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Health effects of a ban on late-night alcohol sales

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Abstract

This paper studies the impact of a ban on late-night off-premise alcohol sales between 10 p.m. and 5 a.m. in Germany. We use three large administrative data sets: (i) German diagnosis related groups-Statistik, (ii) data from a large social health insurance, and (iii) Road Traffic Accident Statistics. Applying difference-in-differences and synthetic-control-group methods, we find that the ban had no effects on alcohol-related road casualties, but significantly reduced alcohol-related hospitalizations (doctor visits) among young people by around 9 (18) percent. The decrease is driven by fewer hospitalizations due to acute alcohol intoxication during the night—when the ban is in place—but not during the day.

KEYWORDS

alcohol control policies, binge drinking, difference-in-differences, road casualties, sales restrictions, synthetic control

JEL CLASSIFICATION

I12, I18, D04

1 | INTRODUCTION

Excessive alcohol consumption is a major health risk. It also has a negative impact on society in terms of road accidents, hospital admissions, and crime (Francesconi & James, 2019). Excessive alcohol consumption is particularly harmful for adolescents and young adults because it can negatively influence their brain development and increase the risk of alcohol dependence later in life (Enoch, 2006). However, in many countries, there is a high prevalence of excessive drinking among young people (World Health Organization, 2018b).

Several policy measures have been introduced to tackle harmful drinking in general and among young people in particular. These have included minimum legal drinking age laws, drunk driving laws, and taxes on alcohol. In its most recent global status report on alcohol and health, the WHO argues: "The most cost-effective actions, or best buys, include increasing taxes on alcoholic beverages, enacting and enforcing bans or comprehensive restrictions on exposure to alcohol advertising across multiple types of media, and enacting and enforcing restrictions on the physical availability of retailed alcohol" (WHO, 2018a,b: 14). While there is a comprehensive literature on the consequences of minimum legal drinking age, underage drunk driving laws, and alcohol taxes for alcohol consumption and alcohol-attributable harm,[1] less was known about the health effects of policies regulating alcohol trading hours. However, a growing literature is filling this gap (see, e.g., Avdic and von Hinke, 2021; Barron et al., 2022; Baughman et al., 2001; Stoppel, 2021; Wicki et al., 2020) and the reviews by Stockwell and Chikritzhs (2009), Wilkinson et al. (2016), and Sanchez-Ramirez and Voaklander (2018) provide insightful overviews of the effects of these policies. There is a general consensus across these reviews that restricting alcohol trading hours has the potential to reduce alcohol-related harm but that the effectiveness depends on the outcomes analyzed, the exact circumstances, and the design of the policy. Many of the studies reviewed focus on sales restrictions on specific days, such as "Sunday liquor laws" (Bernheim et al., 2016; Heaton, 2012; McMillan & Lapham, 2006), while others focus on bar closing hours (Green et al., 2014; Green & Krehic, 2022; Martin Bassols & Vall Castello, 2018; Tesch & Hohendorf, 2018).

We complement these studies by focusing on more of a "light touch" regulation, namely a ban on the sale of alcoholic beverages between 10 p.m. and 5 a.m. at off-premise outlets (e.g., gas stations, kiosks, and supermarkets). Compared to other alcohol control policies, this ban is relatively easy to legally bypass, for example, by buying alcoholic beverages before 10 p.m. or at on-premise outlets after 10 p.m., as on-premise outlets and other times of the day were not affected by the law. This unique alcohol control policy measure was implemented on March 1, 2010, by the German state of Baden-Württemberg and we study the impact of this ban on alcohol-related hospital stays, doctor visits, and road casualties. Marcus and Siedler (2015) find that this late-night alcohol sales ban reduced alcohol-related hospitalizations among young people in the short run by about seven percent, while Baumann et al. (2019) show that the ban reduced recorded assaults but not recorded robberies.

