“Does alcohol consumption at the age of 21 causally increase the fatal of car crashes among drivers?”

I. Abstract

In the United States, alcohol-related traffic accidents remain a major public safety concern, especially among adults who have just turned 21 and can legally consume alcohol. This study examines whether alcohol consumption at the age of 21 causally increases the likelihood of fatal car crashes. Using data from the National Highway Traffic Safety Administration (NHTSA) for the period 2019–2023, we apply a fuzzy regression discontinuity design that exploits the discontinuous change in legal drinking eligibility at age 21 as an instrument for alcohol involvement. The first-stage results confirm that alcohol consumption at age 21 increases significantly. However, the two-stage least squares (2SLS) estimates show no statistically significant causal effect of alcohol consumption on fatal crashes near the age of 21. These findings suggest that although alcohol use rises sharply at the legal drinking age, it does not translate into a higher risk of fatal accidents among young drivers.

II. Introduction

Alcohol-impaired driving remains one of the leading causes of traffic fatalities in the United States. According to the National Highway Traffic Safety Administration (NHTSA), nearly one-third of all traffic deaths involve a driver with a blood alcohol concentration (BAC) above 0.08%, the legal threshold uniformly adopted by all 50 states in 2005. Despite decades of policy interventions aimed at reducing drunk driving, alcohol-related crashes continue to pose substantial public health and economic challenges. Young adults—particularly those who have just reached the legal drinking age—represent a high-risk group for both alcohol consumption and risky driving behavior.

The Minimum Legal Drinking Age (MLDA) of 21, established nationwide in 1984, has been one of the most influential alcohol-control policies in the United States. A large body of research shows that raising the drinking age substantially reduces alcohol consumption and related harms. For example, Carpenter and Dobkin (2009) identify a sharp increase in alcohol consumption and mortality at age 21 using a regression discontinuity design, while Dee (1999) finds that states adopting a higher drinking age experienced significant declines in traffic fatalities. These studies emphasize the role of the MLDA in shaping drinking behavior and improving road safety outcomes.

However, less attention has been paid to whether turning 21—the point at which individuals gain legal access to alcohol—directly increases the likelihood of alcohol-related traffic fatalities in recent years. This localized effect is important because young adults just above the legal threshold are the most likely to engage in heavy episodic drinking and impaired driving.

This study examines whether reaching the legal drinking age of 21 causally increases the risk of alcohol-related traffic fatalities in the United States. Using microdata from the National Highway Traffic Safety Administration (NHTSA) covering the period 2019–2023, we implement a fuzzy regression discontinuity design (RDD) that exploits the discontinuous change in legal drinking eligibility at age 21 as an instrument for alcohol involvement. The first-stage results confirm a sharp increase—approximately 5.9%—in alcohol consumption at the age threshold, indicating strong compliance with the policy. However, the two-stage least squares (2SLS) estimates reveal no statistically significant increase in the probability of fatal crashes. These findings suggest that while turning 21 leads to higher alcohol use, the resulting increase in drinking does not translate into a higher risk of fatal accidents among young drivers.

III. Data

This study uses micro-level data from the National Highway Traffic Safety Administration (NHTSA) covering the years 2019 to 2023. The dataset provides detailed information on traffic crashes, driver characteristics, alcohol test results, and crash outcomes for all U.S. states. To estimate the causal impact of legal drinking eligibility on alcohol-related crashes, the analysis focuses on five key variables: the driver's age, blood alcohol concentration (BAC), crash severity (measured by fatal or severe outcomes), state, and year of the incident.

After combining and cleaning multiple yearly files, observations were restricted to drivers aged 18 to 24, a range that closely surrounds the legal drinking threshold of 21. Cases with missing or invalid BAC readings and those with unclassified outcomes were removed. The final sample consists of approximately 27,742 driver-level observations, ensuring sufficient statistical precision to estimate discontinuities around age 21.

IV. Research Design and Methodology

The goal of this study is to estimate the causal impact of alcohol consumption on the likelihood of severe or fatal traffic accidents. To address potential endogeneity in drinking behavior, the analysis employs a fuzzy regression discontinuity design (RDD) that exploits the discontinuous change in legal drinking eligibility at the Minimum Legal Drinking Age (MLDA) of 21 as an exogenous source of variation in alcohol consumption. The key intuition is that drivers just below and just above the age threshold are similar in all observable and unobservable characteristics, except for their legal ability to purchase and consume alcoholic beverages. Therefore, any discrete change in the probability of severe or fatal crashes at the cutoff can be interpreted as the causal effect of alcohol consumption on crash outcomes. To control for time-invariant regional factors and yearly policy changes, the model includes state and year fixed effects.

