. In column 2 we include only observations with information on school characteristics. In column 3 we exclude around 3,000 students who participated in PISA in 2018 who have been flagged by the OECD due to concerns about the reliability of the data. In column 4 we consider children with at least one college-educated parent and, in column 5, children with less educated parents. All regressions include Weights. 95% confidence intervals (in brackets) and p-values have been calculated using wild bootstrap. *Mean* includes the counterfactual mean, calculated as the observed mean in treated regions after accounting for the estimated effect of the MLDA.

Table 7: Impact on educational attainment

	(1)	(2)	(3)	(4)	(5)	(6)
	Upper secondary			College		
MLDA 18	-0.010		-0.002	0.021		0.034
	[-0.20,0.11]		[-0.27,0.18]	[-0.06,0.16]		[-0.10,0.25]
	(0.486)		*(0.885)*	*(0.092)*		*(0.093)*
MDLA 18 full treat		-0.011			0.024	
		[-0.19,0.14]			[-0.04,0.20]	
		(0.506)			*(0.099)*	
MDLA 18 partial treat		-0.007			0.014	
		[-0.75,0.09]			[-0.35,0.13]	
		(0.805)			*(0.333)*	
Sample						
Magnitude (%)	-1.28		-0.30	5.09		8.26
Mean	0.79	0.78	0.79	0.42	0.42	0.42
N	610,207	610,207	554,724	610,207	610,207	554,724

Notes: In columns 1–3 the outcome variable is a binary indicator equal to 1 if individual completed upper secondary education. In columns 4–6 the outcome variable *college* is 1 if an individual pursued higher education. 95% confidence intervals (in brackets) and p-values (in parentheses) have been calculated using wild bootstrap. The sample comprises individuals aged 16 to 25 in the 2021 census. Columns 1 and 4 estimate effects on the full sample. Columns 2–3 and 5–6 estimate effects excluding individuals who reside in a different province from which they were born. Controls include gender, year of birth and province of birth. *Mean* includes the counterfactual mean, calculated as the observed mean in treated regions after accounting for the estimated effect of the MLDA.

Table 8: Impact on consumption of other substances

	(1)	(2)	(3)	(4)	(5)	(6)
	Cigarettes last 30 days		Cannabis last 30 days		Tranquilisers/Sleeping pills	
	At least once	Daily	At least once	Days	Last month	Last year
MLDA 18	-0.015	-0.005	0.004	0.097	-0.006	-0.012
	[-0.06,0.01]	[-0.02,0.02]	[-0.05,0.03]	[-0.39,0.54]	[-0.02,-0.00]	[-0.03,-0.00]
Magnitude (%)	-6.35	-5.74	3.77	13.11	-9.36	-10.54
Mean	0.23	0.08	0.12	0.74	0.06	0.11
p-value	0.19	0.50	0.62	0.35	0.04	0.04
N	249,321	249,321	246,721	246,721	227,717	227,968

Notes: Estimates of the MLDA increase on self-reported smoking and other drug consumption measures for individuals aged 14 to 17 from the High School Survey on Drug Use. Controls include age, father's education, mother's education, gender, month of birth, country of birth and month of survey. Weights applied. 95% confidence intervals (in brackets) and p-values have been calculated using wild bootstrap. *Mean* includes the counterfactual mean, calculated as the observed mean in treated regions after accounting for the estimated effect of the MLDA.

Table 9: Impact on leisure activities

	(1)	(2)	(3)	(4)	(5)	(6)
	Goes out at night		Goes out afternoon	Internet	Videogames	Sport
	Days per month	Arrival time	Days per month	(daily)	(std)	(std)
MLDA 18	0.136	0.091	0.113	0.019	0.023	-0.020
	[-1.09,0.67]	[-0.18,0.49]	[-7.72,3.81]	[-0.14,0.22]	[-0.05,0.12]	[-0.08,0.13]
Mean	3.22	2.30	6.92	0.82	-0.01	0.05
p-value	0.75	0.46	0.70	0.16	0.46	0.52
N	237,287	251,146	145,088	146,603	164,202	169,825

Notes: Estimates of the MLDA increase on self-reported time use for individuals aged 14 to 17 from the High School Survey on Drug Use. The dependent variables are indexes standardised to mean 0 and standard deviation 1. Controls include age, father's education, mother's education, gender, month of birth, country of birth and month of survey. Weights applied. 95% confidence intervals (in brackets) and p-values have been calculated using wild bootstrap. *Mean* includes the counterfactual mean, calculated as the observed mean in treated regions after accounting for the estimated effect of the MLDA.