We built on these previous studies and extend them in several important dimensions. First, we study two novel outcomes: alcohol-related doctor visits and alcohol-related road casualties. These additional outcomes allow for a more comprehensive picture of the health consequences of the late-night ban. While hospitalizations are a relevant outcome, it is important to study whether they are just the tip of the iceberg, that is, to examine whether less severe outcomes (doctor visits) and outcomes outside the health sector (road casualties) are affected as well. Second, we improve the analysis of hospitalizations in several ways. While Marcus and Siedler (2015) only use the primary diagnosis, our data include information on all diagnoses. This allows us to obtain a more complete picture of the ban's effect on hospitalizations by considering, for instance, individuals who were concussed due to drunk driving but whose primary diagnosis was related to the concussion. Further, our data contain the exact time of hospitalization, which allows us to examine hospitalization during the night and during the day separately. This is another important aspect because the ban restricts *late-night* alcohol sales. Additionally, this helps us validate the causal identification strategy, as hospitalizations during the day can serve as a placebo outcome. Moreover, we can draw on information about the whole population of Germany allowing for a more precise estimation. Finally, we can now investigate longer-term effects,[2] which is important, as there are both supply and demand-side factors as to why the short- and long-run effects of the ban are likely to differ. Demand-side factors include the fact that consumers are slow to adapt to new situations (see, e.g., Allcott & Rogers, 2014). For instance, over time, alcohol consumers might become more adept at avoiding the ban by stocking up beforehand. Supply-side factors include the possibility of gas stations applying for restaurant licenses, which would allow them to sell alcohol on the premises, but for which the application process might take some time as there are usually additional requirements for approval of the license (including having a restaurant area at the gas station).[3]

We use three different large administrative data sets (German diagnosis related groups [DRG]-Statistik, data from a large statutory health insurance fund (SHI), Road Traffic Accident Statistics (RTAS)) and exploit the ban on late-night off-premise alcohol sales in a quasi-experimental framework, estimating two types of difference-in-differences (DiD) models. The first approach is a conventional DiD approach, which focuses on changes in health outcomes in the treatment state relative to the other federal states. Our second approach combines the synthetic control group (SCG) method with DiD. In the SCG method, the development of the health outcomes for the treatment and the control group is, by construction, almost identical in the period prior to the implementation of the law.

For both estimation methods, we find a strong and robust reduction in the number of hospital admissions and doctor visits among young people aged 15–24 years following the implementation of the law. Our preferred estimates imply that quarterly alcohol-related hospitalizations decrease by about 8–12 admissions per 100,000 same-age individuals. This corresponds to a decline of around 8–13% relative to the means. Similarly, there is a significant reduction in alcohol-related doctor visits of five visits per quarter and 100,000 same-age population, which corresponds to a reduction of nearly 20%. We interpret these findings as a large reduction, because individuals can easily and legally circumvent the ban on late-night off-premise alcohol sales—even if it is strictly implemented—by legally buying alcoholic beverages before 10 p.m. and/or by (continuing) to drink in bars, restaurants, and clubs after 10 o'clock in the evening. We document that the reduction is driven by fewer hospitalizations due to alcohol intoxication during the night—when the ban is in place—but not during the day. Further, we show that the effects on alcohol-related hospitalizations and doctor visits persist several years after the introduction of the ban, while there is little evidence that the effects differ by gender. However, in contrast to these findings, we find no significant reduction in alcohol-related road casualties during the night after the implementation of the ban. The empirical results are robust to a variety of robustness checks (observation window, comparison group, inference, time trends).

The paper is structured as follows. Section 2 provides background information on the ban on late-night off-premise alcohol sales and other relevant alcohol policies in Germany. Section 3 then goes on to describe the three administrative data sets and the empirical approach. The main results from difference-in-differences and the SCG are presented in Section 4. Section 5 probes the robustness of the findings, and Section 6 reports further results on the evolution of the treatment effect and effect heterogeneity. Section 7 concludes.

2 | INSTITUTIONAL BACKGROUND

On March 1, 2010, the German state of Baden-Württemberg implemented a ban on late-night off-premise alcohol sales.[4] As a result, supermarkets, kiosks, and gas stations were no longer allowed to sell alcoholic beverages between 10 p.m. and 5 a.m. on any day of the week. The sale and consumption of alcoholic beverages on-premise (i.e., in restaurants, pubs, bars, and clubs) was not restricted and remained legal for those over the minimum legal drinking age.[5] According to the law, the aim of the ban was (1) to reduce binge drinking, particularly among young people and (2) to lower alcohol-related violence, crime, and harm. The state government at the time also justified the introduction of the law by referring to the protection of minors. Before the ban on late-night alcohol-sales came into effect, it was possible to buy alcohol day and night. In particular, gas stations in Germany were often open around the clock and were allowed to sell alcoholic beverages 24/7.