Model Specification:

The framework is surrounded by the age from 18 to 24, creating narrow window around the policy cutoff to approximate local random assignment. The running variable which measures each driver's age relative to the legal drinking threshold is defined as:

$$\boldsymbol{Running\ variable = AGE_i - 21}$$

The treatment variable equals one if the driver is legally permitted to drink alcohol which is defined as:

$$\boldsymbol{TREATMENT_i = 1\ if\ AGE_i \geq 21}$$

As shown in Figure 1, the average rate of alcohol use among drivers under 21 remains notably above zero. Specifically, at ages 18, 19, and 20, the proportion of drivers with a blood alcohol concentration (BAC) above 0.08% is approximately 38%, 41%, and 45%, respectively. This pattern indicates that not all individuals comply perfectly with the minimum legal drinking age. Some drivers below 21 consume alcohol illegally, while some drivers above 21 choose to abstain. Consequently, treatment assignment around the cutoff is imperfect, confirming that the regression discontinuity design is fuzzy rather than sharp.

<u>First stage:</u>

$$\boldsymbol{Alcohol\_use\_predicted_i = \alpha_0 + \alpha_1 * Treatment + f(Age) + f(Age)^2 + StateFE + YearFE + \epsilon_i}$$

Second stage (LATE estimate):

$$\boldsymbol{Fatal\ Accident_i = \beta_0 + \beta_1 Alcohol\_use\_predicted_i + f(Age) + f(Age)^2 + StateFE + YearFE + \mu_i}$$

Identification Assumptions

To validate the identification strategy, several diagnostic checks were performed. First, as shown in Figure 2, the average of alcohol consumption increases sharply to 0.53 at the age of 21 from 0.45 at the age of 20 , consistent with the legal drinking threshold. Furthermore, Table 1 reports that the first-stage estimates indicate a statistically significant 5.9% increase in alcohol use at the legal drinking age, with an F-statistic of 17.89 , significant at the 10% level. These results confirm that using age 21 as an instrumental variable for alcohol consumption is relevant and strong.

In addition, Figure 3 presents a histogram of the distribution of driver ages in the sample. The distribution is smooth and continuous around the cutoff, with no visible spikes or gaps at the threshold. This suggests that there is no manipulation or sorting in the running variable (age), supporting the continuity assumption required for a valid regression discontinuity design.

V. Result:

For the first stage, Table 1 shows that the coefficient on treatment is 0.059 ($p < 0.01$). This indicates that turning 21 increases the probability of alcohol use by approximately 5.9 percentage points. The first-stage F-statistic =17.89 exceeds the conventional threshold of 10, confirming that the instrument — being age 21 or older — is strongly relevant. In addition, many of the state and year dummy variables are statistically significant such as Alaska, California, Texas,etc. suggesting meaningful variation in alcohol use across states and over time.Table 2 presents the fuzzy regression discontinuity estimates using legal drinking eligibility as an instrument for alcohol use. The estimated coefficient on alcohol use is −0.1505 ($p = 0.33$), indicating no statistically significant causal effect of alcohol consumption on the probability of fatal accidents among drivers near the age of 21. Although the point estimate is negative, it is not statistically distinguishable from zero, suggesting that the increase in drinking induced by turning 21 does not translate into a higher risk of fatal crashes.

VI. Robustness check:

To support the research results, robustness checks were conducted. First, different bandwidths of ±2, ±3, and ±4 years around the cutoff age of 21 were used to re-estimate the model. Table 4 indicates that none of the bandwidth specifications yield statistically significant results. These estimates confirm that, across all specifications, the effect of alcohol use on fatal accidents remains statistically insignificant and similar in magnitude, verifying that the main finding is not driven by the choice of bandwidth. Second, placebo cutoffs were implemented at ages 19, 20, 22, and 23 to test whether discontinuities appear at other points in the age distribution where no policy change occurs. The results in Table 3 show one significant discontinuity in fatal crashes at the age of 20, while the other cutoff points are insignificant. This placebo test supports the validity of the 21-year cutoff as the only policy-driven discontinuity. In conclusion, these robustness checks confirm that the findings are not sensitive to bandwidth selection or age thresholds, reinforcing the reliability of the main results

VII. Discussion and Conclusion

This study provides evidence that although turning 21 significantly increases alcohol consumption, it does not translate into a higher likelihood of fatal traffic accidents. Using a fuzzy regression discontinuity design with state and year fixed effects, the findings indicate that the minimum legal drinking age (MLDA) policy remains effective in limiting underage drinking without increasing fatal crashes once individuals become legally eligible to drink.