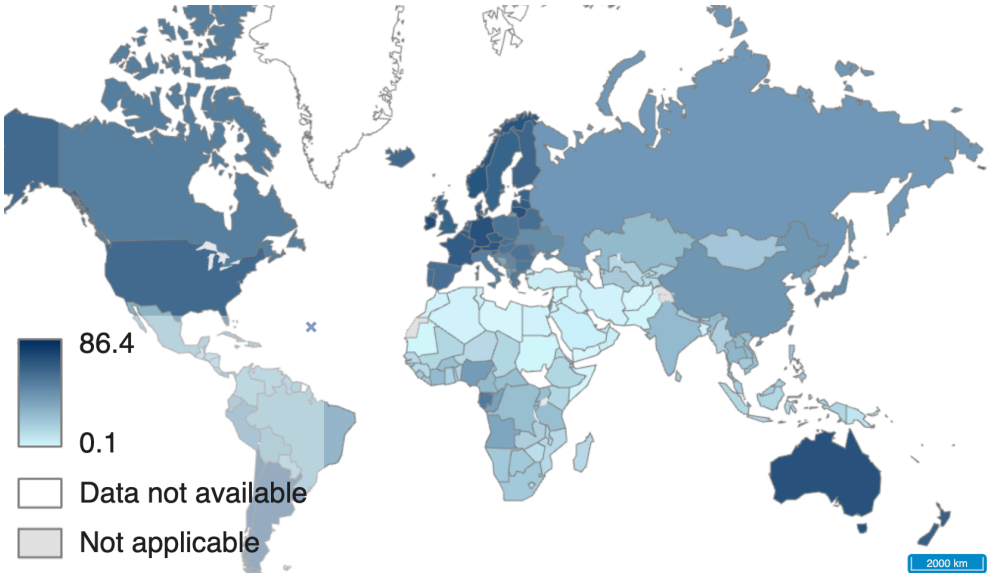
Table 10: Impact on student effort

	(1)	(2)	(3)
	Homework time		
MLDA 18	-0.097	-0.099	-0.097
	[-0.22,0.04]	[-0.23,0.06]	[-0.22,0.04]
Sample	Full	Full	Restricted
Indiv. controls	Yes	Yes	Yes
School controls	No	Yes	No
p-value	0.25	0.32	0.25
N	121,560	104,474	121,560

Notes: Estimates of the MLDA increase on self-reported time devoted to homework for individuals in PISA. The dependent variable is standardised to mean 0 and standard deviation 1 to account for changes in reporting over time. In column 1 the sample includes all students who participated in PISA exams in Spain between 2003 and 2022. In column two we consider only students with non-missing information on school characteristics. In column 3 we exclude around 3,000 students who participated in PISA in 2018 who have been flagged by the OECD due to concerns about the reliability of the data. All columns include controls for individual-level attributes (age in months, father's education, mother's education, gender, month of birth, immigrant status and socioeconomic status). Column 2 also includes school-level attributes (class size, computers per student, number of lectures per week). All regressions include Weights. 95% confidence intervals (in brackets) and p-values have been calculated using wild bootstrap. *Mean* includes the counterfactual mean, calculated as the observed mean in treated regions after accounting for the estimated effect of the MLDA.

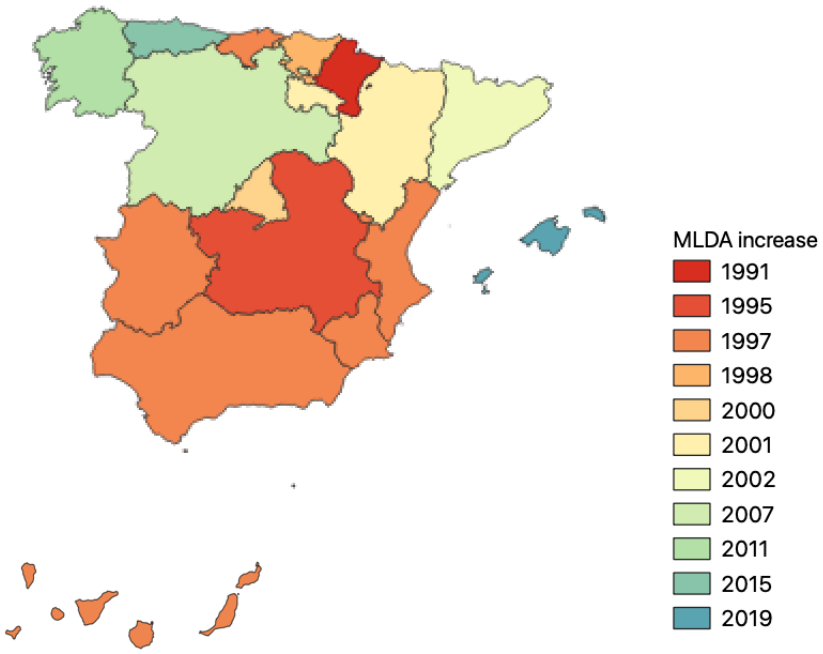
Figures

Figure 1: Alcohol consumption in past year (%), 15-19 years old, 2016



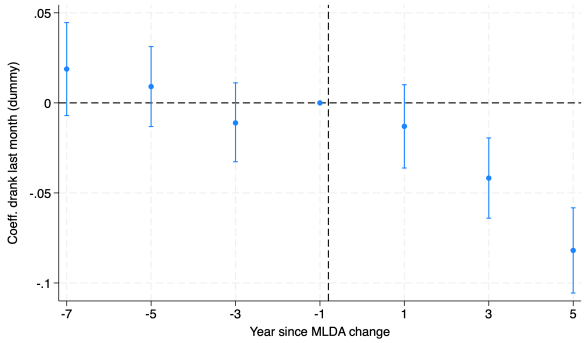
Notes: Prevalence of teenage consumption in the past month from WHO (2019).