There are good reasons to believe that the law was rather strictly implemented. Supermarkets and gas stations are run by large chains and they took great care to ensure that the law was respected. In addition, the penalties for infringements for kiosks, gas stations, and supermarkets were set relatively high at 5,000 euros, and the police were strict about enforcing the law. Third, we looked through both regional and national newspapers and did not see any reports suggesting that the law was not strictly enforced. Further, we carried out a new online survey in May 2016 across Germany among young people[6] and descriptive statistics from this online survey suggest that the ban was strictly enforced, as 84% of the young people living in Baden-Württemberg had heard of the ban and 96% of them correctly stated that the late-night alcohol sales ban starts at 10 p.m. Moreover, 84% of young respondents in Baden-Württemberg had not been able to buy alcoholic beverages during these late hours at all. This suggests that the clear majority of young people changed their shopping behavior and did not buy alcoholic beverages after 10 p.m. However, it also suggests that the ban was not 100% strictly enforced, as 16% of young people seem to have managed to buy alcohol during nighttime hours on at least one occasion.

The time line of the ban was as follows: on July 21, 2009, the draft bill was submitted and it was discussed in the state parliament for the first time on July 30, 2009. Three months later, on November 4, 2009, the parliament approved the law and it came into effect on March 1, 2010 (State Parliament of Baden-Württemberg, 2009a,b,c). Seven years after its implementation, a new state government decided to abolish the ban. Instead, local authorities were granted the right to enact local alcohol consumption bans, limited in time and place. It was argued that due to this right, there was officially no longer a need for the ban (State Parliament of Baden-Württemberg, 2017).[7] The lifting of the ban on late-night alcohol sales came into force on December 8, 2017.[8]

The ban on late-night alcohol sales mainly affected adolescents and young adults. One main justification for the introduction of the law given by the state government at the time was that it aimed to protect minors from excessive drinking and alcohol-related harm. Second, young people mainly drink late in the evening and at night,[9] tend to buy alcohol at off-premise outlets, and consume it in public places before moving on to clubs and discos (i.e., pre-drinking). Third, adolescents and young adults often still live with their parents and are therefore likely to have fewer opportunities for keeping alcohol at home and purchasing supplies than adults. Fourth, they are more price-sensitive and are less likely to mainly consume alcohol in bars and clubs, where alcoholic beverages are much more expensive. In Germany, for example, a bottle of beer (0.33 ml) costs around one euro in kiosks and supermarkets and about three times as much in bars and pubs. Finally, the Youth Protection Act is strictly enforced in bars, pubs, and clubs and young people aged 16–18 are not allowed to consume hard alcoholic beverages and have to leave the premises after midnight.

Overall, the ban on late-night off-premise alcohol sales is a policy measure that does not seriously restrict individual freedoms, as it is still possible to legally buy alcohol before 10 p.m. in kiosks, gas stations, and supermarkets and after 10 p.m. in bars, pubs, restaurants, and clubs.

One potential threat to our estimation methods is that there may have been other policy changes or shocks in the treatment state in the year 2010 that might have influenced alcohol consumption and alcohol-related hospitalizations and doctor visits. We have investigated this carefully and have not found any information on such possible threats.[10] Note that the minimum legal drinking ages, alcohol taxes, drunk driving laws, driving license regulations,[11] and the German Law for the Protection of the Youth are federal laws that do not vary across states.

3 | DATA AND EMPIRICAL STRATEGY

In order to study the effects of the ban on late-night off-premise alcohol sales on alcohol-related hospital stays, alcohol-related doctor visits, and road casualties, we use three large administrative data sets, (i) the German DRG-Statistik, (ii) data from a large SHI, and (iii) the RTAS.

