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Fabian T. Dehos
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Binge Drinking and Alcohol Related Hospital Stays – Does a Legal Drinking Age Matter for Minors?

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Fabian T. Dehos and Anne Mensen[1]

Binge Drinking and Alcohol Related Hospital Stays – Does a Legal Drinking Age Matter for Minors?

Abstract

This paper evaluates the effectiveness of the German Minimum Legal Drinking Age in reducing excessive drinking and alcohol-related hospital stays. We add to previous studies by looking at a considerably earlier cutoff at age 16, when teenagers in Germany gain legal access to beer, wine, and sparkling wine. Using detailed survey data, we find considerable increases in moderate alcohol consumption and self-perceived drunkenness at age 16, but rather negligible effects for excessive drinking patterns which may lead to coma or deaths. Likewise, our analysis of daily-hospital-admission data reveals no discontinuities in hospital stays due to acute alcohol intoxication. Admissions due to physical injuries, in contrast, increase by about 11% at age 16 which coincides with teenage drinking patterns and incidents when drunken teenagers fall or get into a fight.

JEL-Codes: I12, I18, J13, K32

Keywords: Alcohol; minimum legal drinking age; binge drinking; hospital admissions

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[1] Fabian T. Dehos, RWI, RUB, and UDE; Anne Mensen, RWI, RUB, and Leibniz Science Campus Ruhr. *– We thank Boris Augurzky, Thomas Bauer, Ansgar Wübker, and internal seminar participants for valuable remarks and suggestions. Anne Mensen gratefully acknowledges funding by the Leibniz Science Campus Ruhr.* *- All correspondence to: Fabian T. Dehos, RWI, Hohenzollernstr. 1-3, 45128 Essen, Germany, e-mail: fabian.dehos@rwi-essen.de*

1. Introduction

Worldwide, more than 3 million people died in 2016 as a result of harmful use of alcohol (WHO, 2018). Excessive alcohol consumption is particularly prevalent among teenagers. In Europe, more than 24% of teenagers aged 15 to 19 practice heavy episodic drinking, which is the highest among WHO regions (WHO, 2018).[1] Notably, acute alcohol intoxication is the leading cause of hospital admissions for teenagers aged 15 to 17 in Germany (Destatis, 2018).

Drawing on a regression discontinuity (RD) design, this paper investigates the German access regulation to alcohol at age 16 and its impact on excessive drinking and alcohol-related hospital stays. In Germany, drinking is socially accepted, alcohol is broadly available at a low price, and age-based regulations are among the lowest in the world. Teenagers are legally allowed to purchase beer, wine and sparkling wine, when they turn 16 and all types of alcoholic beverages at age 18. At the same time, 18 constitutes the legal age of adulthood, which comes with further rights and obligations such as full legal capacity, access to most establishments during the entire night, and unrestricted vehicle use. To avoid these confounders, we focus on the 16th birthday threshold, which is particularly important as it targets a very young group of teenagers who are still undergoing physical and mental development.

Using detailed survey data from the German Federal Centre for Health Education (FCHE) and from the European School Survey Project on Alcohol and Other Drugs (ESPAD), we analyze the impact of the German Minimum Legal Drinking Age (MLDA) on commonly used drinking indicators, and perceived drunkenness. In addition, we exploit a nationally representative sample of inpatient data from a large German health insurer. With these data, we examine whether changes in drinking patterns translate into increased hospital admissions due to acute alcohol intoxication, which is a severe direct result of excessive alcohol consumption.

Our results show discontinuous increases in alcohol consumption and perceived drunkenness at age 16. Teenagers are 28% to 38% more likely to participate in binge drinking occasions and the self-assessed degree of drunkenness increases by 29% once they turn 16. Since the commonly defined binge-drinking thresholds of four or five drinks may hide important insights, we follow Carpenter et al. (2016) and Dehos (2022) and look at the entire

[1] Heavy episodic drinking is defined as 60 or more grams of pure alcohol at least once per month.

drinking distribution. The impact of the German MLDA is strongest in reducing low to moderate levels of drunkenness but fades out with increasing amounts of alcohol and higher levels of perceived drunkenness.

The negligible effects at the upper end of the drinking distribution correspond to our analysis of hospital stays, where we do not find an impact of the MLDA on admissions that are diagnosed as an acute alcohol intoxication. For teenagers hospitalized due to physical injuries, e.g. bone fractures or concussion, in contrast, we estimate an 11% increase in hospital admission rates. The latter effect tends to be driven by alcohol consumption, when, for instance, drunken teenagers tumble or get into a fight. Although we cannot fully rule out a novice driver effect for light motor vehicles at age 16, our heterogeneity analysis and descriptive evidence point, if anything, to a minor impact of traffic accidents on inpatient admissions.

Our analysis contributes to the literature evaluating policies that aim at protecting minors from excessive and harmful alcohol consumption, e.g. price policies, availability restrictions, or late-night bans on sales (Conover and Scrimgeour, 2013; Marcus and Siedler, 2015).[2] The effectiveness of MLDA restrictions in reducing risky alcohol consumption and its consequences have been increasingly analyzed over the last years. Exploiting the discontinuity in legal access to alcohol, these studies investigate the impact of adolescent drinking on criminal engagement and victimization (Carpenter and Dobkin, 2015; Hansen and Waddell, 2018; Chalfin et al., forthcoming), drug use (Crost and Guerrero, 2012; Yörük and Yörük, 2013), risky sexual behavior (Yörük and Yörük, 2015; Koppa, 2018), and academic performance (Carrell et al., 2011; Lindo et al., 2013). The focus of these studies lies primarily on the US, Canada, and Australia. Only recently, interest has shifted to European countries, where drinking levels are among the highest in the world and age restrictions comparatively low.[3]

Most previous studies on health outcomes look at mortality and adolescents aged 18 or above (e.g. Carpenter and Dobkin, 2009; Carpenter et al., 2016). A notable exception is a recent study by Ahammer et al. (2022) analyzing hospitalization at the Austrian MLDA at age 16. Using administrative data of one federal state, i.e. Upper Austria, the authors find a large

[2]See OECD (2021) for a summary of policies and best practices.

[3]For studies on traffic accidents and alcohol induced crime in Germany see Kamalow and Siedler (2019) and Dehos (2022); for insights on victimization in the Netherlands see Bindler et al. (2021).

and significant 42% increase in hospital admissions due to acute alcohol intoxication, but no changes in other hospitalization outcomes. Our analysis of the German MLDA, in contrasts, reveals increases in hospitalization rates due to physical injuries but no discontinuities due to alcohol intoxications.

Despite close regional connectedness and similar regulations, cultural differences in excessive drinking may influence the effectiveness of the MLDA. As outlined by Ahammer et al. (2022, Fig.1) heavy drinking incidences among drinkers are nearly three times higher in Austria than Germany. WHO (2016b) data point into a similar direction showing a 6.1% prevalence of harmful alcohol use during a given calendar year for adults in Austria, but only a 3.4% prevalence in Germany.[4] For Denmark, Datta Gupta and Nilsson (2020) investigate an increase of the MLDA from 15 to 16 years using a difference-in-differences approach. Consistent with our results, the authors find a significant impact on inpatient admissions due to physical injuries but none for alcohol intoxication. With a 3.6% prevalence of harmful alcohol use (WHO, 2016b), Denmark tends to be much more similar to Germany in terms of excessive drinking patterns. Besides, the price of alcohol is particularly high in Denmark, which further limits the budget of teenagers and thus, excessive consumption possibilities where acute alcohol intoxications are likely to occur.

In addition, we contrast our hospitalization analysis with teenage drinking patterns along the drinking distribution and thus, corroborate our findings. These insights are informative for policy makers: While binge drinking indicators of four or five drinks on one occasion are commonly used, they do not directly result in hospitalization due to acute alcohol intoxication. A detailed look at the full drinking distribution is thus be more insightful. Considering that the effectiveness of age-based access regulations also differ in seemingly similar settings, our results emphasize the importance of cross-country comparisons.

The remainder of the paper is structured as follows: Section 2 provides background information on the institutional setting in Germany. Section 3 describes our data and discusses the empirical strategy. Section 4 outlines the results of the consumption and hospitalization

[4]Following the WHO (2016b) definition, prevalence of harmful alcohol use refers to adults aged 15 and above diagnosed with ICD-10 code F10.1.

analysis, robustness checks, and a discussion of our findings. Section 5 concludes.

2. The German Minimum Legal Drinking Age

Germany has a stepwise age-dependent access restriction to alcohol in place, with the 16^{th} and 18^{th} birthday as its thresholds.[5] The legal cutoff for sales of fermented alcohol, i.e. beer, wine and sparkling wine, is the 16^{th} birthday. At age 18, access to distilled alcohol, e.g. spirits and spirit-containing beverages, is granted. The regulations are set out in the German federal Youth Protection Act (YPA). But different to other countries, teenagers and adolescents do not commit an administrative offense or legal misconduct in Germany if they possess alcohol or drink below a specific age. To enforce the MLDA, the German legislature sanctions retailers or adults with fees of up to 50,000 Euros if they sell alcohol to non-entitled teenagers or if they permit their consumption.

