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ABSTRACT

Minimum Legal Drinking Age and the Social Gradient in Binge Drinking*

Low minimum legal drinking ages (MLDAs), as prevalent in many European countries, are severely understudied. We use rich survey and administrative data to estimate the impact of the Austrian MLDA of 16 on teenage drinking behavior and morbidity. Regression discontinuity estimates show that legal access to alcohol increases the frequency and intensity of drinking, which results in more hospital admissions due to alcohol intoxication. The effects are stronger for boys and teenagers with low socioeconomic background. The policy's impact is not driven by access. Data from an annual large-scale field study shows that about 25 percent of all retailers sell even hard liquor to underage customers. In line with this, perceived access to alcohol is very high and hardly changes at the MLDA. However, teenagers consider binge drinking at weekends to be less harmful after gaining legal access.

JEL Classification:	I12, I18, H75, J13
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I. Introduction

Europe has the highest level of alcohol consumption in the world. In 2016, more than 10.3 million disability-adjusted life-years were lost due to alcohol abuse in the EU+ (European Union member states, Norway and Switzerland) (World Health Organization, 2019). More than 10 percent of all deaths in Europe are attributable to alcohol abuse (World Health Organization, 2018). The comparatively low minimum legal drinking ages (MLDA) in Europe are often considered as one explanation for the higher prevalence of teenage binge drinking relative to the US. While most of the European countries uphold an MLDA of 18 years, some countries, such as Austria, Belgium, Denmark, Germany, or Switzerland, allow on- and off-premise sales of beer and wine to teenagers as young as 16 years. Critics of a low MLDA argue that an early onset of drinking can have detrimental long-run effects on both physical and mental health, since the developing brain is particularly vulnerable to the impact of alcohol (Ewing *et al.*, 2014). In contrast, proponents argue that allowing teenagers the experience of drinking at an earlier age results in more responsible alcohol consumption.

Over the last decade, we have witnessed rising interest in the impact of MLDA regulation on risky behavior and health. Many studies use survey data to investigate the impact of the MLDA on alcohol and drug consumption (Carpenter *et al.*, 2007; Crost and Guerrero, 2012; Yörük and Yörük, 2011; Crost and Rees, 2013; Deza, 2015). Studies that use administrative data typically focus on the impact of the MLDA on mortality, in particular fatal accidents (Dee, 1999; Carpenter and Dobkin, 2009; Carpenter *et al.*, 2016), but also crime (Carpenter and Dobkin, 2015; Hansen and Waddell, 2018; Chalfin *et al.*, 2019) or schooling (Carrell *et al.*, 2011; Lindo *et al.*, 2013). Due to data constraints, only few studies were able to investigate morbidity effects of the MLDA, although these effects constitute a major cost factor in health systems (Carpenter and Dobkin, 2017; Callaghan *et al.*, 2013). Moreover, the existing evidence on the effects of MLDA regulation stems almost exclusively from the U.S. or Canada, where the MLDA is considerably higher than in Europe.[1] Finally, even though MLDA regulation might have varying impacts across the socioeconomic distribution, little is known about these potentially heterogeneous effects. This is not least due to a lack of access to administrative data on teenage health outcomes that can be linked to data on parental characteristics.

We apply a regression discontinuity (RD) design to comprehensively study the impact of a particularly low MLDA of 16 years in Austria, a country with very high alcohol consumption by international comparison. We start with rich survey data from the *European School Survey Project on Alcohol and Other Drugs* (ESPAD) to understand the impact of the MLDA on teenagers' self-reported drinking behavior. The detailed information provided in the survey

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[1]The notable exceptions analyze the impact of a decrease in the MLDA from 20 to 18 in New Zealand (Boes and Stillman, 2013, 2017; Conover and Scrimgeour, 2013) and the impact of an MLDA of 18 in Australia (Lindo *et al.*, 2016) on hospitalizations and mortality. Only recently, the first papers appeared that investigate MLDA effects in European countries with a low MLDA of 16 (Datta-Gupta and Nilsson, 2020; Dehos, 2020; Kamalow and Siedler, 2019).

data allows us to go beyond average effects, and estimate MLDA effects along the drinking distribution. In a next step, we use administrative data from a universal healthcare provider to investigate the effects of the MLDA on alcohol-related hospitalizations. In all analyses, we study heterogeneous effects by socioeconomic background and gender. In a final step, we provide evidence on the mechanisms underlying these effects. In particular, we ask to which degree the MLDA restricts access to alcohol. To this end, we obtained data from an annual large-scale field study, which sends underage test buyers to retailers in an attempt to buy alcohol. Additionally, we examine information provided in the ESPAD on teenagers' perceived access to alcohol as well as attitudes towards alcohol.

Our results show that upon gaining legal access to alcohol, teenagers significantly increase the frequency and intensity of drinking, which results in negative health effects. The probability of drinking alcohol on at least one day during the last week increases by around 12 percentage points, the probability of drinking at least two days increases by 9 percentage points, and the probability of drinking on at least three days increases by 4 percentage points. In terms of quantities, we find that the probability of consuming at least 180 to 240 grams of pure alcohol (which corresponds to an extra nine to twelve pints of beer) during the last week increases by 10 percentage points. The MLDA effects are larger for boys and for teenagers with low socioeconomic background. This change in drinking behavior results in negative health effects. We find that the probability of being hospitalized with an alcohol intoxication increases by 0.036 percentage points or 42 percent at the MLDA cutoff. Again, these effects are larger for boys and for teenagers with low socioeconomic background. Interestingly, these socioeconomic gradients are not visible prior to gaining legal access to alcohol. Instead, they emerge at the MLDA cutoff, become statistically significant and economically meaningful, and then remain visible until the age of 22. These results are robust to using different functional forms and kernel weighting techniques. Teenagers from families with a history of severe alcohol abuse are a notable exception. For this high risk group, MLDA is not effective at all.

Investigating the mechanisms behind these effects, we show that MLDA legislation does not severely impede teenagers' access to alcohol. The mystery shopping data indicate that about 25 percent of all retailers sell even hard liquor to underage customers. When asking teenagers how difficult it is to get access to alcohol, the MLDA legislation seems to be even less binding: Roughly 85 percent of teenagers below 16 years of age perceive access to non-distilled alcohol as easy. This set of results suggests that the negative impact of MDLA legislation on alcohol consumption can hardly be fully explained by restrictions to alcohol access. Interestingly, the share of teenagers who perceive regular heavy drinking at weekends as risky significantly declines from 70 to 60 percent at the MLDA cutoff too. We argue that this might reflect a normative impact of the legislation. Teenagers below 16 years of age may simply feel obliged to obey and abstain from drinking despite its availability. Once drinking becomes legally allowed and also socially more accepted, teenagers change their attitudes towards alcohol and drink more frequently and more intensely. Our findings do not support the idea that lower MLDAs

help teenagers to ease into drinking and to consume alcohol responsibly (Wechsler and Nelson, 2006).

Most closely related to our work is a paper by Datta-Gupta and Nilsson (2020). They show that the introduction of a MLDA of 15 in Denmark and the following increases to 16 and 18 (for hard liquor) reduced injuries but had no significant impact on alcohol intoxication. The authors find different responses for boys and girls, but no consistent differences across socioeconomic groups. An important difference between Datta-Gupta and Nilsson (2020) and our setting is that alcohol is very cheap in Austria, in particular in comparison to Denmark and the other Scandinavian countries, which should be particularly relevant for the consumption decision of teenagers whose budget is limited. Moreover, Datta-Gupta and Nilsson (2020) use a difference-in-differences setup to estimate the impact of changes in the MLDA. The treatment group is under 15 year olds for their first reform (i.e., the introduction of a MLDA), 15–16 year olds for their second reform (i.e., the *increase* of the MLDA), and 16–18 year olds for their third reform (i.e., the increase of the MLDA for hard liquor). In contrast, we apply an RD design to estimate the impact of gaining access to alcohol for teenagers after they turned 16. Thus, we exploit a different margin of the MLDA treatment. Finally, while Datta-Gupta and Nilsson (2020) use rich administrative data, we combine administrative data with survey data and data from a field study to also investigate the channels behind the effects.

The remainder of the paper is structured as follows. Section II provides background information on alcohol consumption and MLDA laws in Austria. Section III introduces the survey and administrative data used, while Section IV presents the RD design that we apply to estimate the causal effects of the MLDA on drinking and health. In Section V, we present the empirical results. In Section VI, we compare adolescent drinking behavior in Austria and the U.S. This helps to relate our results to the existing US-dominated literature. Section VII concludes the paper.

II. Background

II.1. Alcohol consumption in Austria

Over the past 60 years, alcohol consumption has markedly converged across countries. The left panel of Figure 1 plots per capita consumption of pure alcohol in liters for several Western industrialized countries from 1960 to 2014.[2] While France and Italy started at very high levels, they have substantially reduced alcohol consumption between 1960 and 2014. Great Britain and the U.S. on the other hand started at lower levels, but have seen increasing consumption over this period.

To better understand the intensity of drinking among people who generally drink alcohol, it

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[2]The per capita consumption variable does not exclude children. Consequently, average alcohol consumption levels of adults are clearly higher than depicted here. The data have been collected by Holmes and Anderson (2017).

is worthwhile to investigate patterns of binge drinking. A common measure used to this end is the share of drinkers (15 years and older), who have had at least 60 grams of pure alcohol on at least one occasion during the past 30 days. Note that 60 grams of alcohol correspond to six standard drinks or to roughly half a litre of wine or three pints of beer, respectively. The right panel of Figure 1 shows that the share of people having had a binge drinking incidence during the past month varies substantially across countries.[3] While binge drinking is rather uncommon in New Zealand or Italy, around a quarter of adults in the U.S. experienced at least one heavy drinking incidence during the past month. In Great Britain, even every third person who drinks alcohol had at least one binge drinking incidence during the past month.

Figure 1 shows that Austria stands out in both average alcohol consumption and the occurrence of binge drinking among regular drinkers. In the left panel, we observe that Austria's per capita consumption of pure alcohol was already at a rather high level of 8.7 liters in 1960 and even further increased over the following decades. With a per capita consumption of 10.4 liters in 2014, Austria has a higher alcohol consumption level than any other country depicted in this figure. In the right panel, we see that more than 50 percent of all drinkers aged 15 and older in Austria had at least one binge drinking incidence during the past month. This number is considerably higher than in any other country listed in this figure. These facts make Austria a particularly interesting country to study the impact of a low MLDA on alcohol abuse.

II.2. Austria's MLDA laws

In Austria, legal access to alcohol is regulated by MLDA laws as part of the Law for the Protection of Children and Young People.[4] Before the laws were harmonized in 2019, MLDA varied across the Austrian federal states. Most states permitted teenagers to legally access non-distilled alcohol such as beer and wine at the age of 16, and distilled alcohol at the age of 18.[5] The states of Burgenland, Lower Austria, and Vienna allowed universal legal access to both non-distilled and distilled alcohol at the age of 16. As part of the harmonization process in 2019, the age limits were set to 16 for non-distilled alcohol and 18 for distilled alcohol country-wide.

The state-specific laws also define sanctions in case of non-compliance. The severity of these sanctions vary depending on whether minors, adults, or companies violate the laws.[6] Non-compliance of teenagers is defined as acquiring or consuming alcoholic beverages below the MLDA threshold, or providing other teenagers below this threshold with alcoholic beverages. In case of violation of the law, authorities may require teenagers to participate in an instruction and consultation meeting or to do community service. Moreover, monetary fines for repeated

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[3]The data from 2010 are published by World Health Organization Global Health Observatory (GHO).

[4]Besides the minimum legal drinking age, the law also defines minimum legal ages to acquire tobacco and related products and permitted hours for adolescents of different age.

[5]This gradual access to alcohol depending on its alcohol content can also be found in other European countries such as Belgium, Denmark, Germany, or Sweden (see https://fra.europa.eu/en/publication/2017/mapping-minimum-age-requirements/purchase-consumption-alcohol).