Figure 2: MLDA increase across Spanish regions

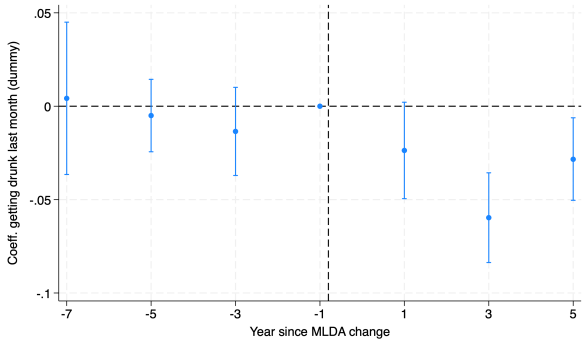


Notes: Map of Spanish regions and timing of MLDA bans. Whenever a region experienced more than one regulatory change in the MLDA (one partial, one full) we code the year in which the full reform took place.

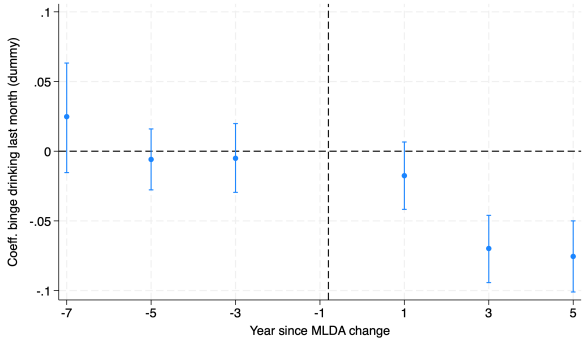
Figure 3: Event study, various drinking measures



Drinking in last 30 days



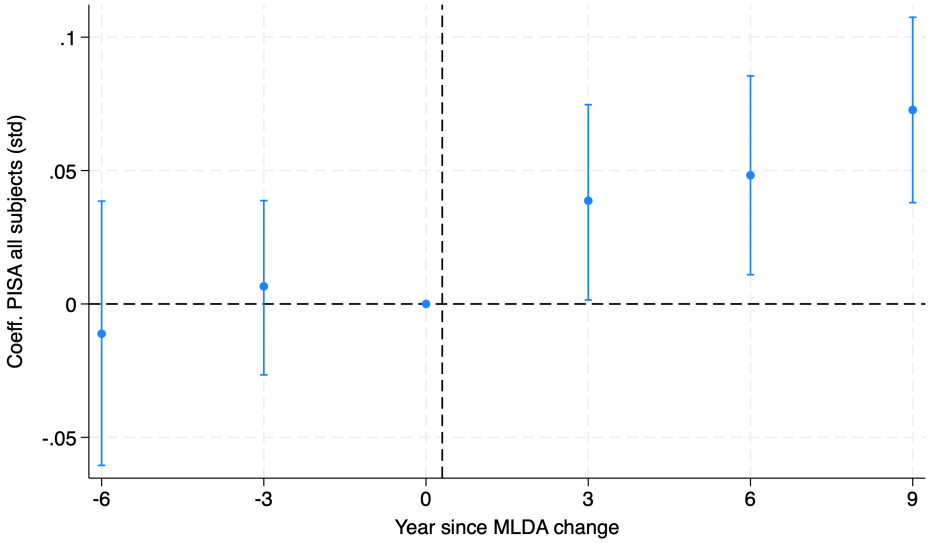
Get drunk in last 30 days



Binge drink in last 30 days

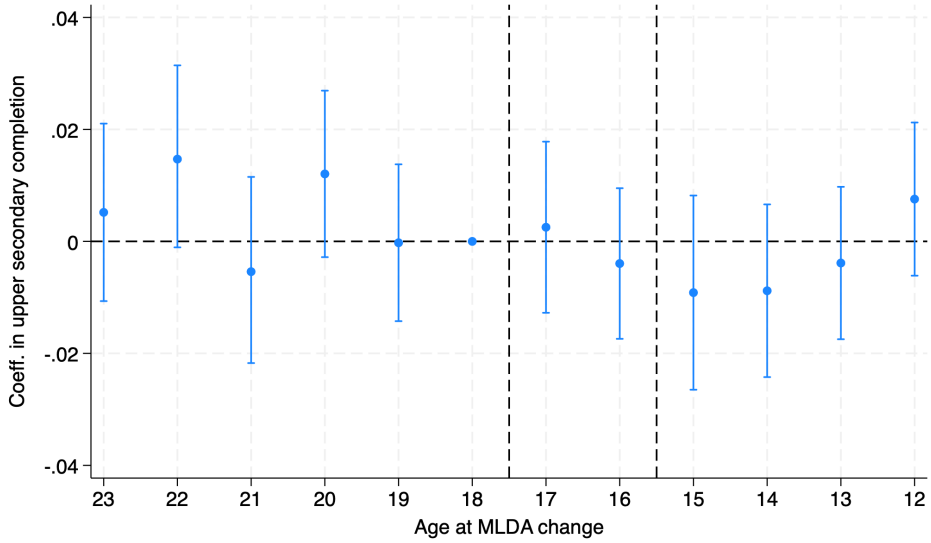
Notes: Event study of the prevalence in drinking measures from the High School Survey on Drug Use. Controls include age, father's education, mother's education, gender, month of birth, country of birth and month of survey. Weights applied. The base year is the year prior to the MLDA increase. 95% confidence intervals have been calculated using wild bootstrap.