The German DRG-Statistik is an administrative data set that includes reimbursement-relevant information covering all German hospitals (*Fallpauschalenbezogene Krankenhausstatistik*). It provides information about all inpatients in all German hospitals. This includes individuals who are admitted to the emergency department only if they are treated as inpatients, that is, if they stay overnight. While it includes very little background information about the inpatients (except, e.g., age, gender, and place of residence), it does contain detailed information about the admission of the patient (e.g., date and time) and an extensive set of clinical details (e.g., ICD-10 codes).

While the DRG-Statistik covers only inpatient cases, our second main data set, the SHI data, also covers outpatient doctor visits (recorded on a quarterly basis). These outpatient doctor visits also include individuals who are admitted to hospital emergency departments, but do not stay overnight. Thus, we are able to examine both inpatients' and outpatients' behavior using the SHI data. The SHI is one of the largest health insurance funds in Germany, with more than two million insured in 2019.[12] The SHI data contain similar demographic information to the DRG data. However, due to data confidentiality, our SHI data do not contain the hour of hospital admission. We can therefore only use the DRG-Statistik to distinguish between alcohol-related hospital admissions during the night—when the ban on late-night alcohol sales ban was in place in the treatment state—and during the day, when the ban was not in place.

The RTAS (German Statistical Offices, 2018) include all traffic accidents on German roads that were recorded by the police. This includes car accidents but also accidents with bikes, pedestrians, trucks, and other vehicles. The data cover both accidents resulting in injured people and those only resulting in car body damage—as long as the police recorded the accident. Generally, the police must be notified if an accident results in a high level of property damage or in a person or persons being injured or even killed. Moreover, due to liability reasons there are strong incentives to call the police in other cases as well, as most insurance companies require an official police report. This is particularly true in cases where the driver is not the vehicle owner (e.g., in the case of rental cars or company vehicles), if guilt is disputed, or if the other party involved in the accident is suspected to be under the influence of alcohol or drugs. The data include basic demographic information of all individuals involved in the accident (e.g., age, gender) as well as whether any of the initiators of the accident were under the influence of alcohol.[13] Further, the time of the accident is recorded.

For all three data sets we have information for the years 2005–2014. In our main analysis, we focus on individuals aged 15–24 as, based on theoretical expectations and evidence from previous studies (Marcus & Siedler, 2015), this is the age group for which the ban is most relevant.

3.1 | Outcome variables

We construct five main outcome variables. All outcomes are based on 15–24-year-old individuals. The first four outcomes are based on the German DRG-Statistik and the SHI data and relate to patients with the diagnosis F10.0 (acute alcohol intoxication) according to the International Statistical Classification of Diseases and Related Health Problems (ICD-10), while the fifth outcome relates to alcohol-related road casualties.

The first outcome refers to the number of alcohol-related hospitalizations at night and is based on the DRG-Statistik. Although the ban was effective from 10 p.m. to 5 a.m., we also include hospitalizations between 5 and 8 a.m. to take into account that there might be a time lag between arriving at hospital and receiving the time stamp for inpatient admission (in addition to time lags between the consumption of alcohol and its adverse consequences).[14] This outcome is the most similar to the one used in Marcus and Siedler (2015), but we refine the outcome in several ways. First, our data cover the full ICD-10 code, while Marcus and Siedler (2015) could only work with the first three digits. This is important as it allows us to distinguish acute alcohol intoxication (F10.0) from, for example, alcohol dependence syndrome (F10.2), which is much more unlikely to be affected by a late-night sales ban on alcohol.[15] Assuming that the ban does not affect other F10 diagnoses (like F10.2 “alcohol dependence syndrome”), focusing on F10 instead of F10.0 causes measurement error in the dependent variable.[16] Hence, we exclusively rely on acute alcohol intoxication (F10.0) in our main specification. Second, we can draw on information about the whole population of Germany. Third, in contrast to the other study, our data include not only information on the primary diagnosis but also on secondary diagnoses.[17]

The second outcome also incorporates all alcohol-related hospitalizations, but is different to the first outcome in two aspects. First, it is not based on the whole population of Germany, but on individuals insured by one large SHI. Second, in these data, we cannot distinguish between admissions during the day and those during the night and therefore consider all alcohol-related hospitalizations, irrespective of the time of admission. While, for these reasons, the first outcome seems to be superior, the second outcome is nevertheless important, as it helps us to understand whether we can recover the effects from the DRG-Statistik with the SHI data despite the aforementioned caveats.