[6]See https://www.oesterreich.gv.at/themen/jugendliche/jugendrechte/6.html

FIGURE 1 — Alcohol consumption: international comparison
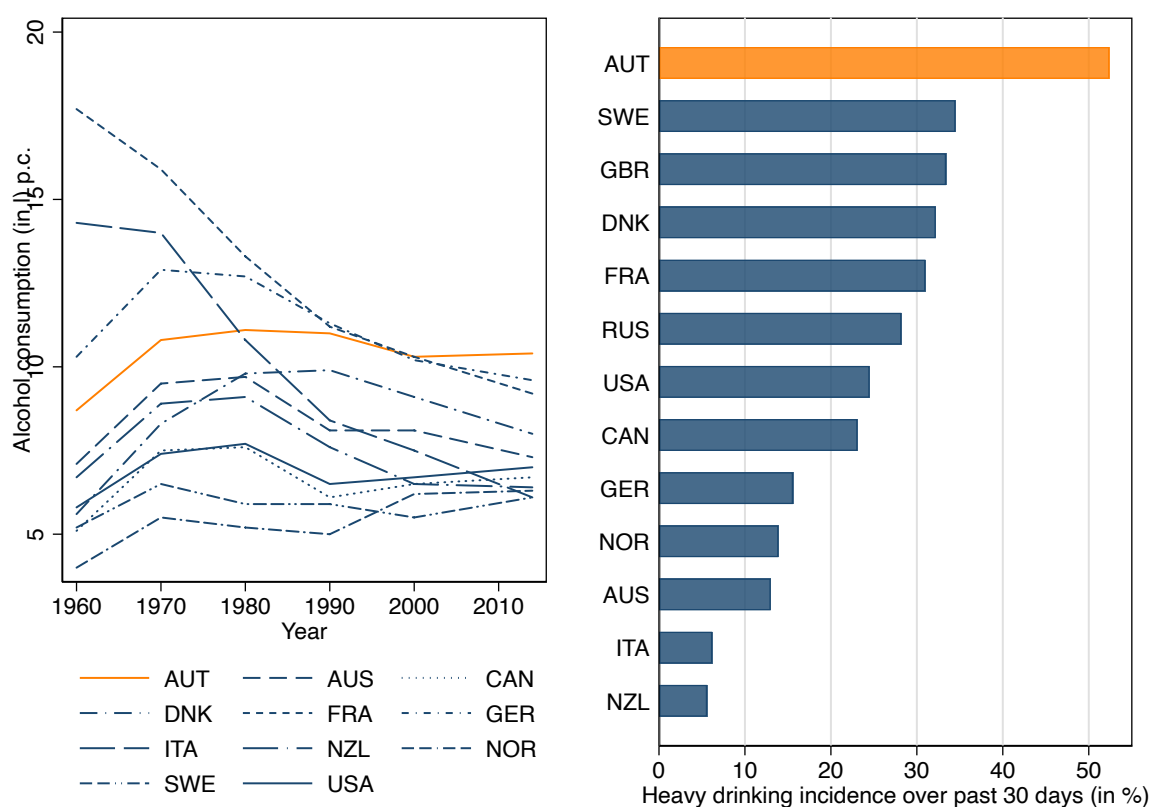
Notes: Our World in Data. The left panel depicts per capita alcohol consumption in liters across countries from 1960 to 2014. The right panel shows the incidence of heavy drinking among adult drinkers in percent over the last 30 days across countries in 2010.

violations of up to Euro 500, or even up to Euro 1,000 can be imposed. Adults may violate the law if they provide teenagers with goods they are not allowed to acquire or consume legally, or if they neglect their obligations as legal guardian or person in charge. Violations are classified as administrative offenses and may incur fines of up to Euro 20,000. In case of non-provision, jail sentences of up tp six weeks can be imposed. Companies, shop owners, and event managers generally face the same sanctions as adults for non-compliance. Moreover, repeated violations of the law must be disclosed to the authorities providing business and event licenses.

III. DATA

III.1. Survey data

To investigate the impact of Austria's MLDA on teenage drinking behavior, we rely on data from the *European School Survey Project on Alcohol and other Drugs* (ESPAD).[7] When ESPAD started in 1995, 20 countries took part in this project that aims at collecting cross-country

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[7]See Guttormsson *et al.* (2016) for more details on the methodology of ESPAD.

TABLE 1 — Summary statistics of the ESPAD data

	All			Age < 16			Age > 16		
	Mean	S.D.	*n*	Mean	S.D.	*n*	Mean	S.D.	*n*
Days drinking (7d)	0.85	1.16	7,289	0.70	1.04	4,191	1.06	1.26	3,098
Grams pure alcohol (7d)	77.66	158.42	7,289	53.77	118.96	4,191	109.98	195.19	3,098
Heavy drinking (30d)	0.53	0.50	7,727	0.45	0.50	4,450	0.62	0.48	3,277
Daily drinking risky	0.64	0.48	7,428	0.63	0.48	4,287	0.66	0.47	3,141
Heavy drinking risky	0.67	0.47	7,306	0.71	0.46	4,210	0.62	0.49	3,096
Easy access non-distilled alc.	0.88	0.33	7,712	0.84	0.37	4,441	0.93	0.25	3,271
Easy access distilled alc.	0.70	0.46	7,706	0.63	0.48	4,436	0.78	0.42	3,270
Age (years)	15.90	0.76	7,748	15.36	0.37	4,462	16.64	0.47	3,286
Female	0.53	0.50	7,748	0.54	0.50	4,462	0.51	0.50	3,286
High SES	0.64	0.48	5,801	0.65	0.48	3,292	0.61	0.49	2,509

Notes: ESPAD 2015, Austria. The table presents summary statistics of under and over 16 year olds. Survey participants that turn 16 in the month of the interview are dropped from the sample.

information on adolescents' substance use. Over the years, the number of participating countries notably increased up to 35 in 2015. ESPAD conducts surveys every four years. For our empirical analysis, we use data from the Austrian country sample of 2015, i.e., from the fifth wave of ESPAD.

Our country sample consists of high school students in grades nine and ten who are born between 1997 and 2001. The survey was conducted via an online questionnaire in Austrian schools between March and July 2015. Since the survey was conducted in schools, only teenagers who attended a school and were present at the day of the survey were observed. Descriptive statistics of the outcome variables and covariates used in the empirical analysis can be found in Table 1. Respondents are on average 16 years old, all are at least 14 and younger than 18 years[8], 53 percent are girls, and 64 percent state that their mother completed at least upper secondary schooling. The latter we use as a proxy for high socioeconomic background. We also have information on the type of school and on the state in which the school is located. Schools and classes within schools can be identified uniquely.

The data set helps us because students are explicitly asked about their drinking behavior, their perception of related risks and harms, and how easy their access is to non-distilled and distilled alcohol. In particular, students state on how many of the last seven days prior to the survey they consumed alcoholic beverages. They also list the quantity and type of alcoholic beverages, from which we can compute grams of pure alcohol consumed during the last seven days. Additionally, students are asked how often they had five or more alcoholic drinks during the last 30 days. We generate a dichotomous variable that indicates whether a student had five or more alcoholic drinks in one occasion at least once during the last 30 days. Students also assess the risk of daily drinking, i.e., having one or more drinks every day, and the risk of heavy drinking at weekends, i.e., having five or more drinks nearly every weekend, by picking one out of four categories (no risk, slight risk, moderate risk, great risk). We create an indicator variable

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[8]See Appendix Figure A.1 for a detailed frequency distribution over age in months.

that takes on the value of one if students select the category "moderate risk" or "great risk", and zero otherwise. Finally, students evaluate how difficult they think it would be for them to get access to non-distilled and distilled alcohol by picking one out of five categories (impossible, very difficult, difficult, rather easy, very easy). We construct an indicator variable equal to unity if they deemed it "rather easy" or "very easy" to obtain the respective type of alcohol, and zero otherwise.

To avoid that students give socially desirable answers and under-report (or exaggerate) drinking, the initiators of ESPAD have made sure that data collection is truly anonymous. This is indeed one of the most important design features, since it is at the very heart of the ESPAD survey to obtain reliable information on teenage drug and alcohol use. The data from Austria were collected via a web survey at school and immediately stored on a central server that could only be accessed by ESPAD's research team. To preserve anonymity, students used anonymous passwords. The teachers were told to explicitly stress the anonymity of data collection. Moreover, teachers were instructed to not walk around in the classroom while the students completed the survey. Anonymity was handled in a satisfactory way in all countries and students did not raise any serious doubts with respect to anonymity issues (Guttormsson *et al.*, 2016). Finally, the survey contains several questions that allow checking for logical consistency, the likelihood of over-reporting, and the likelihood of under-reporting. For Austria, as for most other countries taking part in the ESPAD survey, there is no evidence that under- or over-reporting is a serious issue that might invalidate the results of the survey.[9]

III.2. Administrative data

In addition to the survey data, we use administrative data from the Austrian healthcare system. Austria has a Bismarckian welfare system which provides universal access to high-quality healthcare. Austrian residents have mandatory health insurance administered through nine federal state-specific Regional Health Insurance Funds. We use information from the *Upper Austrian Health Insurance Fund* (UAHIF).[10] The UAHIF covers all private-sector workers, their dependents, and all non-employed residents. It provides insurance for around 1 million people, which represent 75 percent of the Upper Austrian population.[11]

We compile a panel data set for the universe of live births between 1991 and 1995 in Upper Austria. This gives us a sample of 91,208 teenagers, who we observe between the age of 13 and 21. Our panel data set comprises up to 54 entries, one for every month-of-age bin in which the teenager is insured with UAHIF. We observe more than 60 percent of teenagers over the

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[9]The share of students who claim having consumed the dummy drug 'Relevin' is as low as 0.3 percent in the Austrian sample. Moreover, survey respondents are asked whether they would truly report cannabis consumption in the questionnaire if they really consumed it. The share of respondents who would definitely or rather not report drug use is roughly 15 percent; yet, we do not observe any discontinuity in this share at the cutoff age of 16.

[10]Upper Austria is one of nine federal states in Austria and comprises about one sixth of the Austrian population and work force.

[11]The remaining 25 percent are civil servants, self-employed, and distinct occupational groups, such as farmers or public teachers. These groups are insured with other statutory health insurance providers.

TABLE 2 — Summary statistics of the administrative data

	All			Age < 16			Age ≥ 16		
	Mean	S.D.	n	Mean	S.D.	n	Mean	S.D.	n
Prob. alcohol intoxication × 100	0.09	2.92	3,981,294	0.04	2.01	1,315,019	0.11	3.27	2,666,275
Covariates									
Mother age at birth	27.34	4.77	3,981,294	27.27	4.77	1,315,019	27.38	4.77	2,666,275
Girl	0.48	0.50	3,981,294	0.49	0.50	1,315,019	0.48	0.50	2,666,275
High SES	0.69	0.46	3,981,294	0.69	0.46	1,315,019	0.70	0.46	2,666,275

Notes: UAHIF panel. The table presents summary statistics for 91,208 children observed monthly between age 13 and 21. We distinguish between observations from below the age of 16 and from age 16 and above.

entire age range, about three-fourths of teenagers we can track for at least 6 out of 9 years. The main reason for panel attrition is parents switching to an employer in a different federal state or leaving the private sector.

The UAHIF data include detailed information on inpatient and outpatient healthcare services at the individual level. Our main outcome is whether the teenager is hospitalized with an alcohol intoxication. This is indicated by two ICD-10 diagnosis codes: T51 (*'Toxic effect of alcohol'*) and F10.0 (*'Acute intoxication due to use of alcohol'*). Importantly, ICD-10 codes are only recorded for inpatient treatments, which means that we cannot observe alcohol intoxications that had been treated in an ambulatory setting. We note that this may cause our estimates to be biased towards zero, because we only observe more serious cases that require hospitalization. In total, we observe 3,391 intoxications for the teenagers in our data. The unconditional probability that a teenager is hospitalized at least once between age 13 and 21 is 3.2 percent.

Table 2 provides descriptive statistics for our data set. The unconditional probability for a teenager to have an alcohol intoxication in a specific month is 0.09 percent. This corresponds to roughly 62 teenagers per month. Around 48 percent of the sample are girls, the mothers' average age at birth is 27.3 years, and 69 percent of mothers have high socioeconomic status. The latter is determined based on the mother's highest completed education. We define low socioeconomic status as having only compulsory education.

IV. ESTIMATION STRATEGY

To estimate the causal effect of Austria's low MLDA on teenage drinking behavior and health, we employ a sharp RD design. The estimation equation can be expressed as follows:

$$Y_i = \tau D_i + \sum_{k=1}^{K} \alpha_k (age_i - 16)^k + \gamma_k D_i (age_i - 16)^k + \mathbf{x}_i \boldsymbol{\beta} + \varepsilon_i, \tag{1}$$

where Y_i is the outcome variable of teenager i, age_i is i's age in months, which is normalized to zero at the age cutoff, and D_i is a dichotomous variable equal to one if teenager i is older than 16 years, and zero else. By including the interaction of age_i and D_i, we allow the association of the running variable age_i and Y_i to be different to the left and to the right of the age cutoff.

Finally, $\mathbf{x}_i$ comprises a set of covariates specified in the results section, and ε_i is a mean zero error term. Standard errors are clustered at the age (in months) level.

The parameter $\hat{\tau}$ identifies the causal effect of the low MLDA under the assumption that treatment status jumps deterministically and discretely at the threshold of 16 years, whereas all other determinants of Y_i run smoothly across the age threshold. The MLDA laws clearly state that in all Austrian states teenagers gain legal access to non-distilled alcohol at their 16th birthday, i.e., treatment jumps deterministically and discretely at age 16. However, we have to make sure that we assign adolescents correctly to the left or to the right of the MLDA threshold. This means that we need to precisely measure the teenagers' age. The administrative data allow us to do so since we have information on the exact date of birth and the exact date of any hospitalization with acute alcohol intoxication for all adolescents. Yet, in the ESPAD survey data, we only know the participants' year and month of birth. To avoid wrong treatment assignment, we drop all teenagers who turn 16 at some (unknown) day in the month of the ESPAD interview.