Most teenagers are aware of the German MLDA, but restrictions are not perceived as major obstacles. As outlined by Dehos (2022), 90% of teenagers aged 14 to 18 know about the German MLDA. However, only 7.5% of the 14 to 16-year-olds consider the access regulation to beer or wine at age 16 as a difficult or insuperable hurdle. Access to distilled alcohol below the legal age of 18 seems also relatively easy. Only 16% of teenagers aged 14 to 18 note that it is impossible or difficult for them to get a spirit-containing beverage.[6]

Germany constitutes a consumption-stimulating environment, where drinking is socially accepted and alcohol is broadly available at a relatively low price.[7] It is thus not surprising to observe a high teenage drinking prevalence as outlined in more detail in Section 4.1. In Germany, almost 95% of teenagers right below the cutoff at age 16 have already consumed alcohol once in their life. Therefore, the pathway of the German MLDA restricts to intensity and frequency adjustments.

Considering the low costs of drinking, increases in alcohol-related hospital admissions are likely to occur at the MLDA. At the same time, however, enforcement efforts could be too

[5] Note that this section embeds information on the institutional background outlined by Dehos (2022).
[6] Own calculations based on ESPAD (2007, 2011) data.
[7] As outlined by Dehos (2022), the relative beer-to-soft-drink price amounts only 1.2 in Germany, with an average price of €0.72 for a half-liter bottle of standard domestic lager beer and an average price of €0.60 for a similar sized bottle of carbonated soft drink.

weak to make the regulations effective. It is thus an empirical question to investigate if and how hospitalization rates change once it is legal for teenagers to access alcohol.

We restrict our study to the 16th birthday and refrain from an analysis of the 18th birthday threshold. In Germany, 18 constitutes the age of adulthood which comes with full legal and contractual capacity, the right to vote in federal elections, and unrestricted access to almost all restaurants, bars, and clubs for the entire night. Another confounder related to hospital admissions is the option to get a driver's license for regular vehicles at age 18, and for light motorcycles at age 16.[8] As shown by Kamalow and Siedler (2019), the number of traffic accidents increases at both cutoffs for non-alcohol-related incidents, what they attribute to a novice driver effect. Given the study's focus on the 16th birthday, this rules out an adverse impact of alcohol consumption on light motorcycling right at the cutoff. Consistently, teenage alcohol consumption tends to be unaffected by mobility increases at age 16 as outlined by Dehos (2022). But the overall increase of traffic accidents with light motor vehicles might affect hospitalization mechanically. To rule out this confounding channel, we take advantage of our detailed inpatient data and disentangle our hospitalization analysis. Besides, we add further data sources and descriptive insights to our subsequent analysis of injuries to learn more about the underlying channels. In Section 4, we provide further insights and robustness checks to verify our findings and potential pathways.

3. Data and Empirical Strategy

3.1. Consumption Data

We draw on detailed survey data from the European School Survey Project on Alcohol and Other Drugs (ESPAD) and from the Federal Centre for Health Education (FCHE) covering the years 2005 and 2015.[9] Besides detailed insights on teenage drinking, these data are unlikely to suffer from disability bias and other potential confounders for the following reasons: In Germany, teenagers below age 16 do not behave illegally in Germany if they drink. Since regulations aim at adults who sell alcohol to non-entitled teenagers or those who permit

[8]Until 2013, i.e. during our hospitalization analysis, the speed limit for teenagers aged 16 to under 18 was 80 km/h for light motorcycles. Motor-assisted bicycles up to 25 km/h are already allowed at age 15.

[9]FCHE, commonly known as *Bundeszentrale für gesundheitliche Aufklärung (BZgA)*.

respective drinking, there is no reason to fear potential consequences while stating the truth. Most importantly, all surveys guarantee complete anonymity to their respondents which also fosters honest replies. Finally, overall increases in alcohol consumption at age 16 coincide with administratively measured discontinuities in criminal behavior under the influence of alcohol (Dehos, 2022). This provides indirect but convincing evidence that we do not fall for dishonest survey response at age 16.

Considering our primary interest in hospital admissions due to acute alcohol intoxication, we focus the consumption analysis on excessive drinking at the commonly defined threshold for binge-drinking (indicating whether someone consumed 5 or more drinks in one sitting). Panel A, B, and C of Table 1 provide summary statistics of all consumption outcomes used in the analysis. Since some measures are surveyed in ESPAD only, they include fewer observations. Panel D adds information on the individual characteristics of survey participants. As shown in Table C.9 in the Appendix, these covariates evolve smoothly across the 16$^{\text{th}}$ birthday. Consequently, their inclusion should not affect the analysis except for an improved precision.

Our main outcomes are different measures of binge drinking (Panel B) that we contrast with self-assessed drunkenness (Panel C). Since alcohol affects individuals differently, we also investigate the degree of self-perceived drunkenness at the MLDA along different consumption levels. As outlined in Table 1, 50% of individuals aged 14.5 to 17.5 binge drank within the last 30 days and only 27% did not consume any alcohol within this time frame. Overall, Panels A to C reveal decreasing consumption levels for less severe types of drinking and for smaller reference periods where consumption takes place.

3.2. Hospital Admission Data

Our data on hospital admissions stem from rich patient-level data collected from hospital discharge records which include information on cause of hospital admission and the exact age at time of admission. These data come from a large German health insurer and cover a nationally representative sample of 15% of patients who were hospitalized between 2006 and 2011. We have information on patients' exact date of birth, gender, main diagnose, exact date and time of admission as well as discharge. We can thus zoom into the data to provide insights into important heterogeneities.

Table 1: Summary Statistics – Consumption Outcomes

	Mean	s.d.	N	Source
Panel A: Alcohol Consumption				
Drinking Participation Within Lifetime	0.94	0.24	20,789	ESPAD; FCHE
Drinking Participation Within Last 30 Days	0.73	0.44	20,789	ESPAD; FCHE
Overall Amount of Pure Alcohol (in g) on Last Occasion Within Last 7 Days	32.51	46.60	15,725	ESPAD
Panel B: Excessive Alcohol Consumption				
Binge Drinking Participation Within Last 30 Days	0.50	0.50	20,789	ESPAD; FCHE
Binge Drinking Participation Within Last 7 Days	0.29	0.45	15,725	ESPAD
Panel C: Alcohol Intoxication				
Prevalence of Drunkenness Within Last 30 Days	0.20	0.40	19,973[#]	ESPAD; FCHE
Degree of Drunkenness (0 to 10 scale) on Last Occasion Within Last 7 Days	1.90	2.63	15,725	ESPAD
Panel D: Covariates				
Gender	0.49	0.50	20,789	ESPAD; FCHE
Preparatory High School	0.42	0.49	20,789	ESPAD; FCHE
Technical/Pre-Vocational School	0.39	0.49	20,789	ESPAD; FCHE
Comprehensive School	0.15	0.36	20,789	ESPAD; FCHE
Apprenticeship, Job, Other	0.03	0.18	20,789	ESPAD; FCHE
College Degree of a Parent	0.28	0.45	20,789	ESPAD; FCHE

Notes: The sample includes teenagers aged 14.5 to 17.5. Survey data on alcohol consumption stem from the Federal Centre for Health Education (FCHE, *Bundeszentrale für gesundheitliche Aufklärung*) including waves FCHE (2005), FCHE (2007), FCHE (2008), FCHE (2011), FCHE (2015) and the European School Survey Project on Alcohol and Other Drugs (ESPAD) covering waves ESPAD (2011) and ESPAD (2007). Binge Drinking within the last 30 days refers to five or more drinks at one sitting. Within the seven-day-consumption window, binge drinking is four or more drinks in a day for a woman and five or more drinks for a man. The degree of drunkenness is measured on a 0 to 10 scale with 0 indicating no impact and 10 a loss of consciousness.
[#]Variable not included in FCHE wave 2005.

Our focus rests on hospital admissions due to acute alcohol intoxication as a severe direct result of excessive alcohol consumption. Following the ICD-10 classification by the WHO ("International Classification of Diseases and Related Health Problems"), we identify alcohol intoxications through ICD code F10.0 of the main diagnosis. This diagnosis is the leading cause of hospital admissions for individuals aged 15 to 17 (Destatis, 2018).

We also consider hospital admissions due to physical injuries, i.e. external causes covered by ICD chapter XIX. However, we cannot further classify an injury by the course of event as it is done in previous studies outside Europe (e.g. Carpenter and Dobkin, 2017; Lindo et al., 2016). Since German hospitals do not code ICD chapter XX, this information is not available to us. By relying on ICD chapter XIX, we thus concentrate on patients with different types of injuries or other consequences of external causes. These can be related to alcohol consumption if drunken teenagers fall or get into a fight. At the same time, these injuries can occur from any kind of traffic accident.