The third outcome refers to the number of alcohol-related doctor visits and again is based on SHI data. This outcome is only recorded at the quarterly level. The fourth outcome is strongly related to the first outcome, but should rather be seen and interpreted as a placebo outcome. It is based on the DRG-Statistik and refers to the number of alcohol-related hospitalizations during the *day* (i.e., between 8 a.m. and 10 p.m.).

The fifth outcome is based on the RTAS and considers the number of individuals involved in late-night traffic accidents, which occurred under the influence of alcohol.[18] This is an important additional outcome measure, because, around the world, injury from road traffic accidents is one of the leading causes of disability and death among young people (World Health Organization, 2008). Section 6.3 shows that our results are robust to alternative ways of coding the outcome variable from the RTAS.

To make the analysis more comparable across different outcomes, we use quarters as our main time unit. Moreover, we aggregate all five outcomes by the individuals' county of residence and normalize this number by the respective population of 15–24-year-olds. For the DRG-Statistik and the RTAS this refers to the full population in this age range and for the SHI data this refers to the number of individuals in this age range who are insured with this specific health insurance fund. Hence, our outcome variables are the number of alcohol-related hospital admissions among 15–24-year-olds, alcohol-related doctor visits among 15–24-year-olds, and 15–24-year-olds involved in alcohol-related traffic accidents, respectively, per 100,000 inhabitants/insured aged 15–24 in the county. Overall, we work with samples of 16,080 observations each (402 counties × 10 years × 4 quarters).

3.2 | Descriptive statistics

Table 1 presents summary statistics for the five main outcome variables as well as additional variables. It shows that there are around 90 alcohol-related hospitalizations per 100,000 population aged 15–24 per quarter, on average, and 80% of them are admitted to hospital during the night (Panel A). In the health insurance fund data, we observe around 70 alcohol-related hospital admissions per 100,000 population aged 15–24 per quarter, and 27 alcohol-related doctor visits. The average number of 15–24-year-olds in alcohol-related traffic accidents during the night per 100,000 population is around 23 (Panel C). Overall, 46% of our quarterly observations are from the post alcohol-ban period, and 14% are from the treatment state of Baden-Württemberg.

TABLE 1 Summary statistics

Variable	Mean	(Std. Dev.)
Panel A: Hospital diagnosis data (DRG-Statistik)		
Alcohol-related hospitalizations (night)	77.98	(39.08)
Alcohol-related hospitalizations (day)	16.63	(13.01)
Panel B: Health insurance fund data (SHI)		
Alcohol-related hospitalizations	69.54	(67.34)
Alcohol-related doctor visits	27.04	(38.04)
Panel C: Road casualties (RTAS)		
Alcohol-related road casualties (night)	22.87	(14.40)
Panel D: All data sets		
Post period (after March 1, 2010)	0.46	(0.50)
Treatment state (Baden-Württemberg)	0.14	(0.35)
Affected by the ban on late-night alcohol sales	0.07	(0.25)
Number of observations	16,080	

Note: In all three data sets, we use the years 2005–2014 and the number of observations is 16,080 (402 counties × 10 years × 4 quarters). The variables in Panels A, B, and C relate to quarterly numbers per 100,000 15–24-year-olds.

Abbreviation: DRG, diagnosis related groups.

3.3 | Empirical strategy

We estimate basic difference-in-differences (DiD) and two-way-fixed effects DiD regressions and also apply SCG methods. The basic DiD model is:

$$Y_{cst} = \alpha_0 + \alpha_1 \cdot BW_s + \alpha_2 \cdot postban_t + \alpha_3 \cdot alcban_{st} + \varepsilon_{cst}, \quad (1)$$

where Y_{cst} refers to one of our five outcome variables as defined above in county c, in state s, in quarter t. The dummy variable BW_s is equal to one for the treatment state of Baden-Württemberg, and zero otherwise. The second dummy variable $postban_t$ takes on the value one for the post-treatment period (i.e., all quarters after March 2010), and zero otherwise.[19] $alcban_{st}$ denotes our main explanatory variable. It is the interaction term of the variables BW_s and $postban_t$ and is therefore equal to one if the ban on late-night alcohol sales is in force in state s in quarter t, and zero otherwise. ε_{cst} is the error term, which might be correlated within states. We therefore cluster standard errors at the state level.[20]