Nevertheless, this study has several limitations. The dataset does not include exact birthdates, so some drivers recorded as age 21 may, in fact, be slightly younger (for example, 20.48 years old). This imprecision in measuring the running variable may introduce minor noise around the cutoff and slightly weaken the discontinuity. Additionally, the data only capture drivers involved in traffic violations or crashes, which may limit the generalizability of the results to the broader population of young drivers. Those who drink responsibly or do not experience crashes are not observed in the data. Despite these caveats, robustness checks conducted across different bandwidths and cutoff ages support the credibility of the identification strategy.

Overall, the results emphasize that while the MLDA continues to play an important role in shaping drinking behavior, future analyses could be strengthened by incorporating additional covariates—such as time of day (daytime or nighttime), weather conditions, or road characteristics—to improve model precision and better capture contextual risk factors. Future research should also explore heterogeneous effects across gender, geographic regions, and socioeconomic groups to provide more nuanced policy insights into the relationship between alcohol consumption and traffic fatalities.

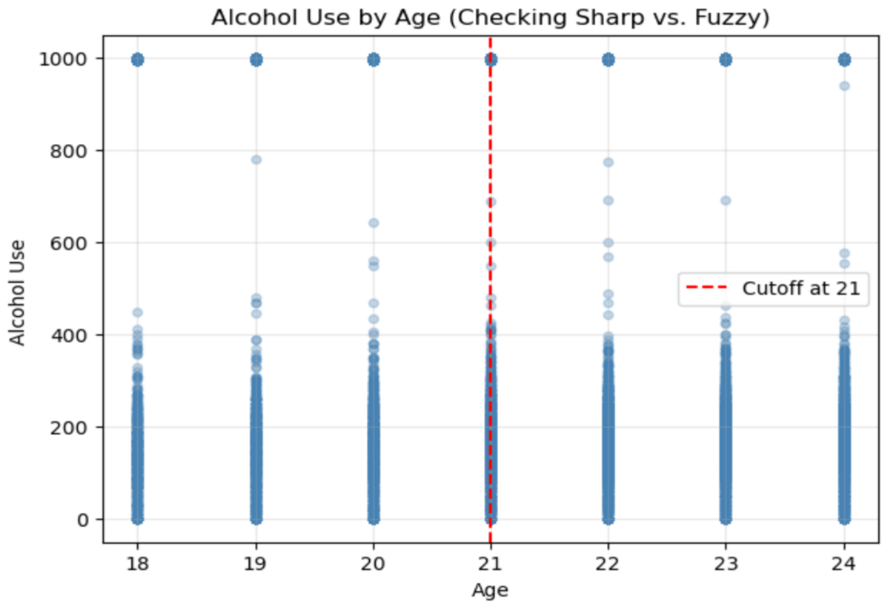

Figure 1. Alcohol Use by Age (Checking Sharp vs. Fuzzy)

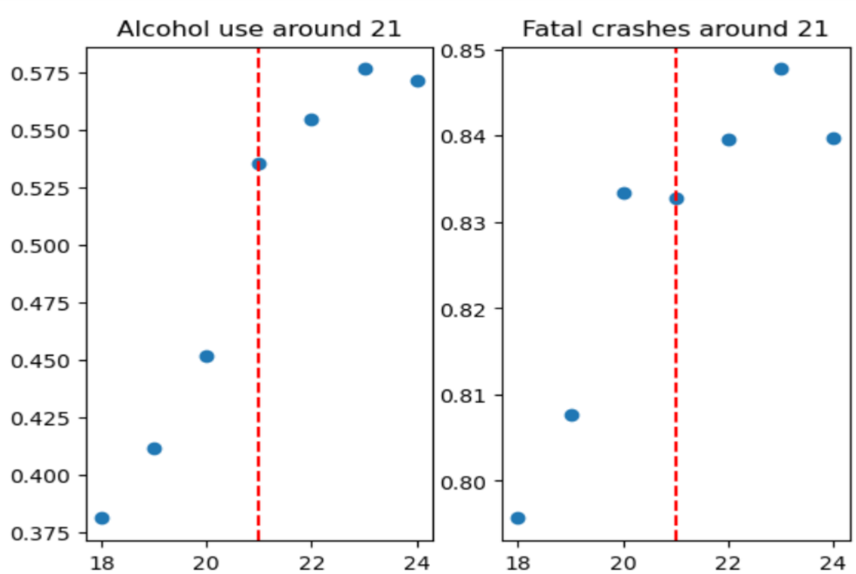

Figure 2. Alcohol Use and Fatal Crashes around the Legal Drinking Age

Note: Axis-x indicates the age from 18 to 24, while axis-y indicates average of alcohol consumption on the left and fatal crashes on the right.