Figure 4: Event study: Effect of MLDA on PISA test scores

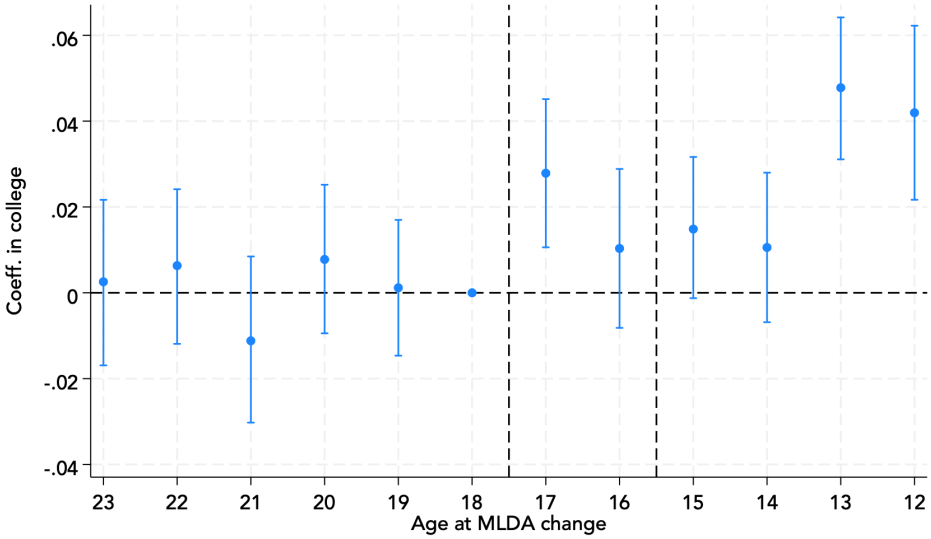


Notes: Event study of standardised test scores in PISA. Regions where PISA exams took place at the same time as final high school exams excluded. Controls include age, father's education, mother's education, gender, month of birth, immigrant status and socioeconomic status. Weights applied. All controls interacted with year of survey. The base year is the year prior to the MLDA increase. 95% confidence intervals have been calculated using wild bootstrap.

Figure 5: Event study: Effect of MLDA on educational attainment



Completing upper secondary education



Going to college

Notes: Event study graph plotting the Impact of MLDA reforms on the probability of graduating from upper secondary education and going to college, by age at the time of the reform. The sample includes 10% of all individuals in the 2021 census. The sample includes individuals born between 1987 and 2002. Controls include gender, year of birth and province of birth. The base age group are those aged 18 at the time of MLDA change. 95% confidence intervals have been calculated using wild bootstrap.