Second, we estimate difference-in-differences models as two-way-fixed effects regressions:

$$Y_{cst} = \beta_1 \cdot alcban_{st} + \gamma_c + \delta_t + \varepsilon_{cst}. \quad (2)$$

We replace the dummy variable BW_s with a set of county fixed effects, γ_c, accounting for time-invariant differences in the level of alcohol-related hospitalizations (doctor visits, road casualties) between the counties (and, hence, also between the German states as the counties are nested in federal states). Further, we replace the indicator for the post-treatment period, $postban_t$, with a maximum set of time (quarter-year) dummy variables, δ_t, controlling for common time shocks that might influence the outcome variables.

We estimate the Equations (1) and (2) by weighted ordinary least squares (OLS). The weights are given by the county's population aged 15–24 in order to obtain the accurate overall effect for the treatment state of Baden-Württemberg.

In addition to estimating basic and two-way-fixed effects DiD models, we also apply SCG methods (see also Abadie et al., 2010). In order to get a synthetic version of the treatment state of Baden-Württemberg, we apply entropy balancing (Hainmueller, 2012) based on lagged outcome variables. Entropy balancing reweights the 358 counties in the other states such that the reweighted control group exhibits very similar characteristics to the treatment group. This balancing is subject to two conditions. First, all counties receive non-negative weights. Second, the weights deviate as little as possible from the original weights (i.e., the county's population in the 15–24 age range). We perform entropy balancing separately for all five outcome variables and, in our main specification, require entropy balancing to reweight the control group based on the outcome values of the complete pre-intervention period.[21] In the robustness section, we work with different lag lengths and discuss the predictive power of the SCG based purely on the pre-intervention period. For robustness purposes, we also apply the SCG weighting scheme proposed by Abadie et al. (2010). For the SCG method, we estimate Equation (2) by weighted OLS, where the weights are given by the entropy balancing procedure.

4 | MAIN RESULTS

4.1 | Visual inspection

Figures 1 and 2 show the trends in the number of quarterly alcohol-related hospitalizations, doctor visits, and road casualties per 100,000 individuals aged 15–24 for the treatment state and the control states in Germany. Since we have data for the years 2005–2014, the figures report numbers for 40 quarters. The continuous vertical line indicates the introduction of the ban on March 1, 2010 in the treatment state, that is, in the 21st quarter.

Figure 1a displays the development of hospital admissions due to alcohol intoxication occurring during the night. Prior to the implementation of the late-night alcohol sales ban, there is an increase from around 62 alcohol-related hospitalizations in the first quarter of 2005 to nearly 100 hospitalizations per 100,000 inhabitants aged 15–24 in the 20th quarter (i.e., the last quarter before the implementation of the ban) in the treatment state. This upward trend is interrupted after the implementation of the law and we observe a slight downward trend thereafter (21st quarter to 40th quarter). In both the treatment and the control states, we observe a strong seasonal pattern, with a peak in the third quarter (July–September) in most years. This is consistent with previous research, as young people tend to (binge) drink more in the summer (Marcus & Siedler, 2015). Overall, we observe quite similar (but not identical) trends in the treatment and comparison group prior to the implementation of the ban on late-night alcohol sales, with slightly lower levels of alcohol-related hospitalizations in the comparison group, on average.