Lee and Lemieux (2010) discuss RD settings like ours that exploit discontinuities in age with inevitable treatment. Three points are worth discussing. First, since all individuals get treated at age 16, our RD approach does not allow for estimating long-run effects of the MLDA. Second, since we observe the same individuals over time in our administrative panel data set, any balance tests would not be meaningful. Third, and probably most importantly, we would overestimate the effect of gaining legal access to alcohol if teenagers systematically reduced drinking in the last weeks prior to their 16th birthday. As we will show later, we do not find any evidence for such behavior. Fourth, there are no other regulations (other than MLDA) which can cause a discontinuity in alcohol-related outcomes. The legal age to drive a car is 18, and to drive a moped 15. Compulsory schooling ends after nine grades, when students are about 15 years of age. Smoking was legal at 16 during our sample period (now 18). However, based on ESPAD data we do not find any evidence for an increase in smoking at age 16, neither at the extensive nor at the intensive margin. Therefore, we are confident that we identify an unbiased effect of the MLDA on alcohol consumption and immediate health consequences in our RD approach.

V. Results

V.1. Effects on drinking behavior

In a first step, we investigate by how much the frequency of consuming alcohol changes when gaining legal access at age 16. To this end, we make use of detailed information provided by teenagers in the ESPAD survey. In particular, respondents report on how many of the last seven days they drank alcohol. We use this information as the outcome variable in our RD model. Table 3 shows the results from this analysis.

In column (1) of Table 3, we start with a basic RD linear spline specification and find that

TABLE 3 — Effects on number of days drinking during the last 7 days

	Lin.Spline (1)	Quad.Spline (2)	Quad.Spline (3)	Quad.Spline (4)
Discontinuity	0.276***	0.270***	0.276***	0.273***
	(0.047)	(0.068)	(0.068)	(0.069)
Sex	No	No	Yes	Yes
Maternal education	No	No	No	Yes
Number of observations	7,289	7,289	7,289	7,289
Outcome mean	0.852	0.852	0.852	0.852

Notes: ESPAD 2015, Austria. The table shows RD estimates of the discontinuous shift in the number of days drinking in the last 7 days at age 16. Respondents who turn 16 in the month of the survey are dropped. *Maternal Education* includes a set of indicators for the mother's highest completed education. Standard errors are clustered at the age (in months) level and shown in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

the number of days teenagers drank alcohol in the last week increases by 0.276 when gaining legal access to alcohol. This effect is statistically significant and economically meaningful. While the average number of days a week teenagers in our sample drank alcohol is 0.852, this number is 0.712 for teenagers younger than 16 but older than 15. Thus, the estimated coefficient measured at the cutoff age of 16 suggests an increase in alcohol consumption days by roughly 39 percent, on average. When we use a quadratic spline instead of a linear spline specification, the estimates stay virtually identical (column 2). Moreover, the effect is robust to controlling for the teenagers' gender (column 3) and their mothers' education (column 4).

In Figure 2, we investigate the effects along the drinking distribution and inspect effect heterogeneities by gender and socioeconomic status. In the upper left panel, we plot the average number of days during the last week teenagers drank alcohol by age in months. The resulting discontinuity at the cutoff age of 16 provides a graphical depiction of the average effect identified in the RD estimation of Table 3. This graph also provides clear evidence that the jump at the cutoff is not just a birthday party effect. Indeed, the notable and discontinuous level shift in drinking is persistent for many months. In the remaining panels, we report estimates from RD linear spline distribution regressions. In the upper right panel, we find that the probability of not having consumed alcohol on a single day during the last week decreases by roughly 12 percentage points after gaining legal access to alcohol. At the same time, it becomes evident that the effect is not just driven by teenagers now drinking once a week. Rather, we find that the probability of drinking on at least two out of the last seven days significantly increases by around 9 percentage points, while the probability of drinking on at least three out of the last seven days still significantly increases by around 4 percentage points.

The lower two panels of Figure 2 depict these RD distribution regression effects by gender and socioeconomic status. If we focus on a dichotomous variable that only measures whether teenagers consumed alcohol or not during the last seven days, we hardly find any difference between males and females. However, once we inspect effects along the drinking frequency dis-

tribution, we find that gaining legal access to alcohol at age 16 induces boys to drink more often than girls. For example, while the probability of having drunk alcohol on at least two (three) of the last seven days increases by roughly 12 (7) percentage points for boys, it increases by only 6 (3) percentage points for girls. The differences by socioeconomic status are less pronounced than the differences by gender. If at all, it seems that the effect of having drunk alcohol on at least one out the last seven days is slightly larger for low than for high socioeconomic status teenagers. These differences diminish as we move up the drinking intensity distribution.

FIGURE 2 — Effect on number of days drinking during the last 7 days
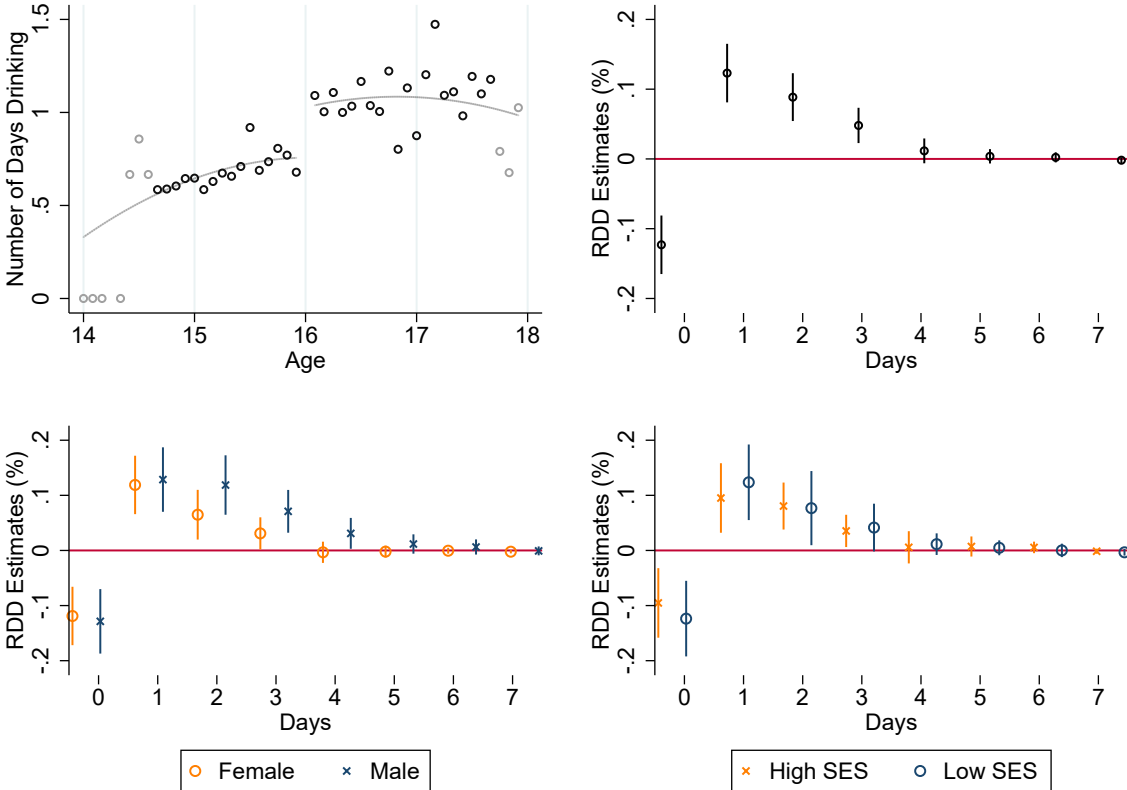
Notes: ESPAD 2015, Austria. The upper left panel plots the average number of days drinking during the last 7 days by age (in months) bins. Respondents who turn 16 in the month of the interview are dropped. Grey circles indicate that the number of observations from the respective age (in months) bin is in the lower quintile of the frequency distribution. The upper right panel shows RD estimates of the effects of the MLDA on $Pr(Frequency \geq X)$ with X being the respective number of days. The bottom left panel shows RD estimates of the effects on $Pr(Frequency \geq X)$ by gender. The bottom right panel shows RD estimates of the effects on $Pr(Frequency \geq X)$ by socioeconomic status. All regressions include linear age (in months) trends that might be different to the left and to the right of the cutoff (linear spline). Standard errors are clustered at the age (in months) level. The whiskers indicate 95 percent confidence intervals.

Apart from investigating the frequency of drinking, we also look at the quantity of alcohol consumed by teenager over the last seven days. Survey respondents state the number and types of drinks they had over the last seven days. From this information, we compute how many grams of pure alcohol was consumed during this period. In the upper left panel of Figure 3,

we plot the average grams consumed by age in months. We observe a clear and discontinuous jump right at age 16. When gaining legal access, the consumption of pure alcohol increases by around 50 grams, which corresponds to an increase of 90 percent compared to the pre-16 level of 55 grams. These positive effects appear along the whole drinking intensity distribution as can be seen in the upper right panel of Figure 3. For example, the probability of consuming at least 180 to 240 grams of pure alcohol (which corresponds to an extra nine to twelve pints of beer) during the last seven days significantly increases by 10 percentage points. If we just look at a simple indicator variable that is one if no alcohol at all was consumed, and zero if any alcohol was consumed, we do not detect any differences between boys and girls or between high and low socioeconomic background teenagers. However, if we inspect effects across the whole distribution of grams of pure alcohol, a different pattern emerges, as can be seen in the lower two panels of Figure 3. For consumption levels of 120 to 240 grams of alcohol and for some very high consumption level categories, the effects are larger for boys than for girls. For consumption levels of 20 to 480 grams of alcohol, the effects are larger for teenagers with low socioeconomic background than for teenagers with high socioeconomic background.

To learn more about the impact of the MLDA law on the intensity of drinking, we now look at reported incidences of binge drinking. ESPAD participants state how many times they had five or more alcoholic drinks on one occasion during the last 30 days. The upper left panel of Figure 4 suggests some increase in the incidence of binge drinking at the MLDA cutoff. This is supported by the RD estimates presented in the upper right panel. We find that the likelihood of not having had a single binge drinking occasion during the last 30 days significantly decreases by 10 percentage points once teenagers gain legal access to alcohol. The upper right panel shows that the probability of having had at least one or two occasions significantly increases by 10 percentage points, while the probability of having had at least three to five significantly increases by 8 percentage points. We even find somewhat smaller yet still significant effects for at least six to nine binge drinking occasions. The graph in the lower left panel shows that boys and girls do not differ in the MLDA effect of having at least one binge drinking occasion in the last 30 days. However, legal access to alcohol induces boys to clearly more often binge drink than girls. The probability of at least three to five binge drinking occasions significantly increases by 10 percentage points for boys but only by 5 percentage points for girls. The heterogeneity with respect to socioeconomic background is somewhat less clear as can be seen in the lower right panel of Figure 4.

Although the survey data allow us to inspect interesting aspects of teenage drinking behavior, they also come with some drawbacks. In particular, teenagers might under-report alcohol consumption at ages younger than 16, where buying and consuming any kind of alcohol is illegal. At the same time, they might boast and over-report alcohol consumption at ages above 16. As mentioned before, however, the ESPAD initiators took great care that the survey was conducted in a truly anonymous way. Since we do not have any evidence for under- or over-reporting from consistency questions that are included in the survey, we cannot fully

FIGURE 3 — Effects on grams of pure alcohol consumed during the last 7 days
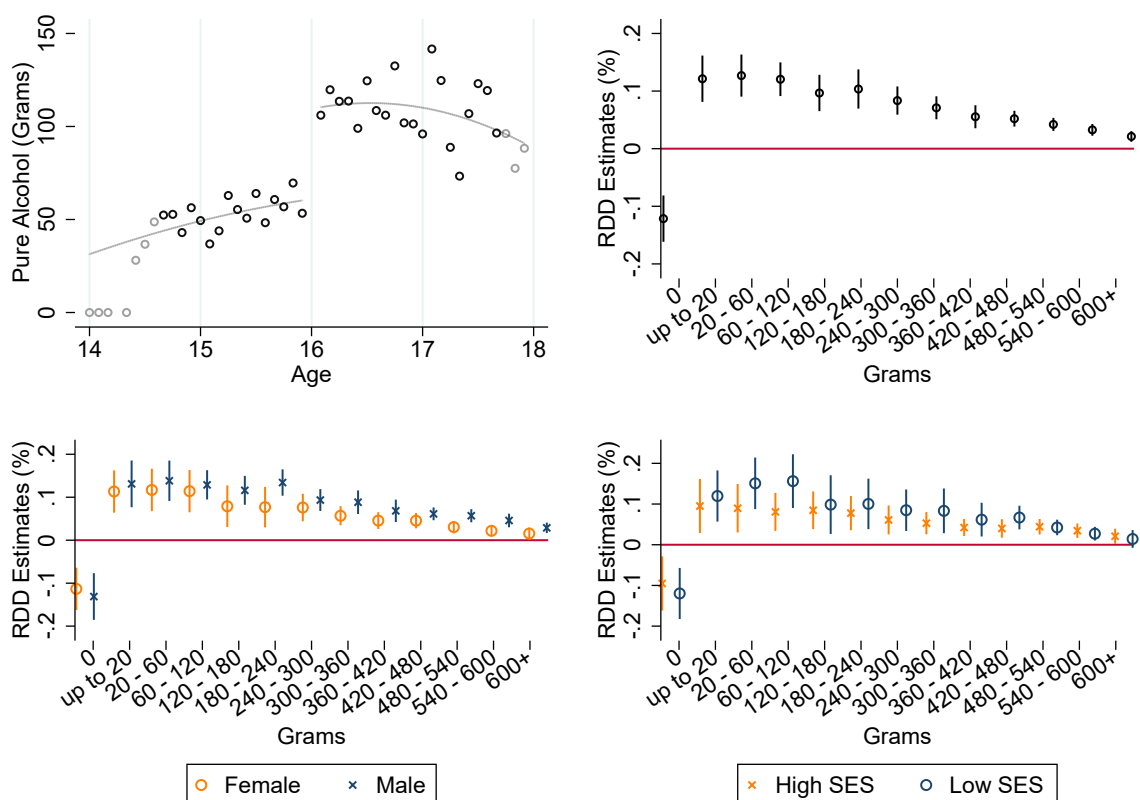
Notes: ESPAD 2015, Austria. The upper left panel plots the average grams of pure alcohol consumed during the last 7 days by age (in months) bins. Respondents who turn 16 in the month of the interview are dropped. Grey circles indicate that the number of observations from the respective age (in months) bin is in the lower quintile of the frequency distribution. The upper right panel shows RD estimates of the effects of the MLDA on $Pr(Quantity \geq X)$ with X being the respective category of the amount of pure alcohol in grams. The bottom left panel shows RD estimates of the effects on $Pr(Quantity \geq X)$ by gender. The bottom right panel shows RD estimates of the effects on $Pr(Quantity \geq X)$ by socioeconomic status. All regressions include linear age (in months) trends that might be different to the left and to the right of the cutoff (linear spline). Standard errors are clustered at the age (in months) level. The whiskers indicate 95 percent confidence intervals.

exclude the possibility of under- or over-reporting. In particular, teenagers might not correctly remember their drinking behavior in the last seven or or even thirty days. This recall bias might systematically differ between treatment and control group if more students under the age of 16 do not drink alcohol at all. To circumvent these problems, we now use administrative data on hospitalizations due to alcohol intoxication. This morbidity variable is surely a rather drastic and rare health consequence of alcohol consumption — around one in thousand teenagers is admitted to hospital each month due to alcohol intoxication. However, it is also a relevant and immediate outcome of alcohol abuse and less prone to biases due to misreporting or false recalling.