Appendix

Table A1: Minimum Legal Drinking Age regulation, by region

Region	Effective from:	Alcohol permitted under 18	Regulation	Source
Andalucia	July 20th, 1997	None	Ley 4/1997, de 9 de julio, de Prevención y Asistencia en materia de Drogas.	BOE-A-1997-18301
Aragon	May 1st, 2001	None	Ley 3/2001, de 4 abril, de prevención, asistencia y reinserción social en materia de drogodependencias.	BOE-A-2001-9342
Asturias	May 20th, 2015	None	Ley 4/2015, de 6 de marzo, de atención integral en materia de drogas y bebidas alcohólicas.	BOE-A-2015-4847
Balearic Islands	February 28th, 2014	No sale or consumption allowed in public establishments	Ley 7/2013, de 26 de noviembre, de régimen jurídico de instalación, acceso y ejercicio de actividades en las Illes Balears.	BOE-A-2014-655
	May 19th, 2019	None	Ley 9/2019, de 19 de febrero, de la atención y los derechos de la infancia y la adolescencia de las Illes Balears.	BOE-A-2019-5578
Basque Country	July 15th, 1998	None	Ley 18/1998, de 25 de junio, sobre Prevención, Asistencia e Inserción en materia de Drogodependencias	B.O.P.V. - 14 de julio de 1998
Canary Islands	February 18th, 1997	None	Ley 1/1997, de 7 de febrero, de Atención Integral a los menores.	BOE-A-1997-5498
Cantabria	November 15th, 1997	None	Ley de Cantabria 5/1997, de 6 octubre, de Prevención, Asistencia e Incorporación Social en Materia de Drogodependencias.	Boletín Oficial de Cantabria núm. 205, de 14 de noviembre de 1997
Castile and Leon	April 7th, 1994	Moderate alcohol content (less than 18%) above 16 years	Ley 3/1994, de 29 de marzo, de Prevención, Asistencia e Integración Social de Drogodependientes de Castilla y León.	BOCL nm. 65, de 6 de abril de 1994
	June 14th, 2007	None	Ley 3/2007, de 7 de marzo, por la que se modifica la Ley 3/1994, de 29 de marzo, de prevención, asistencia e integración social de drogodependientes de Castilla y León.	BOCL nm. 52, de 14 de marzo de 2007
Castile-La Mancha	April 22nd, 1995	None	Ley 2/1995, de 2 de marzo, contra la Venta y Publicidad de Bebidas Alcohólicas a Menores.	Diario Oficial de Castilla-La Mancha núm. 19, de 21 de abril de 1995
Catalonia	June 7th, 1991	Moderate alcohol content (less than 23%) above 16 years	Ley 10/1991, de 10 de mayo, de modificación de la Ley 20/1985, de prevención y asistencia en materia de sustancias que pueden generar dependencia.	BOE-A-1991-14237
	April 8th, 2002	None	Ley 1/2002, de 11 de marzo, de tercera modificación de la Ley 20/1985, de 25 de julio, de Prevención y Asistencia en Materia de Sustancias que Pueden Generar Dependencia.	DOGC nm. 3598, de 19 de marzo de 2002
Extremadura	May 18th, 1997	None	Ley 4/1997, de 10 de abril, de Medidas de Prevención y Control de la Venta y Publicidad de Bebidas Alcohólicas para Menores de Edad.	Diario Oficial de Extremadura núm.57, de 17 de mayo de 1997
Galicia	July 22nd, 1996	Moderate alcohol content (less than 18%) above 16 years	Ley 2/1996, de 8 de mayo, de Galicia, sobre drogas.	BOE-A-1996-14650
	February 28th, 2011	None	Ley 11/2010, de 17 de diciembre, de prevención del consumo de bebidas alcohólicas en menores de edad.	BOE-A-2011-1647
La Rioja	February 18th, 2001	None	Ley 4/2000, de 25 de octubre, de Espectáculos Públicos y Actividades Recreativas de la Comunidad Autónoma de la Rioja.	BOE-A-2000-21563
Madrid	May 12th, 2000	None	Ley 5/2000, de 8 de mayo, por la que se eleva la edad mínima de acceso a las bebidas alcohólicas	BOE-A-2000-9793
Murcia	November 13th, 1997	None	Ley 6/1997, de 2 de octubre, sobre drogas para la prevención, asistencia e integración social.	BOE-A-1998-3169
Navarre	April 6th, 1991	None	Ley Foral 10/1991, de 16 de marzo, sobre prevención y limitación de consumo de bebidas alcohólicas por menores de edad.	BOE-A-1991-23614
Valencian Community	June 19th, 1997	Moderate alcohol content (less than 18%) above 16 years	Ley 3/1997, de 16 de junio, sobre drogodependencias y otros trastornos adictivos.	Diario Oficial de la Generalitat Valenciana núm. 3.016, de 18 de junio de 1997
	August 27th, 2002	None	Ley 4/2002, de 18 de junio, por la que se modifica la Ley 3/1997, de 16 de junio, sobre Drogodependencias y otros Trastornos Adictivos.	BOE-A-2002-14189

Notes: MLDA reforms across Spanish regions, 1991-2019.