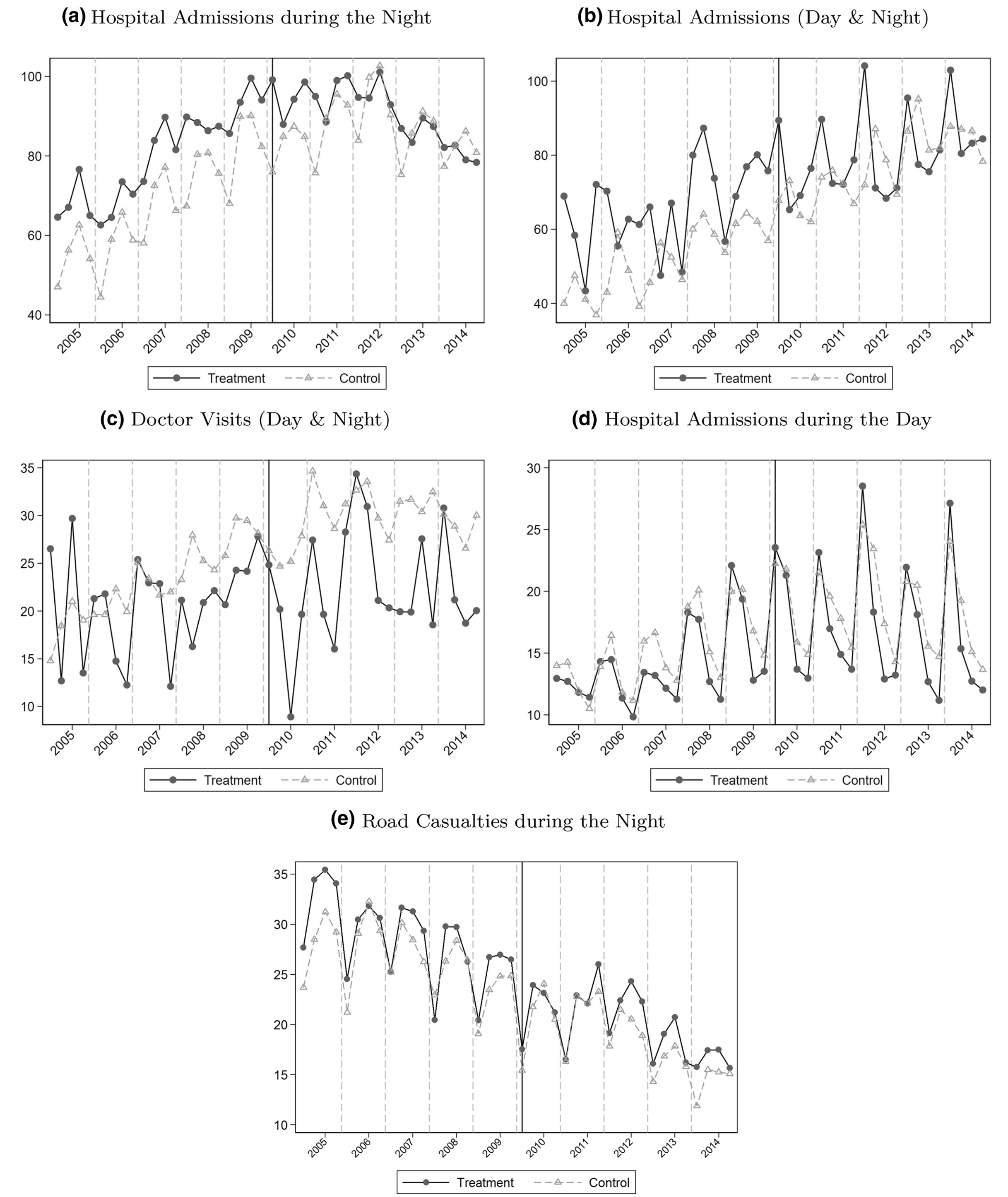

FIGURE 1 Development of Outcomes Before and After the Ban. The figure shows the development of hospitalizations (Panels a, b, d) and doctor visits (Panel c) due to alcohol intoxication as well as the number of individuals involved in late–night traffic accidents that occurred under the influence of alcohol (Panel e), separately for the treatment and control groups for the years 2005–2014. All numbers are quarterly data per 100,000 individuals aged 15–24. The continuous vertical line indicates the introduction of the late-night alcohol sales ban in the treatment state (Baden-Württemberg) on March 1, 2010. The control group is composed of the other 15 federal states in Germany.