All remaining admissions other than alcohol intoxication and injuries make up a residual category which we denote as internal causes. By this means we obtain three mutually exclusive categories of hospital admissions as summarized in Table 2. Our detailed data on hospital admissions show that drunken teenagers are most likely admitted to the hospital on weekends and during the evening or night (see Fig. A.5 in the Appendix). Moreover, 90% of teenagers with an acute alcohol intoxication leave the hospital within 2 days.[10] We exploit these admission details in the heterogeneity analysis of Section 4.5 to approximate external causes which are most likely a consequence of drinking.

Table 2: Summary Statistics – Hospital Admission Rates

Inpatient Admissions per 10,000 Person-Years	
Acute alcohol intoxication	30.79
External causes	124.99
Internal causes	666.02

Notes: This table contains for three major causes of admission the respective hospitalization rates in 10,000 person-years for teenagers aged 14.5 to 17.5. The hospitalization data stem from a large German health insurer and cover a nationally representative sample of 15% of patients who were hospitalized between 2006 and 2011.

In order to make the number of inpatient admissions comparable across countries, we calculate inpatient admissions rates per $10,000$ person-years. Following Lindo et al. (2016),

[10]Teenagers that are hospitalized with an external cause, in contrast, are admitted to the hospital throughout the week and stay longer (see Fig. A.6 in the Appendix).

we divide the number of cases within each day-of-age bin by 0.15 to approximate the German population, multiply by 365 x 10,000, and divide by the estimated resident population of 16-year-olds in Germany as of 2009. In a last step, we divide by 6 (the number of years of hospital data) to obtain the annualized admission rate for each day-of-age bin. Table 4.2 shows the average admission rates per 10,000 person-years for our sample of teenagers aged 14.5 to 17.5. Although external causes cover many different diagnoses, this category is only four times larger than the group of alcohol intoxication, which consists of one single diagnosis.

3.3. Empirical Strategy

We use a RD approach to estimate the impact of the German MLDA at age 16 on excessive drinking and alcohol-related hospital admissions. That is, we compare teenagers slightly below and above the age cutoff who reveal similar individual characteristics but differ in their legal access to alcohol. Equation 1 formalizes the empirical approach:

$$y_i = X_i^{'}\beta + \delta D_i + f(age_i) + \varepsilon_i \tag{1}$$

where y indicates either a consumption measure or a health outcome of individual i. In our preferred specification, we include observations one-and-a-half years around the age cutoff, but we also vary the bandwidth over a broad range as outlined in the robustness section. Vector X denotes a set of dummy variables for individual i. In the analysis of the monthly consumption data, X captures further information on gender, the current school type, the educational background of the parents, the federal state where someone lives, and the survey wave. X also includes birthday indicators, which turn one in the first month after the birthday to absorb potential celebration effects. In the morbidity analysis, we narrow the time frame of these indicators to the precise birthday given the daily structure of the hospitalization data. Since we use hospitalization rates at each age cell, note that we cannot include individual controls in the morbidity analysis of equation 1.

$f(age_i)$ is a flexible polynomial of the running variable age_i, i.e. someone's age recentered at 16. Following previous RD studies on legal access to alcohol, (e.g. Carpenter and Dobkin, 2017; Hansen and Waddell, 2018), we model the age profile of outcome y by a second order polynomial in relative age, which can take different forms on either side of the cutoff. We check the sensitivity of our findings to different functional forms and local linear regressions in the robustness section.

D_i represents a binary indicator being equal to one for individuals over age 16, and zero otherwise. The focus of the analysis rests on the identification of coefficient δ which indicates the discontinuous jump in the outcome variable y_i at age 16. To ensure local randomization of D_i, any relationship between age and the error term ε_i must trend smoothly through the age cutoff. That is, $f(age_i)$ has to be sufficiently flexible to absorb age-related changes in y and no other unobserved determinants of y should increase discontinuously at the treatment threshold. The graphical representation of the results and the robustness to other functional forms suggest an appropriate fit of the age profile through a quadratic polynomial. To strengthen the credibility in the continuity assumption, we stress the smoothness of observables characteristics at the MLDA. As a further balancing test, we check for any systematic sorting or manipulation of the running variable. In contrast to the process-generated insurance data, personal information cannot be fully verified within a survey. Even though it is impossible to change the own age, there might be scope to misreport it in a survey. Similarly, there might be other confounding treatments related to y that coincide with the MLDA. We address these concerns in the robustness and heterogeneity section.

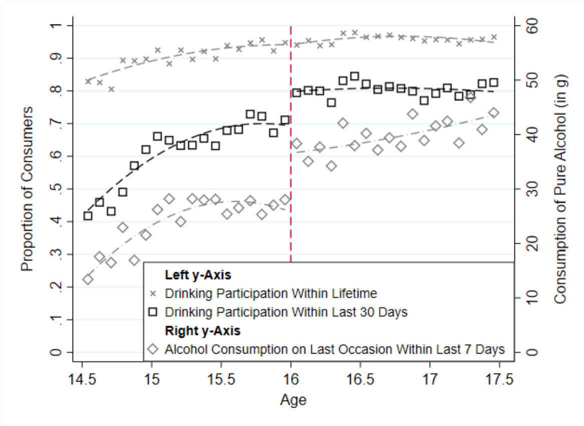
4. Results

4.1. Teenage Alcohol Consumption

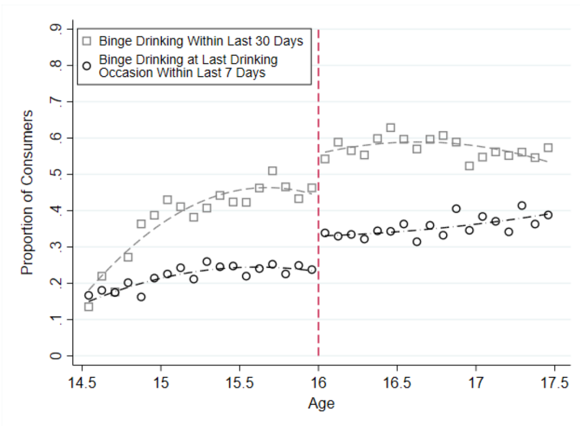
In a first step, we document the age profiles of our consumption measures graphically. Figure 1a includes the age profiles of the overall consumption measures, Figure 1b illustrates the age pattern of excessive drinking outcomes, and Figure 1c shows graphical evidence for different measures of self-assessed drunkenness. Within a figure, each scatter point represents the average outcome at a specific month-of-age cell. In addition, we superimpose in each age profile a quadratic fit which is estimated separately on both sides of the cutoff. Figure 1a reveals for each outcome a discontinuous jump at age 16 except for lifetime consumption. This visual finding points to a considerable impact of the MLDA, but it also suggests that most teenagers experience their first exposure to alcohol already before the 16$^{\text{th}}$ birthday, which dispels potential concerns of structural misreporting at the cutoff. It is also evident that there are high pre-MLDA consumption levels.

Figure 1: Age Profiles of Alcohol Consumption Around Age 16

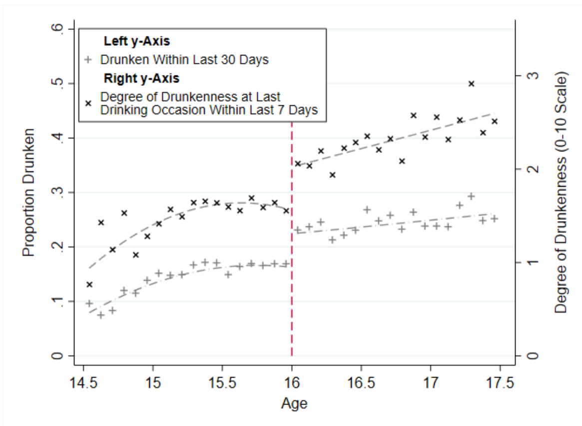
(a) Overall Alcohol Consumption



(b) Excessive Alcohol Consumption



(c) Self-Assessed Drunkenness



Notes: Figures (a) to (c) show for each age cell and consumption type the average monthly drinking behavior. Second order polynomials indicate on each side of the age 16 cutoff the respective age profiles. See notes from Table 1 for further details on the sample.