FIGURE 4 — Effects on binge drinking during the last 30 days
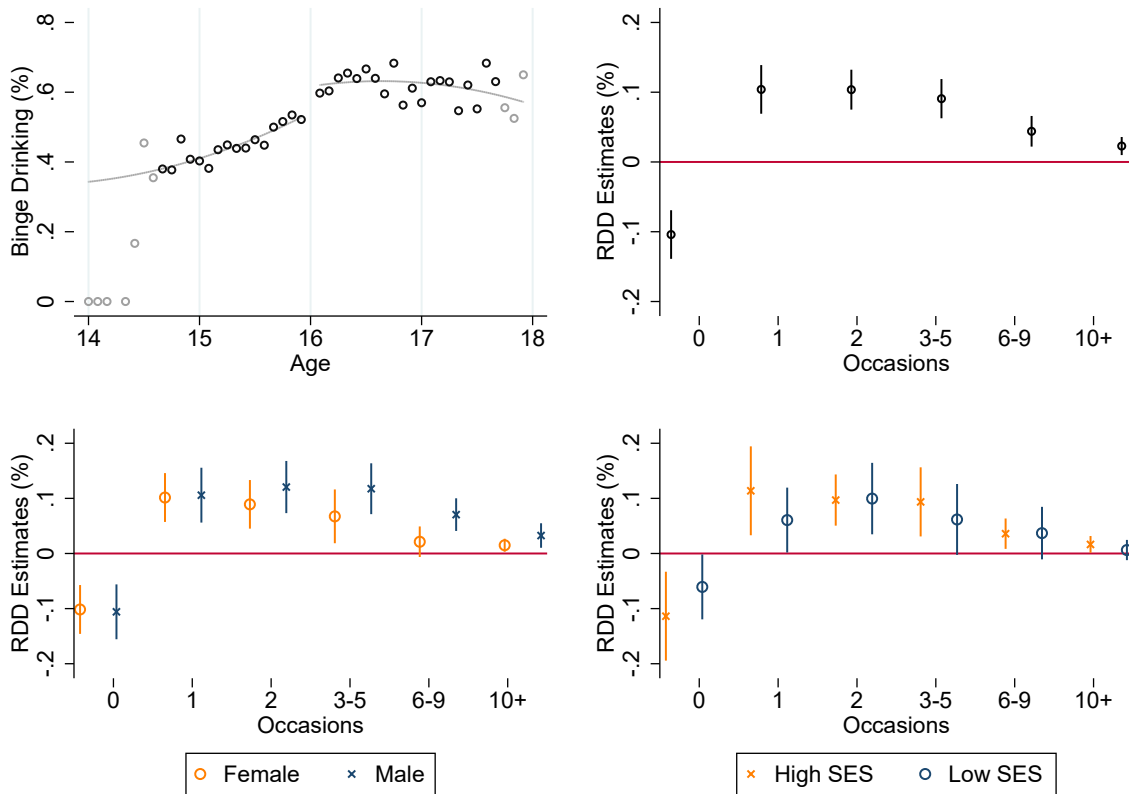
Notes: ESPAD 2015, Austria. The upper left panel plots the share of respondents who report any incidence of binge drinking (five or more drinks in one single occasion) during the last 30 days by age (in months) bins. Respondents who turn 16 in the month of the interview are dropped. Grey circles indicate that the number of observations from the respective age (in months) bin is in the lower quintile of the frequency distribution. The upper right panel shows RD estimates of the effects of the MLDA on $Pr(Frequency \geq X)$ with X being the respective category of the number of binge drinking occasions. The bottom left panel shows RD estimates of the effects on $Pr(Frequency \geq X)$ by gender. The bottom right panel shows RD estimates of the effects on $Pr(Frequency \geq X)$ by socioeconomic status. All regressions include linear age (in months) trends that might be different to the left and to the right of the cutoff (linear spline). Standard errors are clustered at the age (in months) level. The whiskers indicate 95 percent confidence intervals.

V.2. Effects on hospitalizations due to alcohol intoxication

V.2.1. Main results

Using the administrative data from Upper Austria, we start with a simple graphical depiction of probabilities of being hospitalized with an alcohol intoxication by bimonthly age bins. The probabilities are computed by dividing the number of hospitalizations due to alcohol intoxication at a given age by the population of teenagers at a given age in Upper Austria. For representational reasons, these probabilities are multiplied by 100 in Figure 5. We identify a clear discontinuity right at the cutoff age of 16 at which teenagers gain legal access to non-distilled alcohol. This causes the probability of being hospitalized to jump by roughly 0.04 percentage points. Again, the data clearly show that the level shift in hospitalizations due to alcohol

FIGURE 5 — Probability of being hospitalized with an alcohol intoxication
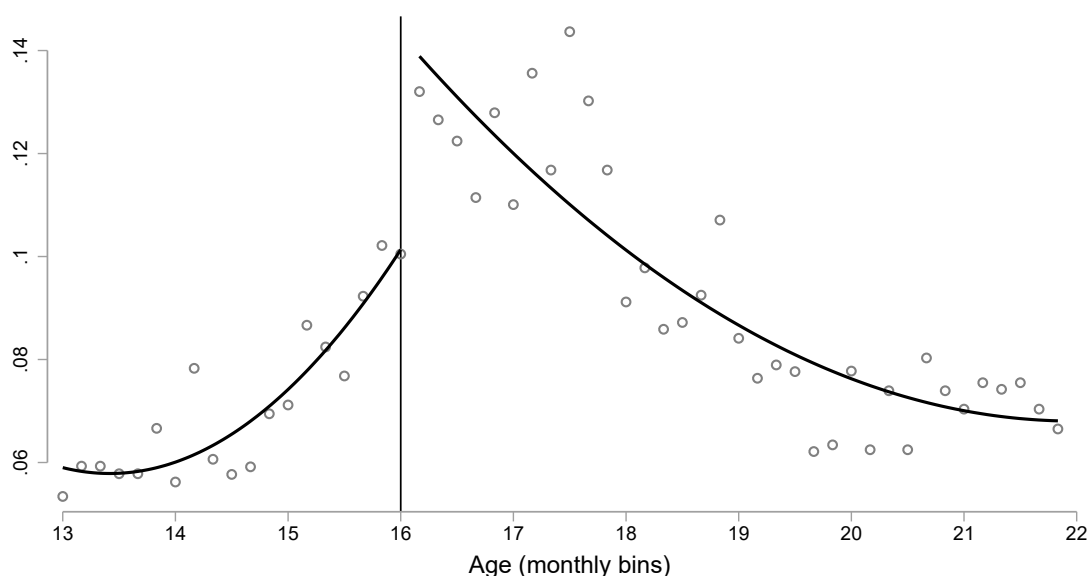
Notes: UAHIF panel. This graph plots mean probabilities of being hospitalized with an alcohol intoxication in a given bi-monthly age bin. Probabilities are adjusted for child sex and year fixed effects and multiplied by 100 to improve readability.

intoxication is not just a birthday party effect, but persists for many months.[12]

To inspect the statistical significance of this first result, we run basic RD regressions as described in Equation (1) and use hospital admission due to alcohol intoxication as an outcome variable. In column (1) of Table 4, we confirm that gaining legal access to alcohol at age 16 increases the probability of being hospitalized with an alcohol intoxication by 0.036 percentage points. This corresponds to a statistically significant and economically meaningful increase of 42 percent. If we distinguish effects by gender, we find that the effect for boys (column 3) is highly significant, and more than two times larger than the marginally significant effect for girls (column 2). At the same time, the discontinuous increase of being hospitalized with an alcohol intoxication is larger for teenagers with low socioeconomic background (column 4) than for those with high socioeconomic background (column 5). Thus, these analyses based on administrative data confirm the drinking behavior pattern we saw in the ESPAD survey data. Particularly boys and low socioeconomic background teenagers react to gaining legal access to alcohol by increasing the frequency and intensity of alcohol consumption, which results in an increased probability of being hospitalized with an alcohol intoxication.

In a next step, we inspect the socioeconomic gradient in alcohol intoxications in more detail. Figure 6 shows the discontinuous jump in alcohol intoxications graphically. We plot gender and year fixed effect-adjusted probabilities of being admitted to hospital by socioeconomic status for each age bin. We observe a slightly increasing age trend in the probability of alcohol intoxica-

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[12]Note that the hospital staff does not have any incentives to hide alcohol intoxications of underage children; they are for example not required to report these intoxications to the police. Thus, the effects cannot driven by misreporting of diagnoses.

TABLE 4 — Effects on the probability of being hospitalized with an alcohol intoxication

	All (1)	Girls (2)	Boys (3)	Low SES (4)	High SES (5)
Discontinuity	0.036***	0.023*	0.048***	0.042**	0.033***
	(0.009)	(0.01)	(0.02)	(0.02)	(0.01)
Sex	Yes	No	No	Yes	Yes
Age at birth fixed effects	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Number of observations	3,981,294	1,922,550	2,058,744	1,219,008	2,762,286
Outcome mean	0.085	0.061	0.108	0.103	0.077

Notes: UAHIF panel. Estimates for the discontinuous shift in the probability of having an alcohol intoxication at age 16. All regressions are based on a monthly age-bin panel and includes quadratic trends that might be different to the left and to the right of the cutoff (quadratic spline). The RD coefficients are multiplied by 100 to improve readability. Standard errors are clustered at the age (in months) level and shown in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

FIGURE 6 — Probability of being hospitalized with an alcohol intoxication by socioeconomic status
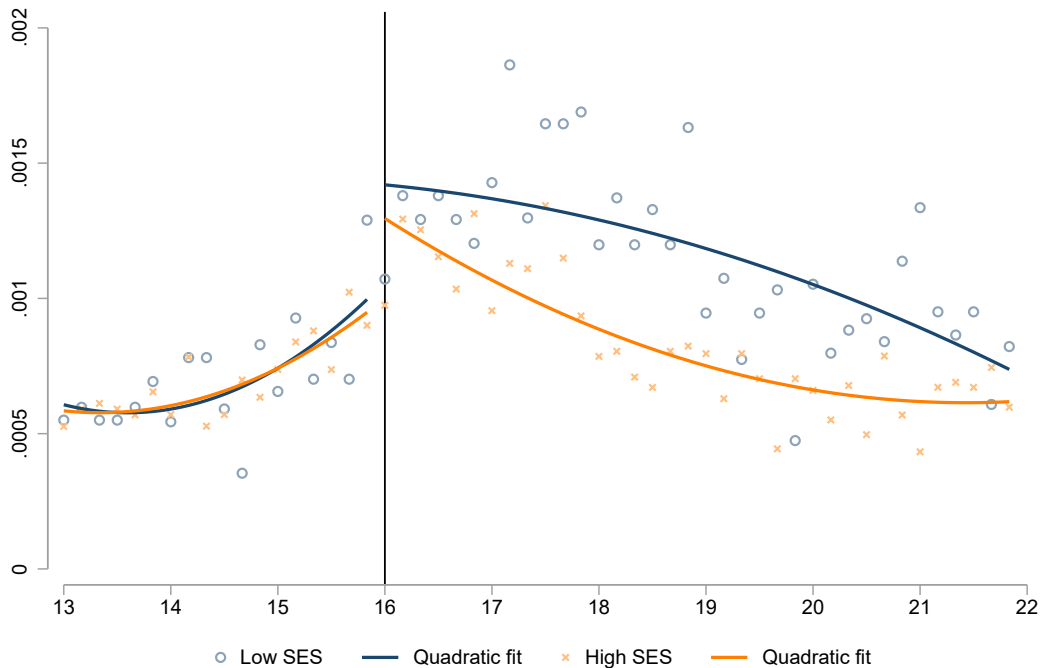
Notes: UAHIF panel. Mean probabilities of being hospitalized with an alcohol intoxication in a given bi-monthly age bin by socioeconomic status. Probabilities are adjusted for child sex and year fixed effects and multiplied by 100 to improve readability.

tion that is parallel for teenagers with high and low socioeconomic background. At the MLDA cutoff, the discontinuous jump is larger for low socioeconomic background teenagers than for high socioeconomic background teenagers (as we already know from Table 4). Strikingly, this difference by socioeconomic background that emerges at the age of 16 remains observable until the age of 22.