Table A2: Variable definitions - High School Survey on Drug Use

Variable	Description
Outcomes of interest	
Alcohol consumption	
Drink last 30 days (days)	Created from an index variable where an individual reports consuming 1–3, 4–5, 6–9, 10–19, or more than 20 days. We take the average number in each category to convert to days. For instance, if the individual reported consuming 10–19 days we code it as 14.5. The highest category is coded as 24.5
Drink last 30 days (dummy)	Binary indicator, 1 if individual reports having consumed alcohol in the last 30 days, 0 otherwise
Get drunk last 30 days (days)	Created from an index variable coded similarly to *Drink last 30 days (days)*
Get drunk last 30 days (dummy)	Binary indicator, 1 if individual reports having been drunk in the last 30 days, 0 otherwise
Binge drink last 30 days (days)	Created from an index variable coded similarly to *Drink last 30 days (days)*
Binge drink last 30 days (dummy)	Binary indicator, 1 if individual reports having had more than 5 drinks at least once in the last 30 days, 0 otherwise
Age first drank	Age individual first consumed alcohol
Age first got drunk	Age individual first got drunk
Having 5 drinks each wkdn is a problem	Binary indicator, 1 if individual states that having 5 drinks each weekend is a problem, 0 otherwise
Access to alcohol	
Easy to access alcohol (index)	Categorical variable where individual states how easy it is to access alcohol. Prior to 2014 the variable had four possible categories, ranging from 'Very easy' to 'Almost impossible'. From 2014 the categorisation changed to two categories divided into 'Easy' or 'Difficult'. We standardise the variable in each year.
Obtained alcohol at bar/shop	Binary indicator, 1 if individual reports purchasing alcohol in a bar/disco or pub, 0 otherwise
Obtained alcohol at house/park	Binary indicator, 1 if individual reports purchasing alcohol at a house or at the park, 0 otherwise
Acquired alcohol themselves	Binary indicator, 1 if individual reports purchasing alcohol themselves, 0 otherwise
Acquired alcohol through adult friend	Binary indicator, 1 if individual reports purchasing alcohol through an adult friend, 0 otherwise
Drink alcohol at bar	Binary indicator, 1 if individual reports consuming alcohol in a bar/disco or pub, 0 otherwise
Drink alcohol at house/park	Binary indicator, 1 if individual reports consuming alcohol at a house or at the park, 0 otherwise
Problems related to alcohol	
Hangover after consuming	Binary indicator, 1 if individual reports having experienced hangover in the last 12 months, 0 otherwise
Could not remember last night	Binary indicator, 1 if individual reports not being able to remember the previous night after having drunk in the last 12 months, 0 otherwise
Could not focus after consuming	Binary indicator, 1 if individual reports not being able to focus after consuming alcohol in the last 12 months, 0 otherwise
Other drugs	
Cigarettes last 30 days	Binary indicator, 1 if individual reports having smoked cigarettes in the last 30 days, 0 otherwise
Smokes daily	Binary indicator, 1 if individual reports smoking daily, 0 otherwise
Cannabis last 30 days	Binary indicator, 1 if individual reports having consumed cannabis in the last 30 days, 0 otherwise
Cannabis last 30 days (index)	Created from an index variable where individual reports whether smoked cannabis at all, less than weekly, less than daily, or daily
Tranquillisers/sleeping pills last 30 days	Binary indicator, 1 if individual reports having consumed tranquillisers or sleeping pills in the last 30 days, 0 otherwise
Tranquillisers/sleeping pills last 12 months	Binary indicator, 1 if individual reports having consumed tranquillisers or sleeping pills in the last 12 months, 0 otherwise
Leisure	
Goes out at night (index)	Standardised index variable where individuals report the frequency of going out in the night. The categories are never, 1-3 nights, once a week, twice a week, 3-4 nights a week, or 4 nights or more
Arrival time when going out at night	Categorical variable ranging from "before midnight", from 0-1 AM, 1-2AM, 2-3AM, 3-4AM, 4-8AM, or "did not come back"
Goes out afternoon/evening	Standardised index variable where individuals report the frequency of going out in the afternoon-evening. The categories are never, 2 or 3 times a year, once or twice a 30 days, at least weekly, or every day
Videogames	Standardised index variable where an individual reports the frequency of playing videogames. For 2012 and 2014 we use a variable including the following categories: never, 2 or 3 times a year, once or twice a 30 days, at least weekly, or every day. For 2016 to 2020 we have more precise indicators with the number of hours that people play daily, from never, less than 30 minutes, 1 hour daily, 2-3 hours daily, and 4 or more. We standardise the values each year
Internet daily	Binary indicator, 1 if individual reports using the Internet every day, 0 otherwise
Sport	Standardised index variable where an individual reports the frequency of different sports or exercising. Categories are never, 2 or 3 times a year, once or twice a 30 days, at least weekly, or every day
Individual controls	
Education father	Categorical variable where individual reports father's education. The categories are no formal education, up to primary education, up to secondary education, vocational education, university education (degree), university education (master or above) or doesn't know. We code an additional category when the value was missing
Education mother	Categorical variable where individual reports mother's education. The categories are no formal education, up to primary education, up to secondary education, vocational education, university education (degree), university education (master or above) or doesn't know. We code an additional category when the value was missing
Country of birth	Categorical variable describing if individual was born in Spain or abroad. We code an additional category when the value was missing

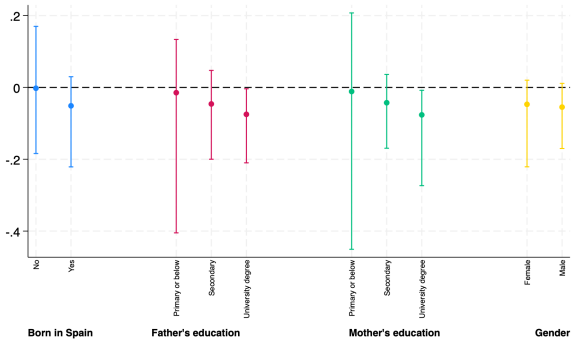
Notes: Variable definitions from the High School Survey on Drug Use, 2004 - 2021.

Table A3: Variable definitions - PISA and census

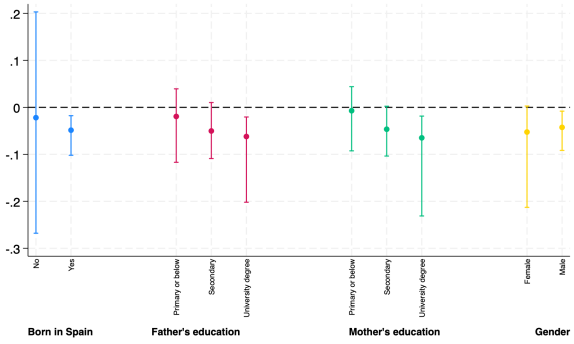
Variable	Description
PISA	
Outcomes of interest	
Average score	Average of all plausible values available per year for all subjects, in points
Math score	Average of all plausible values available per year for math, in points
Science score	Average of all plausible values available per year for science, in points
Reading score	Average of all plausible values available per year for reading, in points
Homework time	Total time spent on homework, standardised per year. Not available for 2009. For 2018 we use an index variable where individuals indicate when they last did homework. 2018 is omitted in the summary statistics.
Individual controls	
Education father	Categorical variable where individual reports father's education. The categories are no formal education, primary education, lower secondary education, upper secondary education, tertiary education, or missing
Education mother	Categorical variable where individual reports mother's education. The categories are no formal education, primary education, lower secondary education, upper secondary education, tertiary education, or missing
Country of birth	Categorical variable distinguishing native students, first-generation students, or non-native students.
Index ESCS	Index of Socio-Economic and Cultural Status. Composite score derived by PISA from three indicators related to family background: parents' highest education, in years, parents' highest occupational status, and home possessions
PISA during finals period	Binary indicator which is 1 in years and regions where the PISA exams coincided with high-stakes final examinations
School controls	
Student to teacher ratio	Total number of students by the total number of teachers in a school
Computer to student ratio	Total computers available for educational purposes over total student enrolment in the school
Instruction time Math	Total minutes of instructional time in Math. In years when total instruction time was not available, we took the average instructional time for English, Math, and Science. We standardise the variable each year
Instruction time Science	As above, for Science
Instruction time Reading	As above, for Reading
Census	
Upper secondary	Binary indicator, 1 if individual reports having attained upper secondary education (above mandatory education - *Educación Secundaria Obligatoria or ESO*), 0 otherwise
College	Binary indicator, 1 if individual has a higher education degree (bachelor's, master's, or above), 0 otherwise
Mover	Binary indicator, 1 if person resides in different region to which they were born in, 0 otherwise