4.1.1. RD Estimates of Consumption Changes

Table 3 complements the graphical inspection and presents for each outcome the point estimate of the discrete jump at age 16. By default, we include in each regression a set of birthday-dummies and a second order polynomial in age that we fully interact with an indicator for being older or younger than the MLDA. Specifications in the even columns of Table

3, also include individual controls. Following previous MLDA studies (e.g. Hansen and Waddell, 2018) we use robust standard errors.[11]

Table 3: Change in Consumption Behavior at Age 16

	(1)	(2)	(3)	(4)	(5)	(6)
	Within Lifetime		**Within Last 30 Days**		**Within Last 7 Days**	
Panel A *Alcohol Consumption*	Drinking Participation		Drinking Participation		Pure Alcohol (in g) on Last Occasion	
Increase at 16	0.001	-0.002	0.106***	0.096***	10.041***	9.116***
	(0.010)	(0.010)	(0.019)	(0.019)	(2.317)	(2.260)
Mean just under 16	0.945	0.945	0.696	0.697	25.551	25.928
Observations	20,789	20,789	20,789	20,789	15,725	15,725
Panel B *Excessive Alcohol Consumption*			Binge Drinking Participation		Binge Drinking Participation	
Increase at 16			0.133***	0.125***	0.097***	0.088***
			(0.022)	(0.021)	(0.023)	(0.022)
Mean just under 16			0.444	0.444	0.229	0.233
Observations			20,789	20,789	15,725	15,725
Panel C *Self-Assessed Drunkenness*			Prevalence of Drunkenness		Degree of Drunkenness on Last Occasion	
Increase at 16			0.059***	0.057***	0.489***	0.447***
			(0.018)	(0.018)	(0.130)	(0.129)
Mean just under 16			0.162	0.161	1.540	1.548
Observations			19,973	19,973	15,725	15,725
Full Set of Controls	No	Yes	No	Yes	No	Yes

Notes: See notes from Table 1 for a description of the sample and the respective data sources. All regressions use a bandwidth of one and a half years and include a second order polynomial in age fully interacted with a treatment dummy for being older than 16, and dummy variables indicating the birthday if the interview was conducted within the same month. Even columns include additional dummy variables for the survey wave, the federal state of residence, the current type of school/training, gender, and whether one of the parents visited college. The age variable is centered on 16 such that the treatment coefficient interprets as the discontinuous increase at this age. To assess the relative size of an increase, all specifications report the "Mean just under 16" which is the predicted average of the outcome variable for an individual right below age 16 holding all other covariates at their means. Robust standard errors of the estimates are reported underneath in parentheses: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Our regression estimates confirm the graphical findings. For binge drinking and the prevalence of drunkenness within the last 30 days, for instance, we estimate a jump of 12.5 percentage

[11] Note that the statistical inference does not change if we cluster standard errors at the running variable.

points (p.p.) and 5.7 p.p. at age 16, respectively (column 4 of Panels B and C). With reference to the pre-MLDA consumption levels, these changes correspond to a 28% and 35% increase, respectively. All binge-drinking coefficients imply a large impact of the MLDA, but their threshold tends to be arbitrary and may not directly link to the occurrence of adverse events like hospital admissions due to acute alcohol intoxication. Following Dehos (2022), we thus look at the entire drinking distribution to investigate whether the MLDA works differently at different consumption levels. In addition, we contrast the impact of the MLDA at different consumption levels to the degree of drunkenness. By these means, we gain further insights on the effectiveness of the MLDA and its potential to reduce hospital admissions due to severe alcohol intoxication.

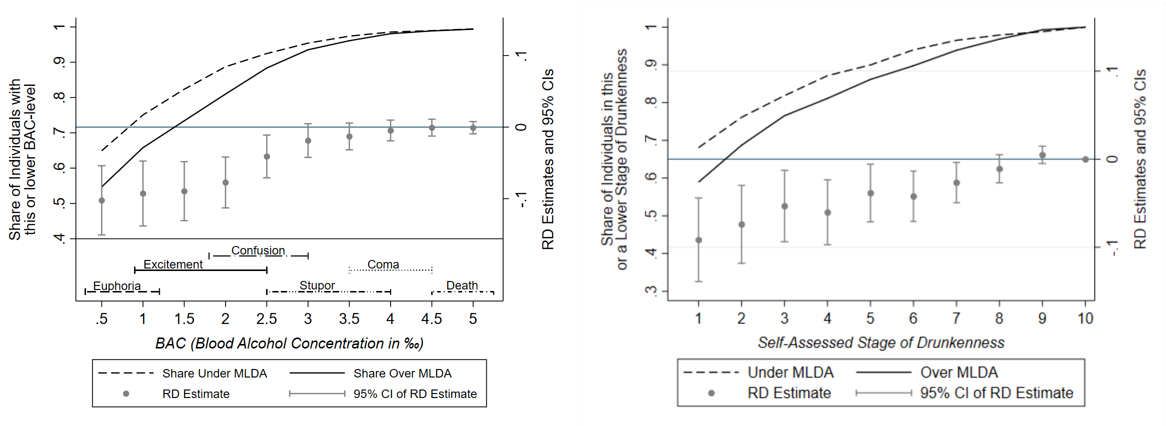
Figure 2 zooms into the consumption behavior at the last drinking occasion within the last seven days. The first graph, i.e. Figure 2a, shows for various consumption levels the corresponding BAC (blood alcohol concentration) levels.[12] The gray dots indicate the BAC difference between individuals right below and right above age 16. The overall impact of the MLDA is strongest for consumption levels below a BAC of 2‰, which coincide with the stages of euphoria, excitement, and confusion. For higher consumption levels, in contrast, MLDA regulations tend to be ineffective. Figure 2b shows a similar pattern for the self-assessed degree of drunkenness. The highest level of drunkenness (scale 10) corresponds to loss of consciousness and is equivalent to the symptom of coma in Figure 2a. Thus, MLDA regulations are more effective in reducing moderate to semi-severe consumption but not excessive levels. A reduction of hospital admissions is therefore more likely to occur for alcohol related injuries rather than for severe alcohol intoxications.

4.2. *Robustness Checks – Teenage Alcohol Consumption*

A comprehensive set of sensitivity checks confirms the robustness of our findings from the consumption analysis along several dimensions. In the following, we briefly describe the different checks, while Appendix B outlines all outcomes in detail. In a first step, we apply different bandwidth choices as shown in Figure B.7. In a second step, we conduct a

[12] See Dehos (2022) for details on the BAC conversion

Figure 2: Impact of MLDA at Different Levels of Alcohol Consumption and Drunkenness at Age 16



(a) Change in BAC-Level

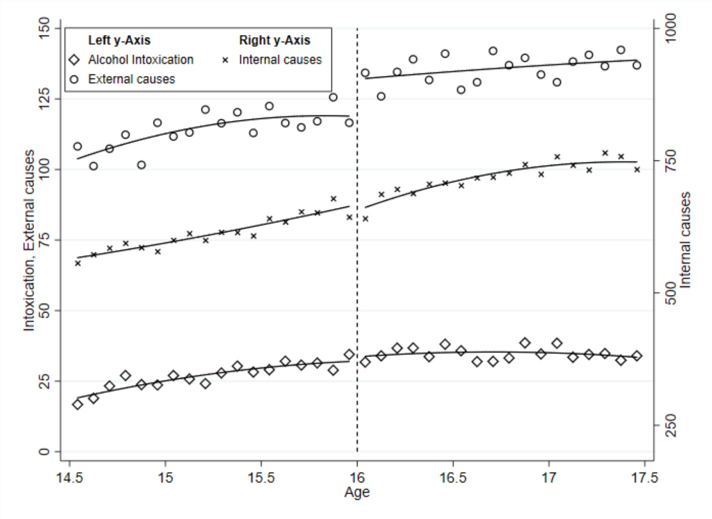
(b) Change in Self-Assessed Degree of Drunkenness

Notes: The dashed (solid) line shows the share of individuals right below (above) the 16^{th} birthday threshold who reached a certain BAC level (Fig. 2a) or reported a specific degree of drunkenness (Fig. 2b) at the last drinking occasion within the last 7 days. The points are the estimated difference and the vertical bars are the respective 95% confidence intervals which are obtained from a regression using a second order polynomial in age fully interacted with a treatment dummy for being older than 16, and dummy variables indicating the birthday if the interview was conducted within the same month.

placebo test and switch the age of an individual with the age of another individual in the sample. Using a Monte Carlo Simulation with 1,000 replications, we obtain a distribution of t-statistics. Following the idea of randomization inference, we contrast this distribution with the t-statistics from the baseline regression using the true age (see Fig. B.8). In a third test, we change the functional form assumption. Table B.7 proves the robustness of the point estimates using a linear age trend (col. 1, 4, 7), a cubic polynomial (col. 2, 5, 8) and a local linear regression with an MSE-optimal bandwidth selector and a triangular kernel (col. 3, 6, 9).

In Table 3, we already documented that the inclusion of covariates leaves our point estimates unaffected. This provides supportive evidence that local randomization around the cutoff is likely to hold. As a more direct test, we check for changes in individual characteristics around age 16 as outlined in Table C.9.

Figure 3: Age Profiles of Inpatient Admission Rates around Age 16



Notes: This Figure shows for each monthly age cell and cause of admission the respective hospitalization rate per 10,000 person-years. Second order polynomials indicate on each side of the age 16 cutoff the respective age profiles. See notes from Table 2 for further details on the data.

4.3. Teenage Hospital Admissions

Figure 3 summarizes our main findings of the hospitalization analysis graphically. The scatter points represent one-month averages for the respective hospital admission rates of alcohol intoxication, external causes, and internal causes. Each line shows a second-order polynomial fit estimated separately on both sides of the 16-year threshold. We observe a smooth increase of alcohol intoxications over the age profile without any discontinuous jump at the 16^{th} birthday. Inpatient admissions for external causes, in contrast, show a clear discontinuity at the birthday threshold. As expected, inpatient admissions for internal causes increase smoothly over the entire age profile.