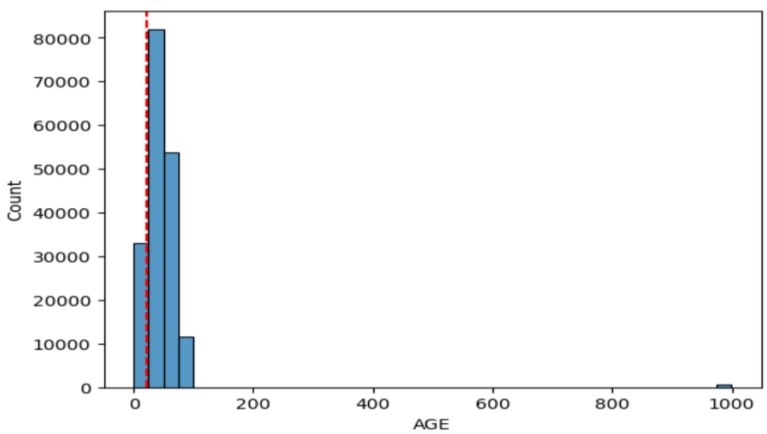

Figure 3. Distribution of the Running Variable (Age) around the Cutoff

DEPENDENT VARIABLE: ALCOHOL USE (BAC > 0.08)	COEFFICIENT	STD. ERROR	Z-STAT	P-VALUE	95% CONFIDENCE INTERVAL
TREATMENT (AGE ≥ 21)	**0.0591***	(0.0140)	4.23	0.000	[0.032, 0.087]
CONSTANT	0.2048***	(0.0190)	11.03	0.000	[0.168, 0.241]
AGE (CENTERED)	0.0224***	(0.0030)	8.42	0.000	[0.017, 0.028]
AGE² (CENTERED)	-0.0033***	(0.0010)	-3.17	0.002	[-0.005, -0.001]
STATE FIXED EFFECTS	Yes				
YEAR FIXED EFFECTS	Yes				
OBSERVATIONS	27,742				
R-SQUARED	0.082				
ADJ. R-SQUARED	0.080				
FIRST-STAGE F-STATISTIC	**17.89**				

NOTE: CLUSTER-ROBUST STANDARD ERRORS IN PARENTHESES.
***P < 0.01, **P < 0.05, *P < 0.1.

Table 1. First-Stage Regression: Effect of Turning 21 on Alcohol Use

DEPENDENT VARIABLE: FATAL ACCIDENT (DOA = 7 OR 8)	COEFFICIENT	STD. ERROR	T-STAT	P-VALUE	95% CONFIDENCE INTERVAL
Alcohol Use (Instrumented by Age ≥ 21)	**-0.1505**	**(0.1555)**	**-0.97**	**0.333**	**[-0.455, 0.154]**
Constant	**0.8212*** **	**(0.0375)**	**21.91**	**0.000**	**[0.748, 0.895]**
Age (centered)	**0.0123** **	**(0.0057)**	**2.16**	**0.031**	**[0.001, 0.024]**
Age² (centered)	**-0.0027*** **	**(0.0010)**	**-2.66**	**0.008**	**[-0.005, -0.001]**
State Fixed Effects	**Yes**				
Year Fixed Effects	**Yes**				
Observations	**27,742**				
R-squared	**-0.006**				
Clusters (States)	**51**				
Instrument	**Treatment (Age ≥ 21)**				
Note:	Cluster-robust standard errors in parentheses. ***p < 0.01, **p < 0.05, *p < 0.1.				

Table 2. Fuzzy RDD (2SLS) Estimates: Effect of Alcohol Use on Fatal Accidents

CUTOFF AGE	ESTIMATED COEFFICIENT (Β)	P-VALUE	SIGNIFICANCE
19	0.907	0.218	Not significant
20	0.520	0.014	Significant at 5%
22	0.446	0.513	Not significant
23	0.288	0.105	Not significant

Table 3. Placebo Tests at Alternative Age Cutoffs

BANDWIDTH (YEARS)	ESTIMATED COEFFICIENT (Β)	P-VALUE	SIGNIFICANCE
±2	-0.404	0.152	Not significant
±3	-0.151	0.333	Not significant
±4	-0.081	0.451	Not significant

Table 4. Robustness to Alternative Bandwidths

Citation

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