Notes: Variable definitions from PISA 2003 - 2022.

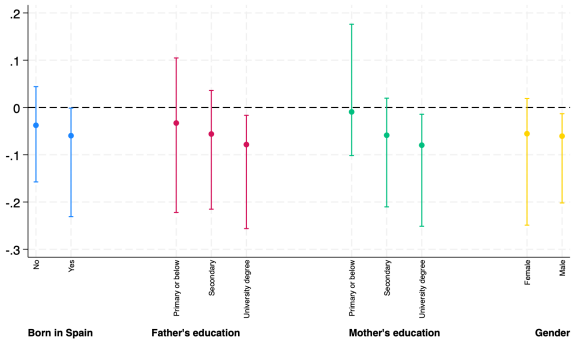
Figure A1: Heterogeneity analyses, various drinking measures



Drinking in last 30 days



Get drunk in last 30 days



Binge drink in last 30 days

Notes: Heterogeneity analyses of the prevalence in drinking measures from the High School Survey on Drug Use by pupil attributes. Controls include age, father's education, mother's education, gender, month of birth, country of birth and month of survey. Weights applied. 95% confidence intervals have been calculated using wild bootstrap.

Table A4: Impact of MLDA on Drinking Behaviour, by Age at Survey Time

	(1)	(2)	(3)	(4)	(5)
	Age at time of survey				
	14	15	16	17	PISA
	Drink last 30 days (dummy)				
MLDA 18	-0.033	-0.048	-0.077	-0.040	-0.062
	[-0.14,0.01]	[-0.12,-0.01]	[-0.13,-0.01]	[-0.10,0.01]	[-0.12,-0.03]
Magnitude (%)	-8.50	-8.18	-10.14	-4.98	-9.52
Mean	0.39	0.59	0.76	0.81	0.65
p-value	0.08	0.04	0.05	0.07	0.03
N	52,486	66,963	67,773	52,874	83,773
	Get drunk last 30 days (dummy)				
MLDA 18	-0.031	-0.043	-0.064	-0.047	-0.045
	[-0.09,-0.00]	[-0.10,0.01]	[-0.09,-0.01]	[-0.12,0.00]	[-0.10,-0.01]
Magnitude (%)	-26.04	-19.89	-18.48	-11.90	-17.57
Mean	0.12	0.21	0.35	0.39	0.25
p-value	0.03	0.08	0.03	0.08	0.03
N	53,631	67,496	67,858	52,756	84,364
	Binge drink last 30 days (dummy)				
MLDA 18	-0.029	-0.034	-0.086	-0.070	-0.051
	[-0.14,0.01]	[-0.10,0.02]	[-0.13,0.03]	[-0.14,0.01]	[-0.22,-0.01]
Magnitude (%)	-16.95	-11.67	-18.57	-13.30	-14.70
Mean	0.17	0.29	0.46	0.53	0.35
p-value	0.07	0.08	0.12	0.07	0.02
N	48,314	58,676	58,354	48,317	73,908

Notes: Columns 1–5 report estimates for individuals aged 14–18, respectively. Column 6 includes individuals eligible for PISA participation (e.g. aged between 15 years and 3 months and 16 years and 5 months). Dependent variables are binary indicators. Controls include age, father's education, mother's education, gender, month of birth, country of birth and month of survey. Weights applied. 95% confidence intervals (in brackets) and p-values have been calculated using wild bootstrap. *Mean* includes the counterfactual mean, calculated as the observed mean in treated regions minus the estimated effect of the MLDA.

Table A5: Impact on teenage educational performance, by subject

	(1) Math	(2) Reading	(3) Science
MLDA 18	0.028	0.095	0.054
	[-0.03,0.19]	[-0.04,0.38]	[-0.05,0.26]
Sample	Restricted	Restricted	Restricted
Indiv. controls	Yes	Yes	Yes
School controls	No	No	No
p-value	0.31	0.09	0.14
N	176,886	176,886	176,886

Notes: Estimates of the impact of MLDA increase on PISA exam results. The score is the average across all plausible values provided in the data standardised to mean 0 and standard deviation 1. We exclude around 3,000 students who participated in PISA in 2018 who have been flagged by the OECD due to concerns about the reliability of the data. All columns include controls for individual-level attributes (age in months, father's education, mother's education, gender, month of birth, immigrant status and socioeconomic status). Weights applied. 95% confidence intervals (in brackets) and p-values have been calculated using wild bootstrap.