4.3.1. RD Estimates of Changes in Hospital Admissions

Table 4 shows the discontinuity estimates at age 16 and confirms the graphical evidence. The point estimate for alcohol intoxication is positive, but small in magnitude and not statistically significant. For external causes, in contrast, we find a statistically significant increase of nearly 14 admissions per $10,000$ person-years, representing an increase of about 11.4%. External causes cover hospital admissions due to different kind of physical injuries, e.g., bone fractures or concussion. The observed increase in external causes could be driven by excessive alcohol consumption, if drunken teenagers tumble or get into a fight. At the same time, they can result from accidents with light motorcycles.

Table 4: Change in Hospital Admissions Rates at Age 16

	(1)	(2)	(3)
	Acute intoxication	External causes	Internal causes
Increase at 16	0.927	13.550 ***	-5.701
	(2.284)	(4.322)	(12.879)
Mean just under 16	32.110	118.456	665.022
Observations	1,095	1,095	1,095

Notes: Each observation is the admission rate per 10,000 person-years at a specific day-of-age cell. All regressions use a bandwidth of one and a half years and a second order polynomial in age fully interacted with a treatment dummy for being older than 16, and dummy variables indicating the birthday. The age variable is centered on 16 such that the treatment coefficient interprets as the discontinuous increase at this age. Robust standard errors of the estimates are reported underneath in parentheses: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Unfortunately, our hospitalization data do not allow us to disentangle the direct cause of the injury.[13] Instead, we use information on exact timing and duration of the admission in the heterogeneity analysis. By this means, we narrow external causes to the dimensions where drinking is likely to occur. In addition, we look at supplementary survey data to quantify the impact of an increased use of light motorcycles at age 16. Since teenagers admitted with an acute alcohol intoxication are often unconscious and unable to drive, there is limited scope that this type of admission is confounded by accidents with light motor vehicles.

4.4. Robustness Checks – Hospital Admissions

As outlined in detail in Appendix C, we prove the robustness of our findings from the hospitalization analysis along several dimensions. In a first step, we apply different bandwidth choices (Fig. C.9). In a second step, we conduct a placebo simulation and shuffle the running variable randomly around (Fig. C.10). In a third falsification test, we stress the robustness of our findings using random birthday cutoffs (Fig. C.11). In a last battery of checks, we test the sensitivity to different functional forms as shown in Table C.8. The point estimates are

[13] In contrast to other countries, German hospitals do not code ICD-chapter XX.

robust to the use of a linear age trend (Panel A), a cubic polynomial (Panel B) and a local linear regression with an MSE-optimal bandwidth selector and a triangular kernel (Panel C). Overall, our main findings remain stable across all specifications and confirm the robustness of the results.

4.5. Heterogeneity Analysis – Hospital Admissions

We break down our hospitalization analysis of acute alcohol intoxications and external causes, i.e. physical injuries, by gender, day of the week, and daytime. Since the overall effects might hide important heterogeneities, these insights are crucial. Besides, we can narrow down admissions due to external causes to those dimensions when drinking is likely to occur.

Panel A of Table 5 reveals substantial pre-MLDA gender differences in admissions due to alcohol intoxication, but there is no discontinuous increase at the cutoff for males nor females. Regarding external causes, we observe a large and statistically significant increase of around 13% at the 16$^{\text{th}}$ birthday threshold for boys and a slightly smaller but insignificant increase of 8.5% for girls.

Panel B shows the point estimates separately for admissions during the week (Monday to Thursday) and admissions on the weekend (Friday to Sunday). The hospitalization rate due to alcohol intoxication right below age 16 is much higher on the weekend. On average, 57 acute intoxication cases per $10,000$ person-years are admitted to the hospital on the weekend, while only approximately 14 acute intoxication cases per $10,000$ person-years are admitted to the hospital on a weekday. However, the respective discontinuity estimates are again insignificant. Increases in admissions due to external causes at age 16, in contrast, prove significant during the whole week but the effect is slightly larger at the weekend.

Panel C shows the estimates by time of the day. We classify admissions during 6 am and 7 pm as day cases and all remaining admissions as during the night. Teenagers with an acute alcohol intoxication have a higher admission probability at night: There are 62 acute intoxication cases per $10,000$ person-years during the night and only 6 cases per $10,000$ person-years during the day. But again, there are no statistically significant increases in alcohol intoxication rates at age 16. Regarding external causes, we observe a 12.2% increase in admissions during the day and a 10.4% increase during the night, although only the increase during the day is statistically significant.

Table 5: Heterogeneity Analysis – Change in Hospital Admissions Rates at Age 16

	(1)	(2)	(3)	(4)
Panel A: Gender	Alcohol intoxication		External causes	
	Female	Male	Female	Male
Increase at 16	3.303	-1.647	7.877	18.988***
	(2.518))	(3.828)	(5.547)	(6.783)
Mean just under 16	22.022	42.223	92.403	144.464
Panel B: Weekday	Alcohol intoxication		External causes	
	Week	Weekend	Week	Weekend
Increase at 16	3.079	-1.943	12.141**	15.428**
	(2.140)	(4.838)	(6.039)	(7.216)
Mean just under 16	13.610	56.776	118.469	118.439
Panel C: Daytime	Alcohol intoxication		External causes	
	Day	Night	Day	Night
Increase at 16	0.432	1.511	15.244**	11.547*
	(1.532)	(4.714)	(5.978)	(6.762)
Mean just under 16	6.466	62.415	124.996	110.728

Notes: Each observation is the admission rate per 10,000 person-years at a specific day-of-age cell. All regressions use a bandwidth of one and a half years and a second order polynomial in age fully interacted with a treatment dummy for being older than 16, and dummy variables indicating the birthday. The age variable is centered on 16 such that the treatment coefficient interprets as the discontinuous increase at this age. Admissions from Monday to Thursday count as during the week and admissions from Friday to Sunday as cases on the weekend. Admissions during 6 am and 7 pm are day cases; all remaining admissions count as during the night. Robust standard errors of the estimates are reported underneath in parentheses: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Since alcohol intoxications are much more likely to occur at the weekend and at night and for short term stays of at least two days (see Panel B and C of Table 5 and Fig. A.5), we further restrict the analysis of external causes to those dimensions where drinking is likely to occur. By this means, we aim to capture physical injuries which are likely to happen as a result of drinking. Reassuringly, we detect a discontinuous increase by 21.5 which is statistically significant at the ten percent level.[14] Considering a respective baseline hospitalization level of 86 admissions per 10,000-person years, this change corresponds to a 25% increase, which is more than twice as large as the overall relative increase in external causes (see Table 4). If our assumptions on the timing and duration of alcohol induced hospital admissions hold, we

[14]Note that this results is not included in Table 5.

approximate physically injured drunken teenagers. This provides suggestive evidence, that the discontinuous increase in hospital admissions due external causes is likely to be driven by a legal access to alcohol. In the next subsection, we aim at further disentangling the increase in external causes.

4.6. Pathways and Mechanism – Hospital Admissions due to External Causes

In this subsection, we add supplementary data sources and descriptive evidence to our analysis of external causes to explain the increase at the 16th birthday and its potential mechanisms. Since German hospitals do not code ICD-chapter XX, we cannot differentiate admissions of physically injured teenagers by its cause. We thus look at supplementary survey and victimization data to identify mechanisms of the German MLDA and a potentially confounding impact of a driver's license for light motorcycles at age 16.

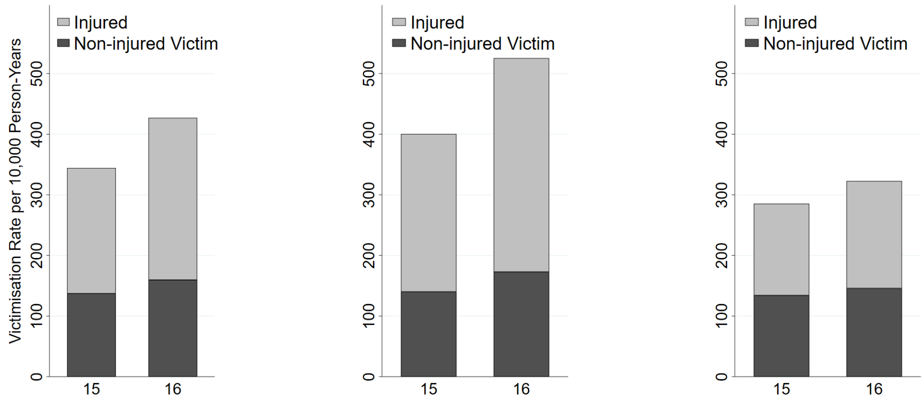
First, we exploit victimization data from the German Crime Statistics which includes all offenses with potential use of violence. Drawing on a special data extract provided by the Federal Police Office of the state of Schleswig-Holstein we can further differentiate injured and non-injured victims.[15] From age 15 to 16, we observe a substantial increase in the victimization rate of injured individuals, while the rate of non-injured victims remains almost unchanged (see Panel A of Fig. 4). This increase coincides with our detected discontinuity in hospital admissions due to external causes and happens primarily to male teenagers as outlined in graphic (b) and (c) of Panel A. Furthermore, victimization increases are driven by assaults, incidences on the weekend, and cases without pre-existing perpetrator-victim-relationship (see Panel B). While we cannot track whether injured victims end up in a hospital, the descriptive outline of Figure 4 points to a plausible pathway to more admissions due to physical injuries at age 16. Besides, findings coincide with recent MLDA studies on victimization in the Netherlands and the US (see Chalfin et al., forthcoming; Bindler et al., 2021).