Table 5 tests whether the age-specific socioeconomic differences in the probabilities of be-

TABLE 5 — *t*-tests for socioeconomic differences in alcohol intoxication by age

	Sample means by SES		Tests for difference in means		
	Low SES	High SES	Diff.	*t*-statistic	*p*-value
	(1)	(2)	(3)	(4)	(5)
(a) Non-treated, age range					
[13, 14)	0.013	0.011	0.003	0.78	0.437
[14, 15)	0.034	0.029	0.005	0.76	0.445
[15, 16)	0.069	0.067	0.003	0.30	0.764
(b) Treated, age range					
[16, 17)	0.126	0.113	0.012	1.12	0.264
[17, 18)	0.173	0.122	0.052	4.30	0.000***
[18, 19)	0.155	0.097	0.058	5.30	0.000***
[19, 20)	0.113	0.090	0.023	2.27	0.023**
[20, 21)	0.120	0.085	0.035	3.55	0.000***
[21, 22)	0.104	0.072	0.033	3.59	0.000***

Notes: UAHIF panel. This table reports piece-wise *t*-tests for differences in the probability of having an alcohol intoxication along the child age distribution. Intoxication probabilities are multiplied by 100 to improve readability. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

ing hospitalized with alcohol intoxication are statistically significant. As we saw in Figure 6, these differences are small and far from conventional significance levels below the age of 16. Once the MLDA is reached, a difference between socioeconomic groups emerges, becomes highly significant at age 17, and stays statistically significant and of meaningful size until age 22. At age 22, the probability of being hospitalized with alcohol intoxication is 0.104 percent for teenagers with low socioeconomic background and 0.072 percent for teenagers with high socioeconomic background. Thus, the likelihood of being hospitalized with an alcohol intoxication is more than 40 percent higher for teenagers with low than for those with high socioeconomic background.

Figure 7 tests the robustness of the results across four different specifications: a) linear spline regressions, b) quadratic spline regressions, c) local linear regressions using uniform kernel weighting, and d) local linear regressions using triangular kernel weighting. As can easily be seen our findings do not depend on a single specification but are robust to specification changes.

FIGURE 7 — Robustness across different RD specifications
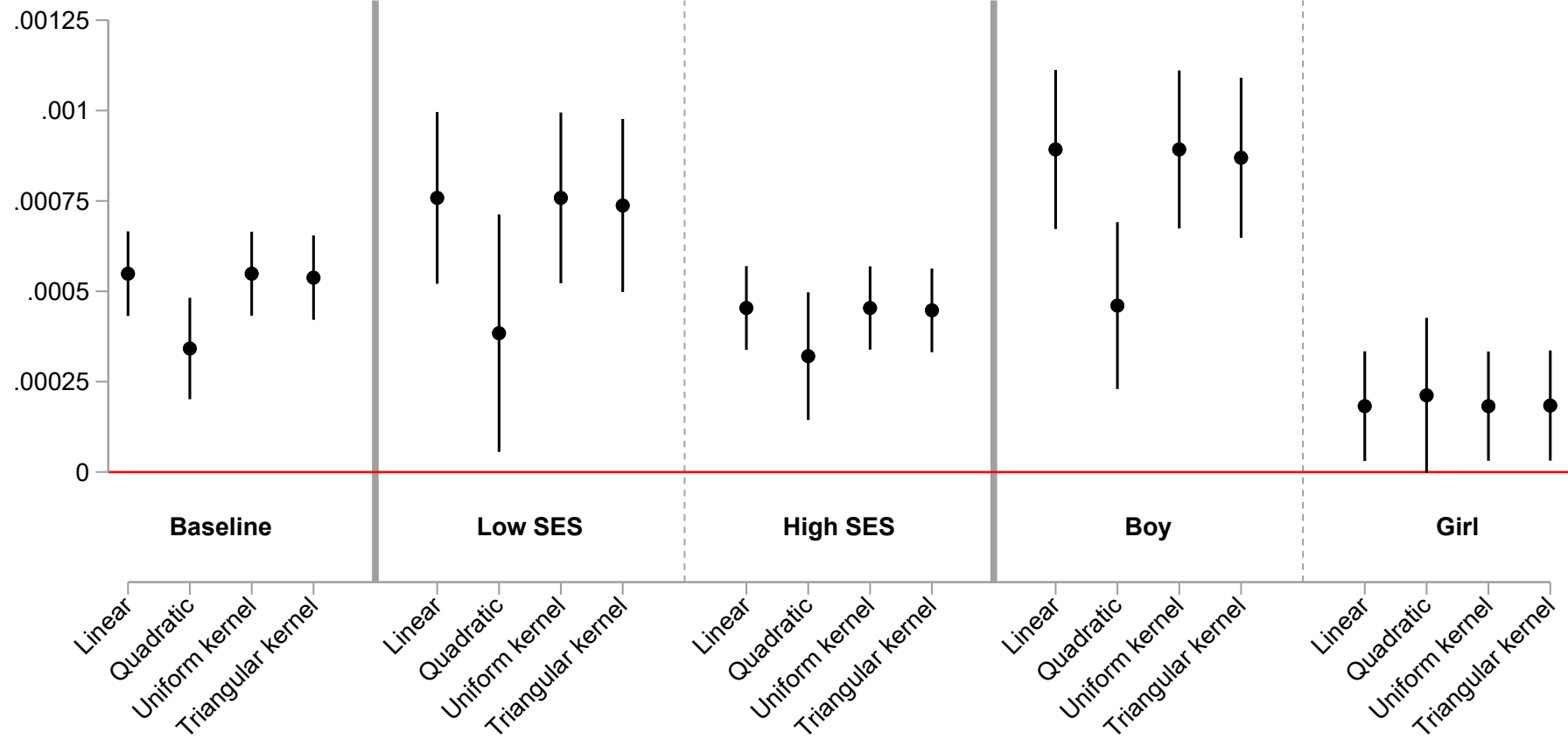
Notes: UAHIF panel. This figure shows estimates for the discontinuous shift in the probability of having an alcohol intoxication at age 16 for different RD specifications: 'Linear' ('Quadratic') uses linear (quadratic) age trends that might be different to the left and to the right of the cutoff (spline regressions) in an RD model, and 'Uniform kernel' ('Triangular kernel') uses a local linear regression with a uniform (triangular) kernel function. We estimate these regressions different subsamples, where the baseline is equivalent to Table 4, 'Low SES' and 'High SES' refer to the mother's socioeconomic status, and 'Boy' and 'Girl' refer to child sex. RD coefficients are multiplied by 100 to improve readability. Standard errors clustered at the age (in months) level. The whiskers indicate 95 percent confidence intervals.

TABLE 6 — Heterogeneity by parents with and without a history of liver cirrhosis

	All (1)	No history (2)	Cirrhosis (3)
Baseline	0.03***	0.03***	−0.02
	(0.008)	(0.008)	(0.1)
Outcome mean	0.09	0.08	0.13
Number of observations	3,981,294	3,940,368	40,926
Low SES	0.04*	0.04**	−0.08
	(0.02)	(0.02)	(0.2)
Outcome mean	0.10	0.10	0.21
Number of observations	1,219,008	1,202,748	16,260
High SES	0.03***	0.03***	0.01
	(0.01)	(0.01)	(0.1)
Outcome mean	0.08	0.08	0.08
Number of observations	2,762,286	2,737,620	24,666

Notes: UAHIF panel. This table presents RD estimates for the discontinuous shift in the probability of having an alcohol intoxication at age 16 by socioeconomic status and by whether either of the parents have had an alcohol-related liver issue between 1998–2015. RD coefficients are multiplied by 100 to improve readability. Each regression includes quadratic trends that might be different to the left and to the right of the cutoff (quadratic spline). Standard errors clustered at the age (in months) level and shown in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

V.2.2. *Family history of alcohol abuse*

In a final step, we exploit the fact that the administrative data allow us to identify teenagers whose parents had a diagnosis of liver cirrhosis between 1998–2015. This provides us with a good proxy for a family history of alcohol abuse. We first run the RD regressions on the whole sample and distinguish between families with and without a recent history of cirrhosis. Then, we additionally split the sample by socioeconomic status. Table 6 shows that we do not find any statistically significant or economically meaningful positive effect of reaching MLDA on teenage alcohol intoxications in families with a history of cirrhosis; this is true for both low and high socioeconomic status families. At first sight, one might be tempted to interpret this as evidence for a deterrence effect. However, looking at the alcohol intoxication means across groups, we reach a different conclusion. If parents have a history of cirrhosis, the incidence of alcohol intoxication is not smaller, and for low socioeconomic status teenagers even considerably higher (by a factor of two). This finding suggests that, in these families, teenagers imitate their parents' behavior and engage more often in excessive drinking, regardless of whether they have already reached the MLDA. Put differently, for this high-risk group the MLDA is not effective.

V.2.3. Substitution behavior and spillovers to other risky behavior

A large literature discusses whether alcohol is a substitute for or a complement to other risky activities, such as drug use. Figure A.2 in the Appendix shows RD estimates of reaching the MLDA on a set of additional health outcomes ranging from injuries and sexually transmittable diseases to drug prescriptions and drug-related treatments; again, we distinguish between teenagers from low and high socioeconomic status families. We do not find any robust evidence for a meaningful impact of the MLDA (and the associated increase in alcohol consumption) on health outcomes other than alcohol intoxication.

V.3. Effects on access to alcohol and risk perceptions

The discontinuous increase in alcohol consumption at the age of 16 shows that MLDA legislation is successful in preventing many (but not all) underage children from consuming alcohol. In this section, we aim at providing evidence on the underlying mechanism. One obvious channel is restricted physical access to alcohol. We have two data sources to evaluate the importance of this channel. First, we use data from an annual large-scale field study, which sends underage test buyers to retailers to buy alcohol.[13] Second, we use ESPAD survey responses on perceived access. The former provide us with objective information on alcohol access at retailers, while the latter refers to self-reported overall access, including access provided by siblings and friends. In a final step, we discuss normative values imposed by alcohol legislation as an additional channel. To this end, we use survey questions on risk perceptions about alcohol as a proxy outcome.

V.3.1. Objective access at retailers

Since 2014, the Upper Austrian government has commissioned the main addiction prevention center (*Institut Suchtprävention – pro Mente Oberösterreich*) to annually organize a large number of underage alcohol purchase attempts across Upper Austria. The test buyers are all under the age of 16. They are trained by experts and accompanied by adult custodians during the procedure. The test purchases were carried out in grocery stores, in petrol station shops, and in restaurants across Upper Austria; the test shoppers were instructed to buy a 0.7 liter bottle of hard liquor (Vodka). Since access to hard liquor is legally restricted up to age 18 in Upper Austria, the success rates of test shoppers represent a lower bound of the success rates we would expect for non-distilled alcohol such as beer and wine.[14] We have access to anonymized micro data on all purchase attempts (except restaurants). Our dataset includes information on the date and place of 4,269 purchase attempts.

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[13]This is a common method to check the compliance with restrictions on alcohol sales (see, e.g., Gosselt *et al.*, 2007).