Table A6: Impact on teenage drinking – by affected region

	Drinking alcohol		Getting drunk		Binge drinking	
	dummy	days	dummy	days	dummy	days
MLDA 18 - Castile and Leon	-0.028	-0.204	-0.029	-0.024	-0.066	-0.144
	[-0.74,0.49]	[-6.67,4.39]	[-0.62,0.46]	[-2.34,1.66]	[-0.97,0.45]	[-4.17,1.93]
MLDA 18 - Galicia	-0.057	-0.385	-0.054	-0.156	-0.057	-0.138
	[-0.52,0.25]	[-4.87,2.97]	[-0.39,0.24]	[-1.29,0.57]	[-0.42,0.19]	[-2.20,1.41]
MLDA 18 - Asturias	-0.072	-0.754	-0.059	-0.168	-0.070	-0.312
	[-1.28,0.89]	[-9.92,9.57]	[-1.07,0.74]	[-3.63,2.68]	[-1.49,0.99]	[-6.29,4.64]
MLDA 18 - Balearic Islands	-0.059	-0.074	-0.054	-0.187	-0.010	0.021
	[-1.45,1.01]	[-8.01,12.66]	[-1.02,0.91]	[-1.77,1.56]	[-0.93,0.99]	[-3.38,4.27]
Mean	0.64	3.17	0.27	0.73	0.37	1.22
N	22,068	22,068	22,721	22,721	23,051	23,051

Notes: Estimates of the MLDA increase in Castile and Leon, Galicia, Asturias and the Balearic Islands on self-reported drinking measures last month for individuals aged 14 to 17. Controls include age, father's education, mother's education, gender, month of birth, country of birth and month of survey. 95% confidence intervals (in brackets) and p-values have been calculated using wild bootstrap. *Mean* includes the counterfactual mean, calculated as the observed mean in treated regions minus the estimated effect of the MLDA.

Table A7: Impact on teenage drinking – restricted comparison group

	Drinking alcohol		Getting drunk		Binge drinking	
	dummy	days	dummy	days	dummy	days
MLDA 18	-0.045	-0.327	-0.044	-0.097	-0.062	-0.172
	[-0.08,0.03]	[-0.75,0.61]	[-0.08,0.00]	[-0.29,0.15]	[-0.09,-0.00]	[-0.40,0.13]
Magnitude (%)	-6.82	-9.65	-15.30	-12.48	-15.51	-12.64
Mean	0.66	3.39	0.29	0.78	0.40	1.36
p-value	0.09	0.12	0.06	0.12	0.05	0.10
N	1,016,286	1,016,286	1,024,584	1,024,584	904,184	904,184

Notes: Estimates of the MLDA increase on alcohol access measures for individuals aged 14 to 17 from ESTUDES. The dependent variables are binary indicators. Controls include age, father's education, mother's education, gender, month of birth, country of birth and month of survey. Estimates on a stacked database where each treated region is compared to regions where the MLDA increase took place 5 years earlier or more. Weights applied. 95% confidence intervals (in brackets) and p-values have been calculated using wild bootstrap. *Mean* includes the counterfactual mean, calculated as the observed mean in treated regions minus the estimated effect of the MLDA.

Table A8: Impact on teenage educational performance – restricted comparison group

	All subjects	Math	Reading	Science
MLDA 18	0.040	0.010	0.068	0.035
	[-0.01,0.13]	[-0.03,0.10]	[-0.06,0.22]	[0.01,0.07]
Mean	0.23	0.21	0.20	0.24
p-value	0.08	0.52	0.10	0.02
N	500,414	500,414	500,414	500,414

Notes: Estimates of the MLDA increase on PISA exam results. Each score is the average across all plausible values provided in the data standardised to mean 0 and standard deviation 1. Pupils aged 15.2 to 16.4. Regions where PISA exams took place at the same time as final high school exams excluded. Controls include age, father's education, mother's education, gender, month of birth, immigrant status and socioeconomic status. Estimates on a stacked database where each treated region is compared to regions where the MLDA increase took place 5 years earlier or more. Weights applied. 95% confidence intervals (in brackets) and p-values have been calculated using wild bootstrap. *Mean* includes the counterfactual mean, calculated as the observed mean in treated regions minus the estimated effect of the MLDA.

Table A9: Impact on teenage drinking – Poisson Quasi-Maximum Likelihood Estimation of count variables

	Drinking alcohol days	Getting drunk days	Binge drinking days
MLDA 18	-0.09	-0.18	-0.17
	[-0.21,0.02]	[-0.37,0.01]	[-0.29,-0.06]
Mean	2.80	0.61	1.06
p-value	0.11	0.06	0.00
N	239,766	241,407	213,332

Notes: Estimates of the MLDA increase in Castile and Leon, Galicia, Asturias and the Balearic Islands on self-reported drinking measures last month for individuals aged 14 to 17. Controls include age, father's education, mother's education, gender, month of birth, country of birth and month of survey. 95% confidence intervals (in brackets) and p-values have been calculated using bootstrap. *Mean* includes the counterfactual mean, calculated as the observed mean in treated regions minus the estimated effect of the MLDA.