In a second step, we draw on the KiGGS baseline study, a representative health survey on children and adolescents in Germany (RKI, 2019) that includes detailed information on the last accident. We differentiate between traffic accidents and injuries due to falls and whether

[15] Since the age of victims is covered on a yearly basis only, we cannot run RD regressions.

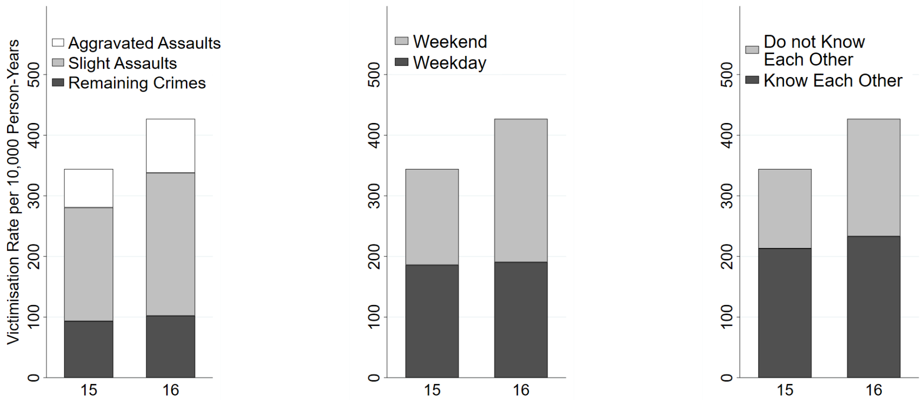
Figure 4: Victimization at the MLDA Through Offenses With Potential Use of Violence

Panel A: Injured and Non-injured Victims



(a) Overall Victimization (b) Male Victims (c) Female Victims

Panel B: Heterogeneity in Victimization



(d) Type of Offense (e) Weekend and Weekday (f) Victim-Perpetrator Relationship

Notes: Figures (a) to (f) show for 15- and 16-year-old teenagers the victimization rates by different socio-demographic and criminological characteristics. Victimization data stem from the Federal Police Office of the German state of Schleswig-Holstein covering the years 2005 to 2015. Following the guidelines for maintaining the Police Crime Statistics, victimization data include all offenses with potential use of violence.

these incidents result in an inpatient hospital admission. As outlined in Panel A of Table 6, the probability of a traffic accidents increases by 1.6 p.p. from age 15 to 16. Consistent with a novice driver effect for light motorcycles, this increase is fully captured by bike accidents (Panel A). A further differentiation reveals a mere shift in bike accidents without a subsequent hospital stay, while inpatient admissions remain unaffected. In sum, these findings mitigate the concern of an increased use of light motorcycles at age 16 as the underlying pathway to more hospital admissions of physically injured teenagers. If anything, the confounding impact remains small.

Table 6: Last Accident Within Past 12 Months

	(1)	(2)	(3)
	Probability of Occurrence		
	at Age 15	at Age 16	Difference
Panel A: Traffic Accidents			
Overall	0.010	0.026	0.016**
by Bike...	0.004	0.020	0.016***
with hospital admission	0.003	0.003	0.000
w/o hospital admission	0.002	0.017	0.015***
Panel B: Fall/Tumble			
Overall	0.072	0.096	0.024*
in Public...	0.054	0.091	0.037***
with hospital admission	0.008	0.021	0.013*
w/o hospital admission	0.046	0.070	0.024*

Notes: The sample includes 1,874 observations covering 15- and 16-year-old teenagers. Data stem from an extended version of the KiGGS baseline study provided by RKI (2019). The indicated means and differences are obtained from univariate regressions using sampling weights and robust standard errors: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

In a last step, we look at accidents due to falls and tumbles (see Panel B of Table 6). The overall probability of a such accidents increases by 2.5 p.p. from age 15 to 16. Since teenagers tend to go out more frequently if they are allowed to drink (Chalfin et al., forthcoming), it is consistent to observe this shift for incidents in public places with an increase in falls with and without subsequent hospital stays. The latter finding coincides with our hospitalization analysis of external causes at age 16 and discontinuities in teenage alcohol consumption at the lower end of the distribution where falls are likely to occur. Taken together, we can verify the overall increase in inpatient admissions due to physical injuries in this subsection, while alleviating the concern of a confounding novice driver effect for light motorcycles.

5. Conclusion

While previous MLDA studies on health consequences focus mainly on mortality outcomes and adolescents aged 18 or above, our analysis adds to the literature by examining excessive drinking behavior and alcohol-related hospital admissions of teenagers aged 16. We focus on acute alcohol intoxication, which is the leading cause why teenagers aged 15 to 17 are admitted to the hospital in Germany (Destatis, 2018). In addition, we analyze external causes, i.e. admissions of physically injured teenagers.

Our results reveal substantial increases in alcohol consumption at age 16, but negligible effects at the upper end of the drinking distribution, where coma and death occur. Consistently, there is no discontinuity in hospital admissions of acute alcohol intoxications at the birthday threshold. The latter finding stands in contrast to evidence on the MLDA-morbidity relationship from the US at age 21 (Carpenter and Dobkin, 2017) and a recent hospitalization study by Ahammer et al. (2022) on Upper Austria at age 16. In line with our results, Datta Gupta and Nilsson (2020) do not find an impact of the Danish access restriction at age 16 on admissions due to alcohol intoxication either. Our findings thus emphasize the importance of cross-country studies of seemingly similar settings. Despite similar average consumption levels in Austria and Germany and a broad availability of alcohol in both countries, cultural differences in excessive drinking (WHO, 2016a) may influence the effectiveness of the MLDA in reducing hospitalization due to acute alcohol intoxication.

Our analysis of inpatient admissions due to physical injuries reveals a significant 11% increase at age 16, which coincides with consumption increases at the lower end of the drinking distribution when teenagers fall or get into a fight. We provide supplementary evidence that this increase is primarily driven by legal access to alcohol and not by a potentially confounding novice driver effect for light motorcycles for at least three reasons: First, we find an even larger increase for physical injuries on dimensions where drinking is likely to occur, i.e. short-term admissions during the night on weekends. Second, victimization of injured teenagers increases from age 15 to 16, while the rate of no-injured remains almost unchanged. Thirdly, survey data on teenage health behavior reveals no changes in inpatient admissions due to bike accidents, but increases in hospitalization due to falls.

Insights along the full drinking distribution further suggest that consumption changes trace back to a minor group of teenagers: 66% of teenagers never exceed, for instance, a BAC level of 1 even though they are legally allowed at age 16. At the same time, only 9% of teenagers increase their consumption level above a BAC of 1 while 25% drink always more irrespective of the age restrictions. Compared to excessive consumption shocks, immediate symptoms might be less severe at lower BAC levels. However, there are adverse long-term consequences such as impairments of the brain (Bonnie and O'Connell, 2004) that come along with persistent increases at these levels. Even though we are unable to quantify these long-term consequences within the present study, there is scope for a stricter enforcement of the German MLDA or sanctions that directly aim at teenagers.

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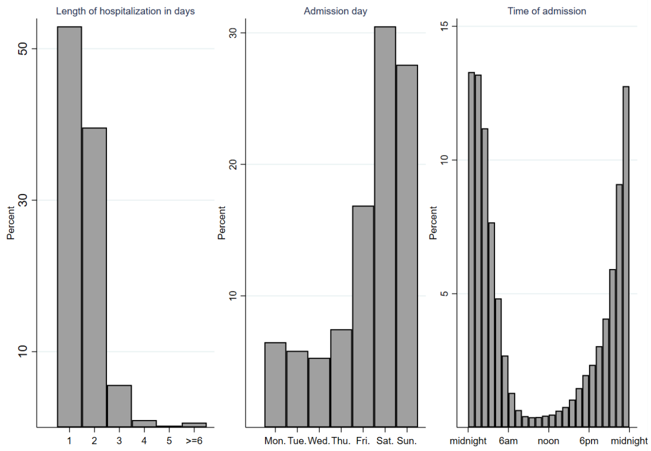
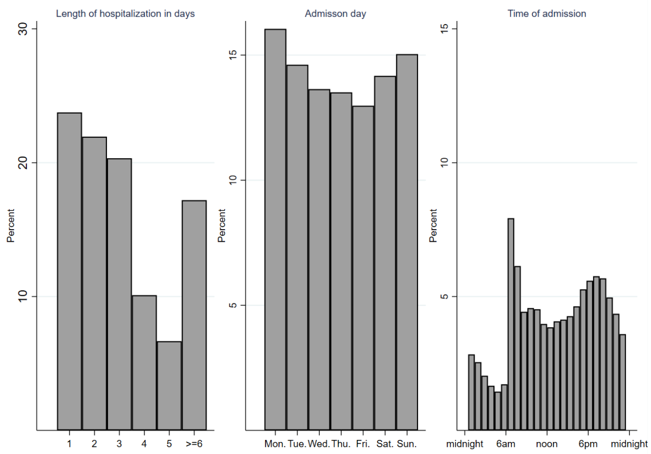
Appendix A. Hospital Admission Data

Figure A.5: Hospital Admissions Due to Acute Alcohol Intoxication



Notes: This figure shows the distribution of hospital admissions due to acute alcohol intoxication by length of stay, admission day, and time of admission. Cases that are admitted at exactly 0.00am are dropped, since these are potential coding errors. See notes of Table 2 for further information on the hospitalization data.