[14]Further details on the survey are available here: https://www.praevention.at/jugend/testkaeufe-jugendschutz

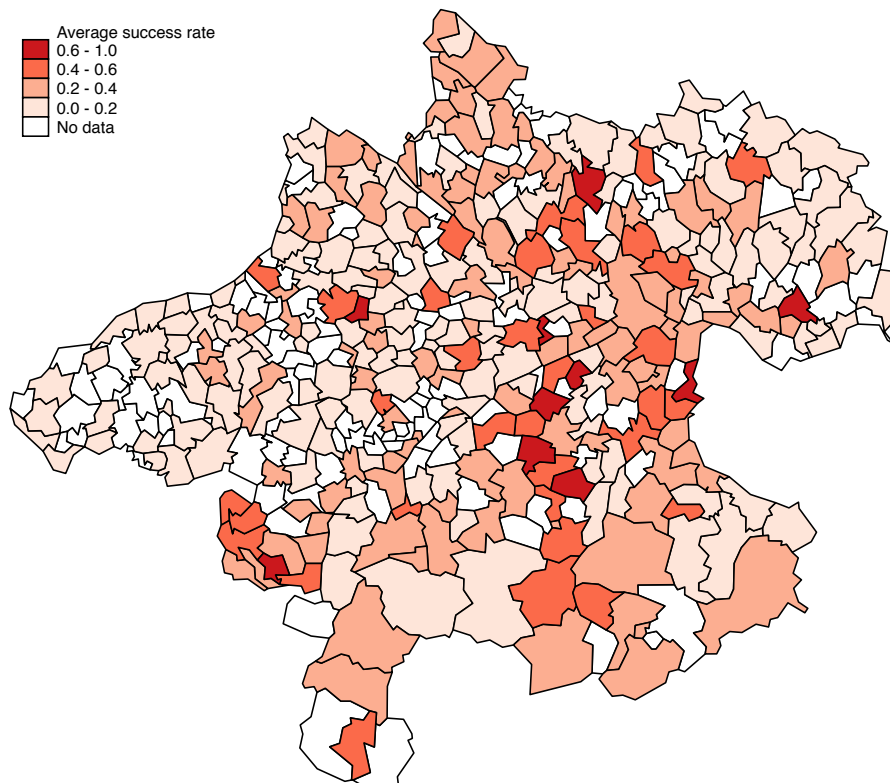FIGURE 8 — Average success rate of test shoppers 2014-2018
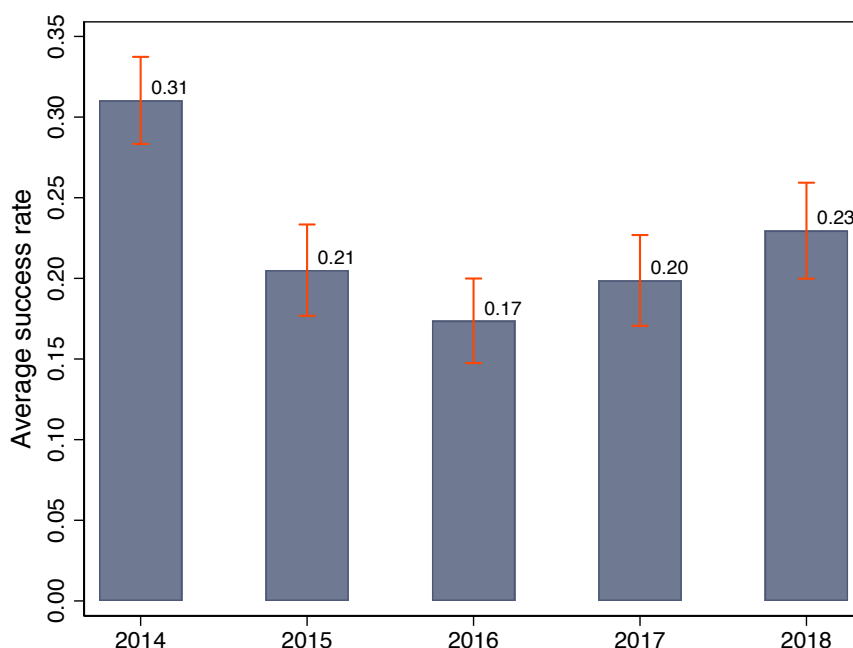
Notes: Figures are based on 4,269 alcohol test purchase attempts in Upper Austrian grocery stores and petrol station shops undertaken by underage test-buyers.

On average, 23 percent of all buying attempts were successful. Put differently, only about three-fourths of all vendors complied with MLDA legislation. Figure 8 shows variation in these success rates across years. In 2014, the success rate was about 31 percent. It has dropped thereafter, and has not surpassed 23 percent ever since. A potential explanation for the drop in 2015 is an impact of the large-scale field study itself. Immediately after the purchase, the accompanying staff informs the vendor about its result. If alcohol was sold, the vendor is asked to behave more responsibly and to comply with the legislation in the future. The vendor also receives a feedback letter, including information material, a few weeks after the test. Only after repeated violations, the vendor is reported to the authorities.

Figure 9 depicts considerable variation in the success rate across municipalities. To test whether underage alcohol sales differ across regions with different socioeconomic structure, we merge municipality-level characteristics to the test purchase data. Among others, we use the unemployment rate, the share of adults with a university degree, and the share of foreigners. Conditional on district and year fixed effects, we do not find any significant correlation between socioeconomic characteristics and average success rates (see Appendix Table A.2).[15] Thus, we do not find any evidence that compliance differs by socioeconomic structure of the neighborhood. This finding is in line with the observation that there is no difference in binge

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[15]Success rates peak in December (0.35) and in summer. We also observe variation across weekdays, with highest success rates on Fridays and Saturdays (about 0.25), and a minimum on Mondays (0.19). See Web Appendix Figures A.3 and A.4 for descriptive evidence.

FIGURE 9 — Average success rate across Upper Austrian municipalities

Notes: Based on 4,269 alcohol test purchases in Upper Austrian grocery stores and petrol station shops undertaken by underage testbuyers in the period between 2014 to 2018.

drinking *before* the age of 16 across children from different socioeconomic backgrounds (see the overlapping curves left of the MLDA cut-off in Figure 6).

V.3.2. Perceived overall access

ESPAD survey responses confirm that most teenagers perceive access to non-distilled alcohol as easy already before the age of 16. In the left panel of Figure 10, we plot the share of teenagers that perceive access to non-distilled alcohol as "rather easy" or "very easy" against age in months. Although we observe some slight increase at the 16 year cut-off, as much as 84 percent of all 15 year olds perceive access to non-distilled alcohol as easy already. Considering perceived access to distilled alcohol, the shares are lower over the whole age distribution. Interestingly, we find that a discontinuous jump at the 16 year cutoff is clearly visible for states whose MLDA laws granted access to distilled alcohol at age 16 at the time of the interview, while it is absent for states that did not grant access to distilled alcohol before the age of 18 (Figure 11).[16] Taken together, these figures suggest that a lack of access to alcohol can hardly fully explain the effectiveness of MLDA legislation.

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[16]Remember that Upper Austria belongs to the staggered MLDA regime group. In unreported ESPAD analyses, we do not find any systematic differences in the MLDA effects on drinking behavior between these regimes.
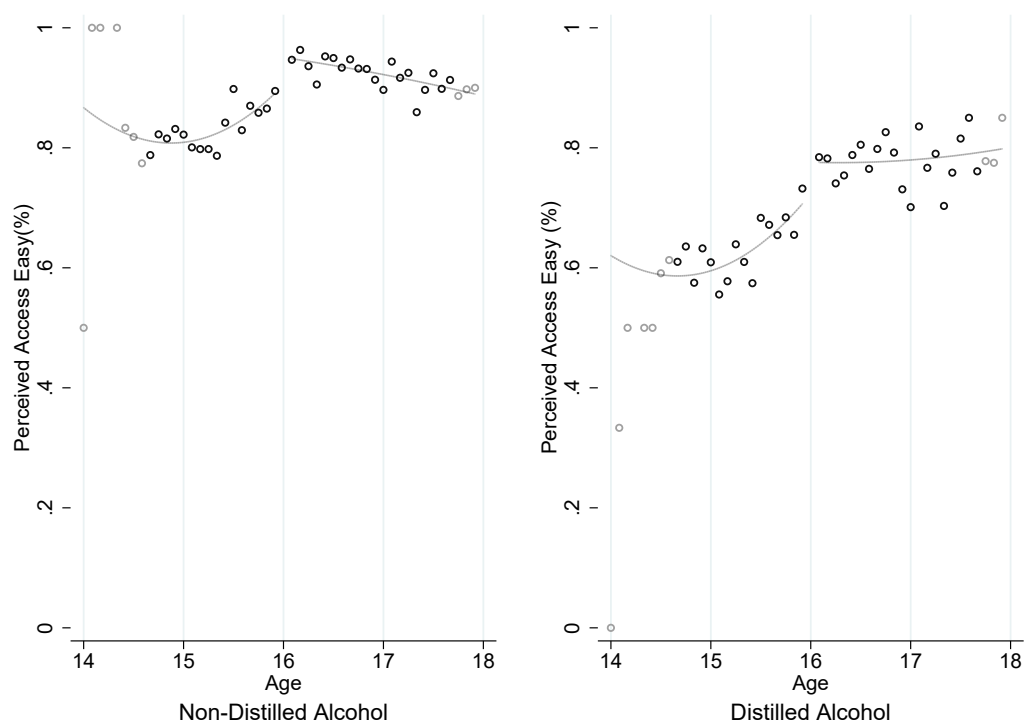
V.3.3. Risk perceptions

A plausible complementary mechanism behind the effectiveness of the MLDA is that the legislation has established a normative value in the sense that some teenagers below 16 years of age simply feel obliged to obey and abstain from drinking despite its availability. Also parents might play a role here: They might become more lenient after their child reaches the age of 16 when drinking becomes not just legally allowed but also socially more accepted. Once, it becomes more accepted, teenagers change their attitudes towards alcohol and drink more frequently and intensely.

This normative mechanism chain is hard to test empirically. However, the ESPAD includes a question on risk perceptions about alcohol, which provides us with a surrogate outcome variable. The survey distinguishes between risk perceptions of daily drinking, i.e., having one or two drinks nearly every day, and risk perceptions of binge drinking at weekends, i.e., having five or more drinks on one occasion nearly every weekend. In the absence of MLDA legislation, one would expect risk perceptions to be a continuous function of age.

Figure 12 presents evidence on the impact of the MLDA on teenagers' risk perceptions of

FIGURE 11 — Perceived access to distilled alcohol by MLDA regime
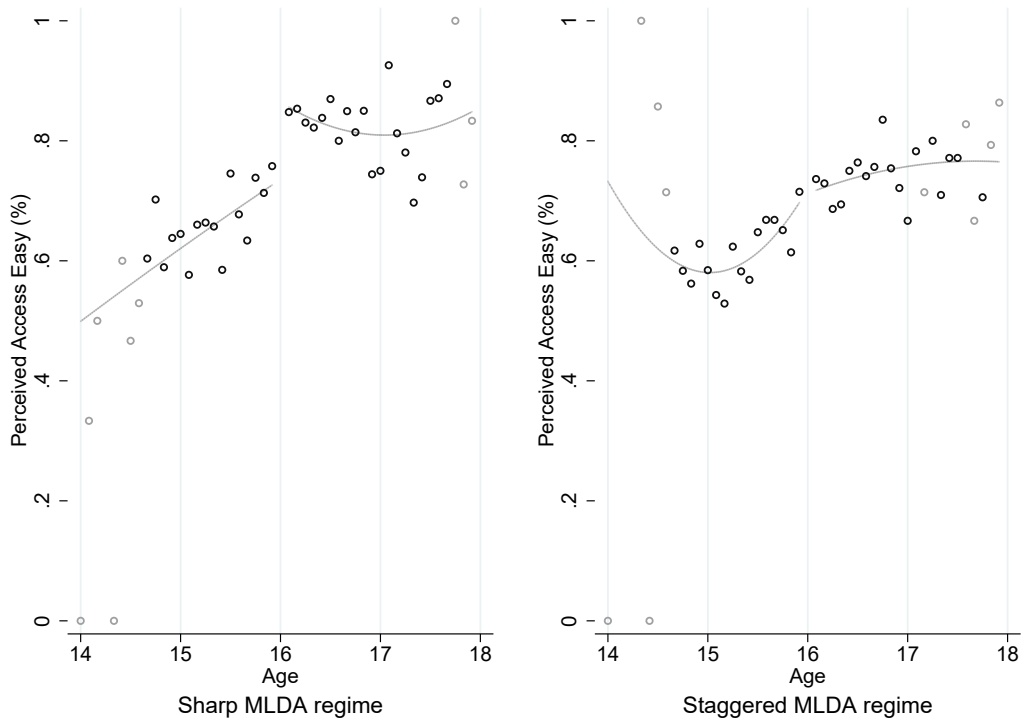
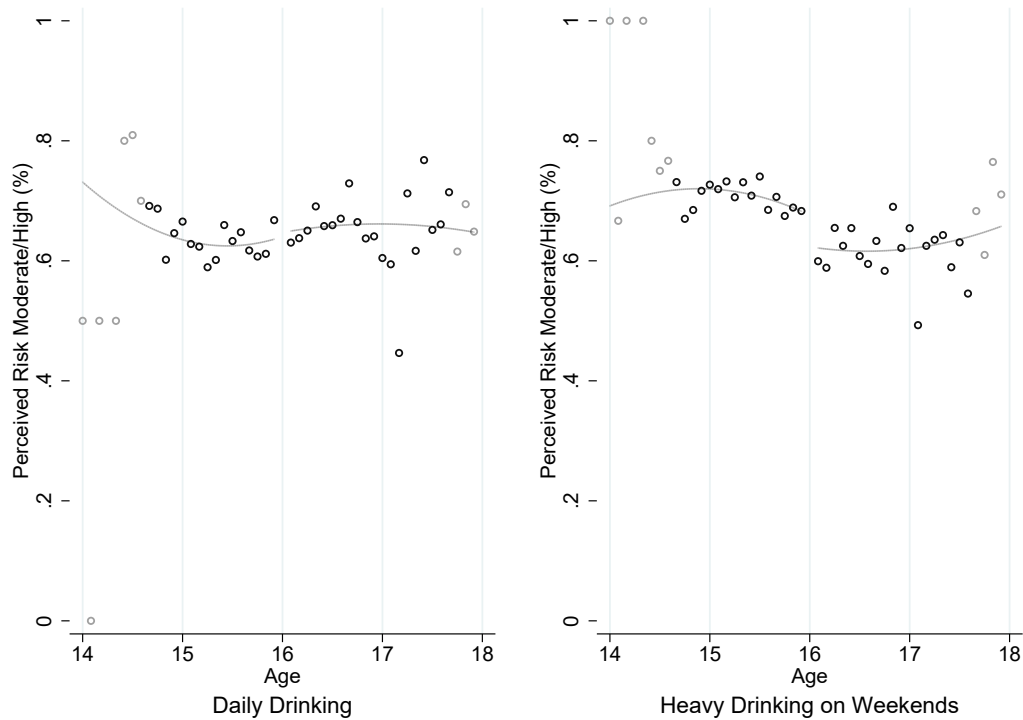Sharp MLDA regime   Staggered MLDA regime