Figure A.6: Hospital Admissions Due to External Causes



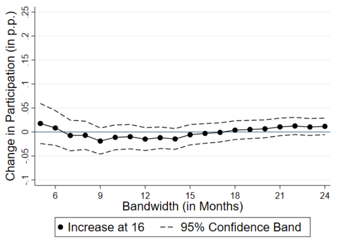
Notes: This figure shows the distribution of hospital admissions due to external causes by length of stay, admission day, and time of admission. Cases that are admitted at exactly 0.00am are dropped, since these are potential coding errors. See notes of Table 2 for further information on the hospitalization data.

Appendix B. Robustness Checks – Consumption Analysis

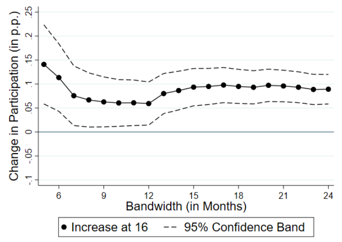
Figure B.7: Robustness to Bandwidth Choice – Consumption Behavior at Age 16

Panel A: Change in Overall Consumption at Age 16

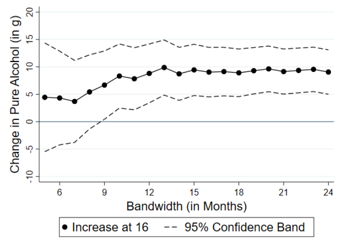
(a) Drinking Participation Within Lifetime



(b) Drinking Participation Within Last 30 days

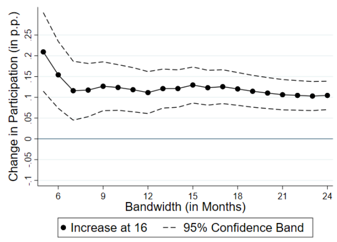


(c) Overall Amount on Last Occasion Within Last 7 Days

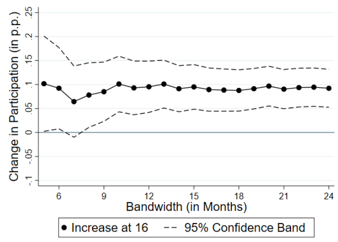


Panel B: Change in Excessive Drinking at Age 16

(d) Binge Drinking Participation Within Last 30 Days

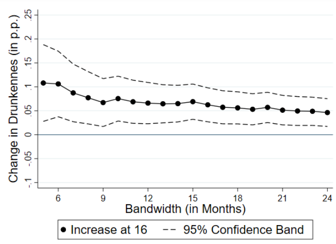


(e) Binge Drinking Participation Within Last 7 Days

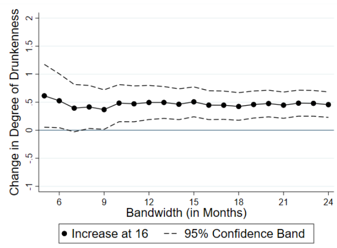


Panel C: Change in Self-Assessed Drunkeness at Age 16

(f) Prevalence of Drunkenness Within Last 30 Days



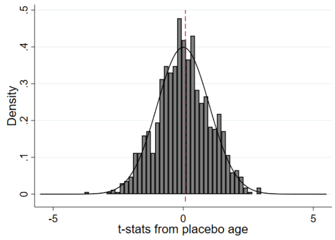
(g) Degree of Drunkenness (0 to 10) on Last Occasion Within Last 7 Days



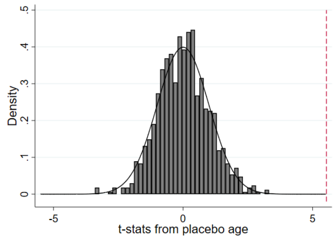
Notes: Figures (a)-(g) show for different bandwidth choices the estimates of a discrete change in the consumption behavior at age 16 and the respective 95% confidence bands. Each regression includes a quadratic polynomial in age fully interacted with an indicator variable for age over 16 and a full set of covariates.

Figure B.8: Placebo Age – Consumption Behavior at Age 16

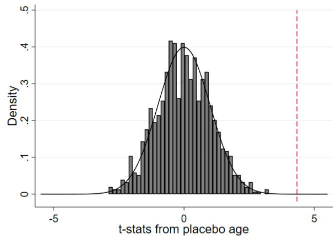
Panel A: Drinking Participation



(a) Lifetime Consumption

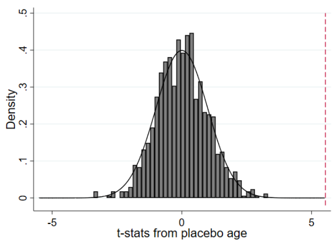


(b) Consumption Within Last 30 days

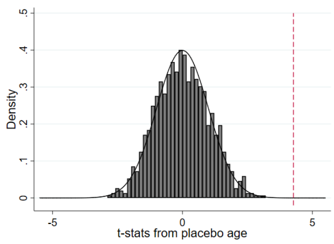


(c) Overall Amount on Last Occasion Within Last 7 Days

Panel B: Drinking Frequency

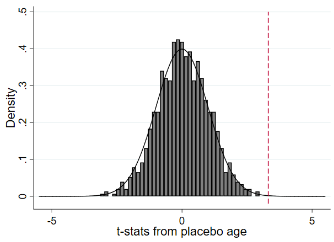


(d) Binge Drinking Participation Within Last 30 Days

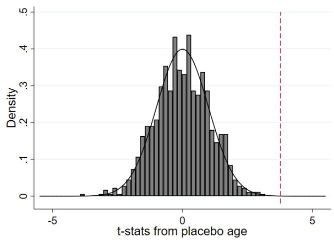


(e) Binge Drinking Participation Within Last 7 Days

Panel C: Drinking Intensity



(f) Prevalence of Drunkenness Within Last 30 Days



(g) Degree of Drunkenness (0 to 10) on Last Occasion Within Last 7 Days

Notes: Each figure shows the empirical distribution of t-statistics for the regression discontinuity (RD) estimates at age 16 that are obtained from a Monte Carlo Simulation based on 1,000 replications. Using the indicated outcome variable and the baseline RD specification, each replication randomly substitutes the age of an individual with the age of another individual in the sample. Each regression includes a quadratic polynomial in placebo age fully interacted with an indicator variable for placebo age over 16 and a full set of covariates. The vertical red dashed line of a figure represents the t-statistics from the baseline regression using the true age.

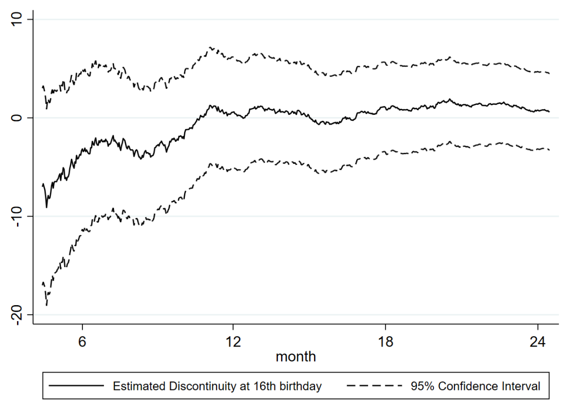
Table B.7: Functional Form – Change in Alcohol Consumption at Age 16

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Within Lifetime			**Within Last 30 Days**			**Within Last 7 Days**		
Specification	linear	cubic	local linear	linear	cubic	local linear	linear	cubic	local linear
Panel A Alcohol Consumption	Drinking Participation			Drinking Participation			Pure Alcohol (in g) on Last Occasion		
Increase at 16	-0.005	-0.021	-0.002	0.050***	0.058**	0.095***	6.958***	7.678**	8.718***
	(0.006)	(0.015)	(0.011)	(0.012)	(0.028)	(0.022)	(1.432)	(3.377)	(2.891)
Observations	20,789	20,789		20,789	20,789		15,725	15,725	
Panel B Excessive Alcohol Consumption				Binge Drinking Participation			Binge Drinking Participation		
Increase at 16				0.079***	0.122***	0.109***	0.069***	0.099***	0.095***
				(0.013)	(0.031)	(0.024)	(0.014)	(0.034)	(0.024)
Observations				20,789	20,789		15,725	15,725	
Panel C Self-Assessed Drunkenness				Prevalence of Drunkenness			Degree of Drunkenness on Last Occasion		
Increase at 16				0.040***	0.083***	0.040	0.326***	0.531***	0.477***
				(0.011)	(0.026)	(0.026)	(0.082)	(0.192)	(0.136)
Observations				19,973	19,973		15,725	15,725	