Notes: ESPAD 2015, Austria. The graph plots the share of respondents by age (in months) bins who perceive access to distilled alcohol (spirits, alcopops) "rather easy" or "very easy" by MLDA regime. The left panel plots the shares for *Sharp MLDA* states, i.e., states which allow legal access to distilled and non-distilled alcohol from age 16. The right panel plots the shares for *Staggered MLDA* states, i.e., states which allow legal access to non-distilled alcohol from age 16 and to distilled alcohol from age 18. Respondents who turn 16 in the month of the interview are dropped. Grey circles indicate that the number of observations from the respective age (in months) bin is in the lower quintile of the frequency distribution.

alcohol. The left panel of Figure 12 plots the share of teenagers considering the risk of daily drinking as "moderate" or "great" by age in months. Around 65 percent of teenagers believe that daily drinking is risky; this share does not change by gaining legal access to alcohol at age 16. The right panel of Figure 12 performs the same analysis for the share of teenagers considering regular heavy drinking at weekends to be risky. This share significantly drops from roughly 70 to 60 percent by obtaining access to alcohol at age 16. We interpret this drop as suggestive evidence for a normative impact of the legislation. Notably, we do not find any change in risk perceptions of drug consumption at the MLDA cut-off (see Figure A.5 in the Appendix). This is in line with the zero effects on hospitalizations due to drugs and other risky health behavior.

VI. A comparison with adolescent drinking behavior in the United States

To put our findings into perspective, we compare teenage drinking behavior in Austria and the U.S. To this end, we first contrast information from the Austrian ESPAD 2015 data to information from more than 13,000 adolescents aged 14 to 17 in the U.S. *Youth Risk Behavior*

FIGURE 12 — Risk perception of daily drinking and heavy drinking at weekends

Notes: ESPAD 2015, Austria. The graph plots the share of respondents by age (in months) bins who perceive daily drinking (left panel) or heavy drinking on weekends, i.e., having five or more drinks in one occasion nearly every weekend (right panel) risky. Respondents who turn 16 in the month of the interview are dropped. Grey circles indicate that the number of observations from the respective age (in months) bin is in the lower quintile of the frequency distribution.

Surveillance System 2015 (YRBSS). We investigate two questions on drinking behavior that are consistently asked across both surveys. The left panel of Figure 13 plots the share of respondents who report drinking at least once during the last 30 days over age in years for both Austria and the U.S. The right panel of Figure 13 plots the share of respondents who report at least one binge drinking incident (meaning five or more alcoholic beverages on one occasion) by age for Austria and the U.S. For both variables, the share is considerably higher in Austria than in the U.S., and this is the case over the entire age spectrum. More than 40 percent of all 14–15 year olds in Austria report at least one binge drinking incidence during the past 30 days, whereas this number is around 10 percent in the US After the Austrian MLDA cutoff at 16, we observe a disproportionate increase in the share of teenagers who report drinking or heavy drinking. The jump at the cutoff in the share of teenagers who report binge drinking is more than two times larger in Austria than in the U.S. Appendix Table A.1 shows that the difference in this increase is highly significant and amounts to 9 percentage points.

Using data from the 2000 to 2006 waves of the *National Longitudinal Study of the Youth 1979* (NLSY79), we also inspect the increase in drinking behavior of U.S. youths at the MLDA cutoff at 21 years of age. In contrast to the YRBSS data, the NLSY97 contains information on

FIGURE 13 — Youth drinking behavior in Austria and in the U.S.
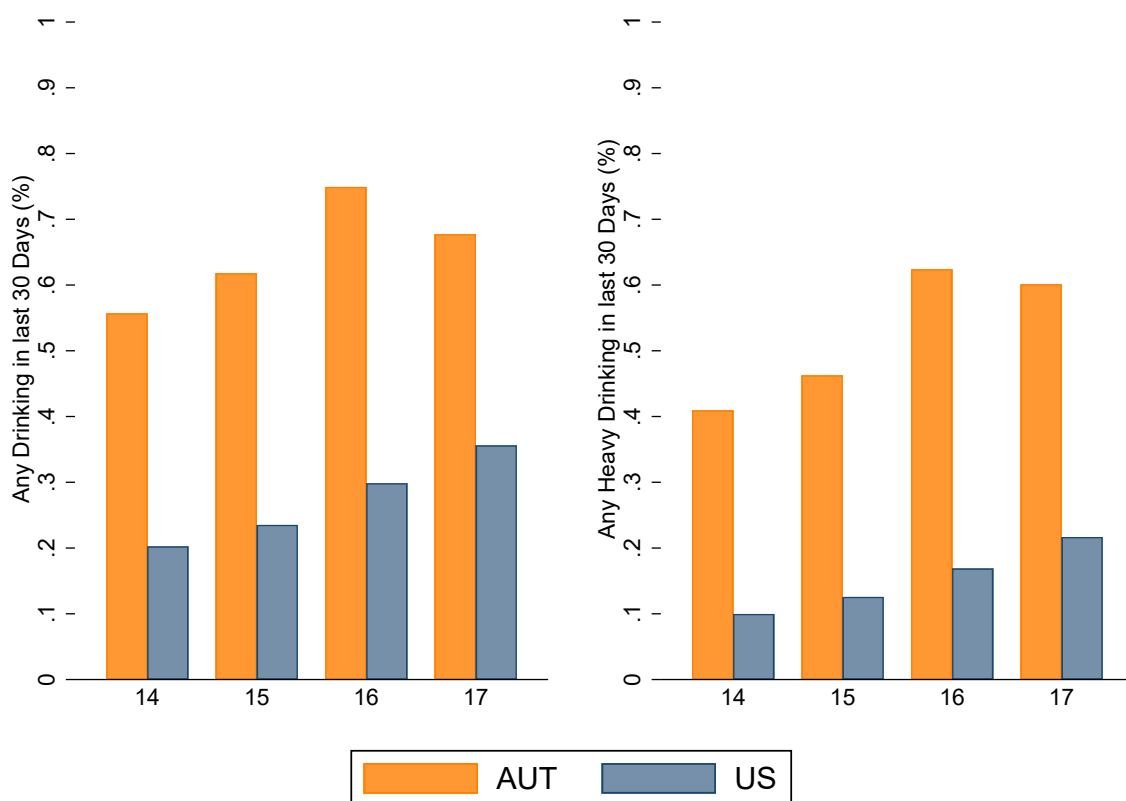
Notes: ESPAD 2015, Austria and YRBSS 2015. The left panel shows the share of respondents by age (in years) who report that they consumed alcohol at least once during the last 30 days. The right panel shows the share of respondents who report that they had at least one binge drinking incidence in the last 30 days, i.e., they consumed five drinks or more on one occasion.

age in months, which is crucial for the RD setup. Moreover, NLSY97 provides information on maternal education, which we use to proxy for socioeconomic background. The downside of the NLSY97 is that we look at a different cohort, since the respondents were born already between 1980 and 1984. Again, we rely on questions that ask how many of the last 30 days youths consumed any alcoholic drink and on how many days they consumed five or more alcoholic drinks on one occasion; the latter we define again as binge drinking. The upper two panels of Figure 14 show RD graphs identifying the impact of the U.S. MLDA on the probability of having consumed any alcoholic beverage during the last 30 days. While the left panel shows the overall effect, the right panel distinguishes between youths from high and low socioeconomic status. Linear spline regressions yield a highly significant jump of 4.8 percentage points right at the MLDA cutoff, with no clear heterogeneity by socioeconomic status. The lower two panels of Figure 14 show the respective RD graphs for the probability of reporting at least one binge drinking occasion during the last 30 days. Also for this variable we observe a discontinuous jump of at the MLDA cutoff. This significant increase of 2.7 percentage points in the overall

FIGURE 14 — Drinking and heavy drinking in NLSY97
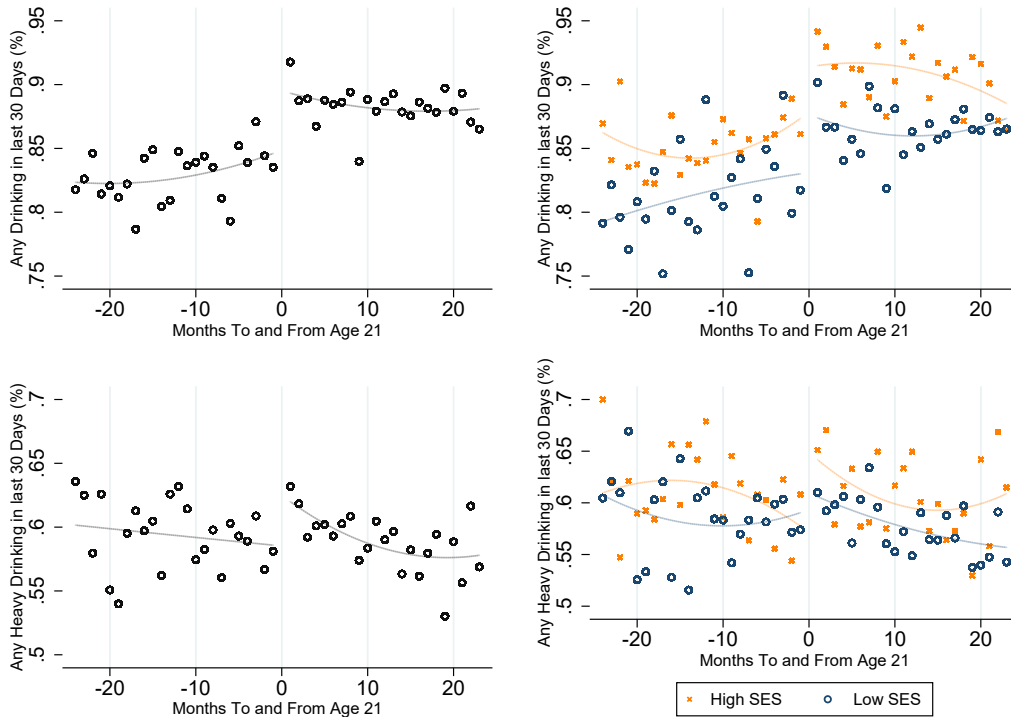
Notes: NLSY97. The upper left panel plots the share of respondents who report that they consumed alcohol at least once during the last 30 days by age (in months) bins. The upper right panel shows these shares by socioeconomic background. The lower left panel plots the share of respondents who report at least one binge drinking incidence (five drinks or more on one occasion) during the last 30 days by age (in months) bins. The lower right panel shows these shares by socioeconomic background. Respondents who turn 21 in the month of the interview are dropped.

sample is driven by youths with high socioeconomic background.

Youth drinking behavior in Austria and the U.S. is very different — both in terms of consumption levels and socioeconomic patterns. Therefore, we are hesitant to use our setting to extrapolate how a MLDA change to 16 in the U.S. would affect teenage drinking and health. Similarly, we should not use the results from the U.S. to draw any conclusions on how an increase of the MLDA in Austria would affect teenage drinking behavior.

VII. CONCLUSIONS

We investigate the impact of a low MLDA of 16 years of age in Austria, a country at the upper end of the world's alcohol consumption and binge drinking distribution. Using rich survey data from the *European School Survey Project on Alcohol and Other Drugs* (ESPAD) and hospitalization registries, we apply a regression discontinuity design to estimate the impact of the MLDA on drinking behavior and morbidity.

Our results show that upon gaining legal access to alcohol, teenagers substantially increase both the frequency and the intensity of drinking. The likelihood of not having had a single drink

over the last seven days shrinks by 12 percentage points. At the same time, the likelihood of having had one to two (three to five) heavy drinking occasions over the last seven days increases by 10 (8) percentage points. As a consequence, we observe a sharp increase in hospitalizations due to alcohol intoxication at the cutoff age of 16. These findings contradict the notion that a low MLDA helps teenagers to ease into drinking (Wechsler and Nelson, 2006).

The effects are stronger for boys and for teenagers with low socioeconomic background. We show that the effects persist for some years and cannot be explained by birthday party effects. By the age of 22, the probability of having been hospitalized with an alcohol intoxication is 0.104 percent for low socioeconomic background teenagers, and thus 40 percent higher than for those with high socioeconomic background.

Investigating the channels, we observe that most teenagers perceive access to alcohol as easy even before turning 16. Data from large-scale mystery shopping tours suggest that, even at the points of sale, MLDA enforcement is not very strict. At the same time, we do observe a conspicuous decline in the share of teenagers who consider regular heavy drinking at weekends risky right at the MLDA cutoff, while we do not see any change in the share of teenagers who consider daily drinking risky. This result might be suggestive evidence in favor of an additional normative channel MLDA regulation entails. Some teenagers below 16 years of age may simply feel obliged to obey and abstain from drinking, despite its availability. Once drinking becomes legally allowed and socially acceptable, they change their attitudes towards alcohol and drink more frequently and more intensely.

Since we lack adequate data and estimates on the benefits of drinking alcohol at young age, we cannot perform an encompassing welfare analysis. However, if we are worried about the socioeconomic gradient, our results suggest that a (stepwise) increase of the MLDA would decrease the number of hospitalizations due to alcohol intoxication, and in particular also reduce the early socioeconomic gradient in teenage binge drinking. As an alternative to raising the MLDA for all, one might think about other measures that particularly target teenagers with a low socioeconomic background to avoid an early socioeconomic gradient in harmful binge drinking. This might also be the preferred option for teenagers from families with a history of severe alcohol abuse, since MLDA regulations are not effective for this high risk group. However, identifying which measures exactly are the most promising to reach this goal is beyond the scope of this paper.

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A. WEB APPENDIX

This Web Appendix (not for publication) provides additional material discussed in the unpublished manuscript 'Minimum Legal Drinking Age and the Social Gradient in Binge Drinking' by Alexander Ahammer, Stefan Bauernschuster, Martin Halla, and Hannah Lachenmaier.

Figure A.1 — Age in months frequency distribution of the ESPAD sample
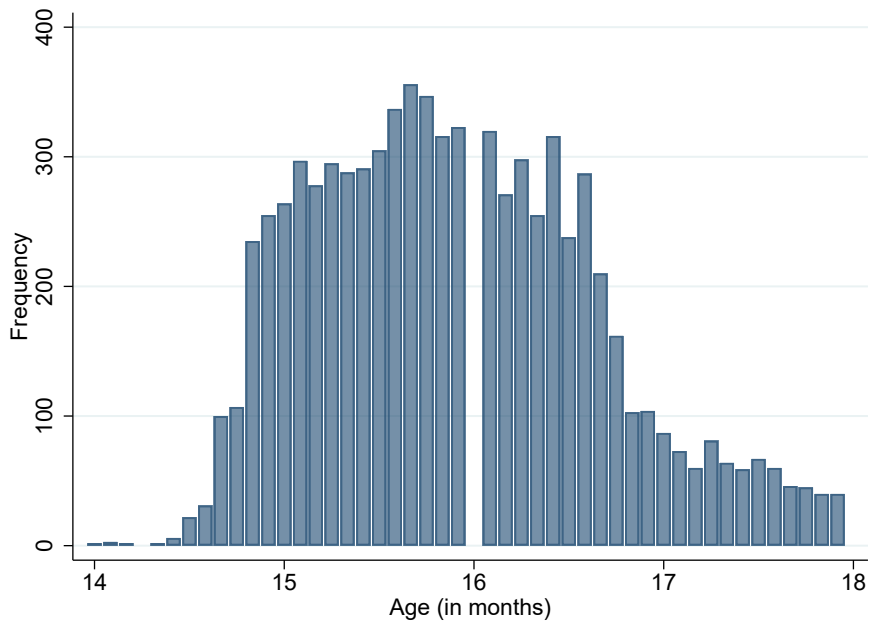
Notes: ESPAD 2015, Austria. This graph shows the frequency distribution of our sample over age in months. Respondents who turn 16 in the month of the interview are dropped to avoid wrong treatment assignment.

A.2

FIGURE A.2 — Other health outcomes

(a) Injury

Low SES = 0.259 (0.189)
High SES = 0.126 (0.100)

(b) Sexually transmittable disease

Low SES = 0.004 (0.004)
High SES = -0.001 (0.002)

(c) Prescribed antiviral drug

Low SES = 0.015 (0.032)
High SES = 0.015 (0.014)

(d) Prescribed antidepressant

Low SES = -0.004 (0.035)
High SES = -0.070*** (0.017)

(e) Prescribed a benzodiazepine

Low SES = 0.008 (0.007)
High SES = -0.013** (0.005)

(f) Prescribed ADHD drug

Low SES = 0.039*** (0.012)
High SES = 0.006 (0.007)

(g) Prescribed opioid

Low SES = -0.018*** (0.006)
High SES = 0.007 (0.007)

(h) Opioid addiction treatment

Low SES = -0.011* (0.006)
High SES = -0.007** (0.003)

(i) Opioid overdose

Low SES = 0.003 (0.002)
High SES = -0.000 (0.001)

○ Low education —— Quadratic fit ✕ High education —— Quadratic fit

Notes: UAHIF panel. Graph plots mean probabilities in a given age–month bin for each outcome. Probabilities are based on the population of children insured at a given age in Upper Austria. We multiply binary outcomes by 100 to improve readability.

FIGURE A.3 — Average success rate of underage alcohol test-buyers across months
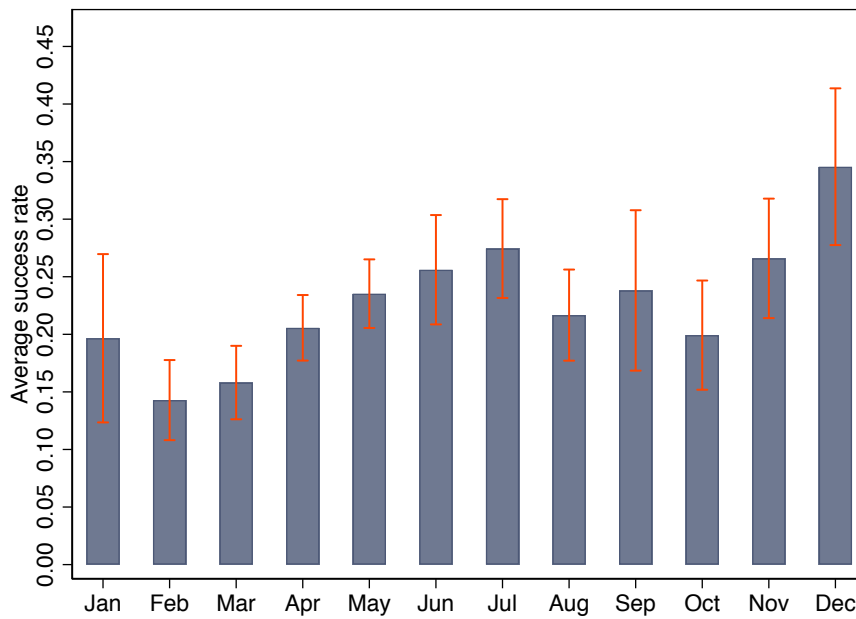
Notes: Figures are based on 4,269 alcohol test purchase attempts in Upper Austrian grocery stores and petrol station shops undertaken by underage test-buyers in the period between 2014 to 2018.

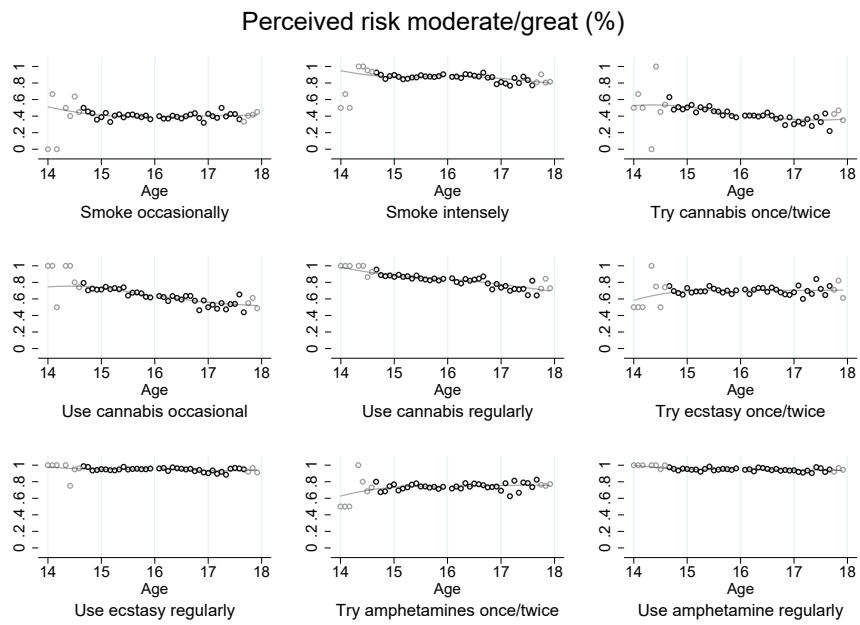FIGURE A.4 — Average success rate of underage alcohol test-buyers across weekdays
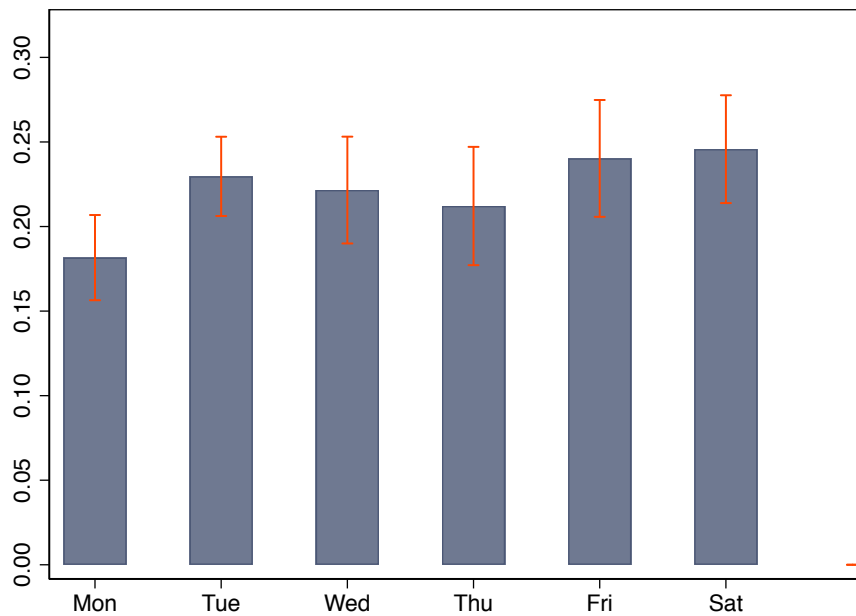
Notes: Figures are based on 4,269 alcohol test purchase attempts in Upper Austrian grocery stores and petrol station shops undertaken by underage test-buyers in the period between 2014 to 2018.

FIGURE A.5 — Risk perception of drug use

Perceived risk moderate/great (%)

Notes: ESPAD 2015, Austria. The graph plots the share of respondents by age (in months) bins who perceive the respective consumption behavior risky. Respondents who turn 16 in the month of the interview are dropped. Grey circles indicate that the number of observations from the respective age (in months) bin is in the lower quintile of the frequency distribution.

TABLE A.1 — Youth drinking behavior in Austria and in the US

	Drinking		Binging	
	(1)	(2)	(3)	(4)
16 and older	0.101***	0.103***	0.074***	0.076***
	(0.008)	(0.008)	(0.006)	(0.006)
Austria	0.382***	0.382***	0.336***	0.336***
	(0.009)	(0.009)	(0.009)	(0.009)
(16 and older X Austria)	0.026**	0.025*	0.091***	0.090***
	(0.013)	(0.013)	(0.013)	(0.013)
Female		0.031***		0.002
		(0.006)		(0.006)
Constant	0.225***	0.209***	0.118***	0.116***
	(0.006)	(0.006)	(0.004)	(0.005)
Number of observations	21,411	21,355	21,411	21,355
Outcome mean	0.427	0.428	0.299	0.299

Notes: ESPAD 2015, Austria and YRBSS 2015. Drinking is a dichotomous variable that is one if the respondent consumed alcohol at least once during the last 30 days. Binging is a dichotomous variable that is one if the respondent reports at least one binge drinking incidence (five or more drinks in one single occasion) during the last 30 days. *16 and older* is a dichotomous varibale that is one if the respondent is at least 16 years old. *Austria* is a dichotomous variable that is one for respondents from the ESPAD 2015 Austria country sample and zero for respondents from the YRBSS 2015. Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

TABLE A.2 — Community-level determinants of successful purchasing attempts by underage test-buyers

	(1)	(2)	(3)	(4)	(5)	(6)
Share with an academic degree[†]	0.008					0.007
	(0.364)					(0.298)
Share with a school leaving exam.[†]		0.010				0.028
		(0.354)				(0.813)
Unemployment rate[†]			-0.002			0.007
			(-0.061)			(0.149)
Share of foreigners[†]				0.007		0.023
				(0.248)		(0.590)
Firms per 1,000 pop					0.013	0.014
					(0.737)	(0.706)
Constant	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
District FE	Yes	Yes	Yes	Yes	Yes	Yes
Pop. density	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	4,267	4,267	4,267	4,267	4,267	4,267
R-squared	0.041	0.041	0.041	0.041	0.041	0.041
F-statistic	9.15	9.15	9.16	9.18.	9.15	7.82
Mean of main independent var	0.112	0.600	0.053	0.138	0.715	–

Notes: Linear probability model of a successful purchasing attempt by underage test-buyers with community-level determinants. Beta coefficients with t-values (based on robust standard errors) in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Estimations are based on 4,267 alcohol test purchase attempts in Upper Austrian grocery stores and petrol station shops undertaken by underage test-buyers in the period between 2014 to 2018. [†] Measured in 2017.