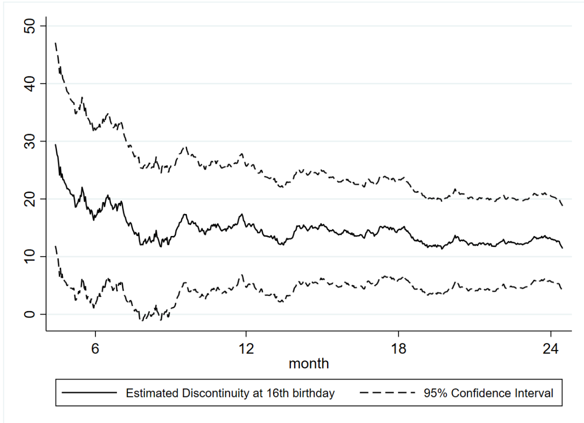
Notes: Age is centered on 16 such that the treatment coefficient interprets as the discontinuous increase at this age. All regressions use a bandwidth of one and a half years. Columns (1), (4), and (7) include a linear age trend [columns (2), (5), and (8) a third order polynomial in age] fully interacted with a treatment dummy for being older than 16, and dummy variables indicating the birthday. Columns (3), (6), and (9) show the results of a local linear regression using an MSE-optimal bandwidth selector and a triangular kernel. Robust standard errors of the estimates are reported underneath in parentheses: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Appendix C. Robustness Checks – Hospitalization Analysis

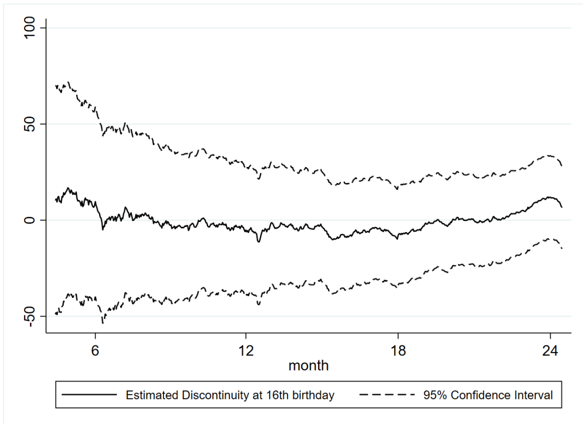
Figure C.9: Robustness to Bandwidth Choice – Hospital Admission Rates at Age 16



(a) Alcohol Intoxication



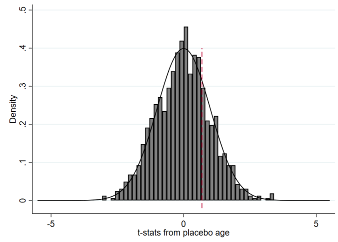
(b) External Causes



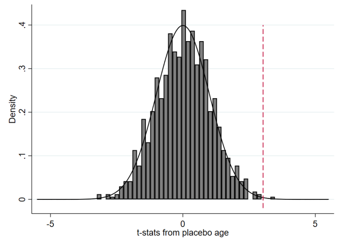
(c) Internal Causes

Notes: Figures (a)-(c) show for different bandwidth choices the estimates of a discrete change in hospital admission rates (in 10,000 person-years) at age 16 and the respective 95% confidence bands. All specifications include a quadratic polynomial in age fully interacted with an indicator variable for age over 16 and a set of birthday-dummies.

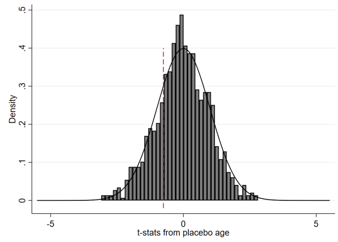
Figure C.10: Placebo Age – Hospital Admission Rates at Age 16



(a) Alcohol Intoxication



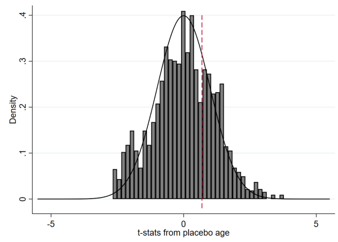
(b) External Causes



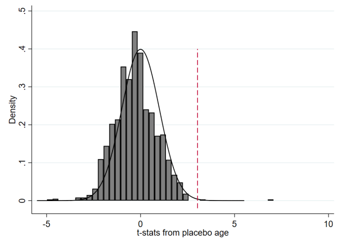
(c) Internal Causes

Notes: Each figure shows the empirical distribution of t-statistics for the regression discontinuity (RD) estimates at age 16 that are obtained from a Monte Carlo Simulation based on 1,000 replications. Using the indicated outcome variable and the baseline RD specification, every replication randomly interchanges the day-of-age information of the aggregated hospitalization rates. Each regression includes a quadratic polynomial in placebo age fully interacted with an indicator variable for placebo age over 16 and a set of birthday dummies. The vertical red dashed line of a figure represents the t-statistics from the baseline regression using the true day-of-age information.

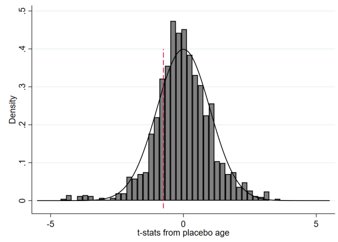
Figure C.11: Placebo Cutoff – Hospital Admission Rates at Age 16



(a) Alcohol Intoxication



(b) External Causes



(c) Internal Causes

Notes: Each figure shows the empirical distribution of t-statistics that are obtained from regression discontinuity (RD) estimates based on placebo cutoffs. The placebo cutoffs are drawn separately from the left and from the right side of the true threshold, i.e. age 16 (1000 reps on each side). Each placebo estimation includes only observations from that same side in order to avoid potential mis-specification due to assuming continuity at the true threshold. As a further condition, each placebo regression requires at least 8 observations on each side of the newly specified placebo cutoff.

Table C.8: Functional Form – Change in Hospital Admissions Rates at Age 16

	(1)	(2)	(3)
	Alcohol intoxication	External causes	Internal causes
Panel A: *Linear age trend*			
Increase at 16	0.974	10.353***	13.041
	(1.540)	(2.967)	(8.099)
Mean just under 16	33.670	122.277	663.278
Panel B: *Cubic age trend*			
Increase at 16	-1.033	15.983***	-4.235
	(3.051)	(5.721)	(18.286)
Mean just under 16	33.668	116.959	665.075
Observations	1,095	1,095	1,095
Panel C: *Local linear regression*			
Increase at 16	1.507	12.974***	-8.926
	(2.335)	(4.236)	(18.835)

Notes: Each observation is the admission rate per 10,000 person-years at a specific day-of-age cell. All regressions use a bandwidth of one and a half years. Age is centered on 16 such that the treatment coefficient interprets as the discontinuous increase at this age. Specifications of Panel A (B) include a linear age trend (third order polynomial in age) fully interacted with a treatment dummy for being older than 16, and dummy variables indicating the birthday. Specifications of Column C show the results of a local linear regression using an MSE-optimal bandwidth selector and a triangular kernel. Robust standard errors of the estimates are reported underneath in parentheses: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table C.9: Change in Sample Characteristics at Age 16

	Preparatory High School	Comprehensive School	Technical / Vocational School	Apprenticeship, Job, Other	Male	College Degree Parent	Number of Survey Participants
Panel A: Overall Sample							
Increase at 16	0.023	-0.002	-0.021	-0.001	0.001	0.018	70.910
	(0.037)	(0.024)	(0.017)	(0.007)	(0.019)	(0.015)	(50.317)
Mean just under 16	0.393	0.437	0.150	0.020	0.486	0.282	713
Panel B: ESPAD Sample							
Increase at 16	-0.015	0.036	-0.022		-0.004	-0.024	47.250
	(0.046)	(0.030)	(0.021)		(0.021)	(0.024)	(52.660)
Mean just under 16	0.410	0.431	0.159		0.479	0.280	585

Notes: Individual characteristics are included in the consumption data which stem from the Federal Centre for Health Education (FCHE) and the European School Survey Project on Alcohol and Other Drugs (ESPAD) covering the years 2005 to 2015. Age is centered on 16 such that the treatment coefficient interprets as the discontinuous increase at this age. For the number number of survey participants, the dependent variable is the number of individuals interviewed at a monthly age cell. All regressions use a bandwidth of one and a half years and include a second order polynomial in age fully interacted with a treatment dummy for being older than 16, and dummy variables indicating the birthday if the interview was conducted within the same month. Since ESPAD interviews students only, there is no information on those who do not stay in school. However, this is a minority in Germany at this age. Robust standard errors of the estimates are reported underneath in parentheses: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.