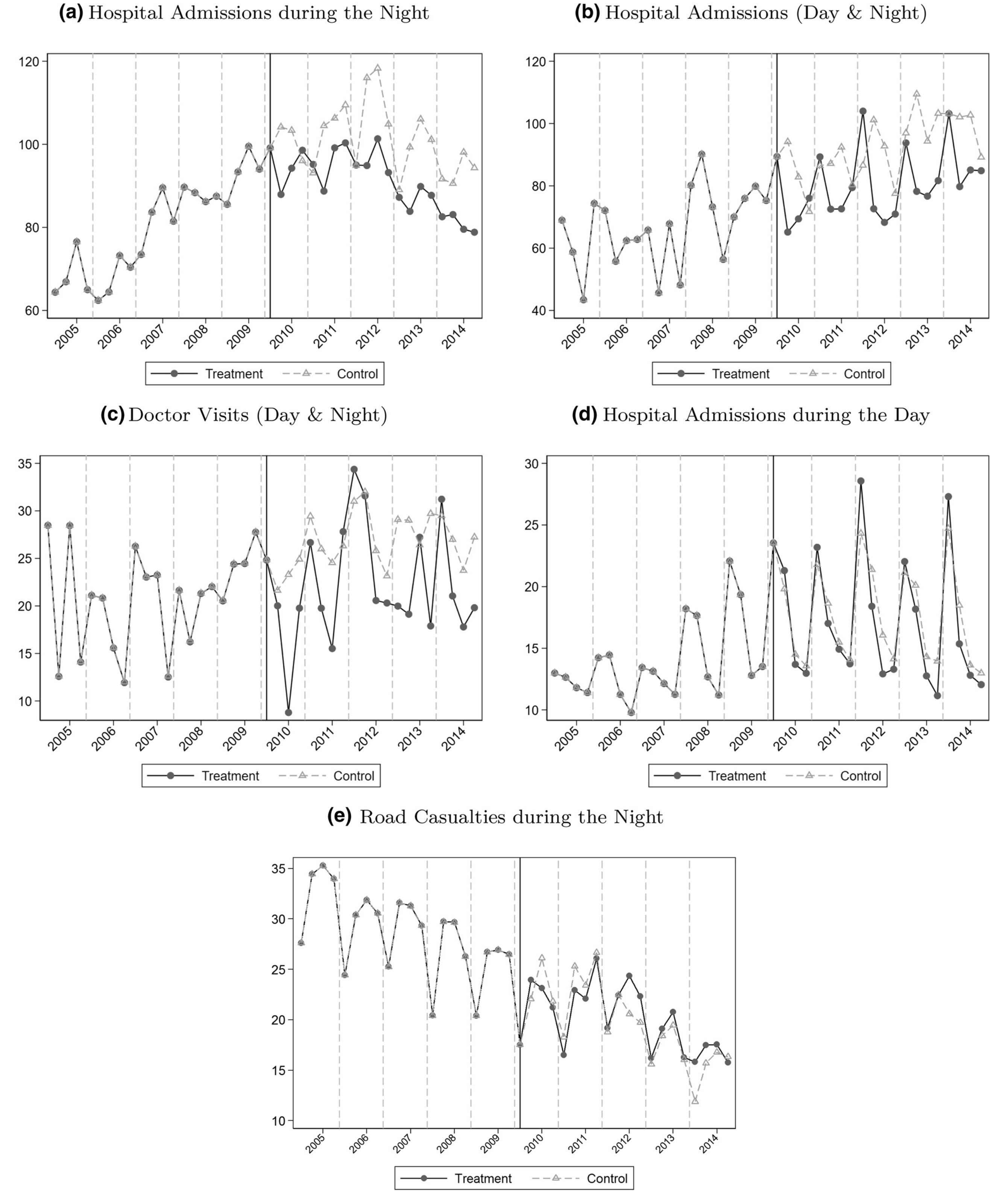

FIGURE 2 Development of Outcomes Before and After the Ban (Synthetic Control). The figure shows the development of hospitalizations (Panels a, b, d) and doctor visits (Panel c) due to alcohol intoxication as well as the number of individuals involved in late–night traffic accidents that occurred under the influence of alcohol (Panel e), separately for the treatment and control groups for the years 2005–2014. All numbers are quarterly data per 100,000 individuals aged 15–24. The continuous vertical line indicates the introduction of the late-night alcohol sales ban in the treatment state (Baden-Württemberg) on March 1, 2010. The control group is a synthetic control group (SCG) composed of a weighted average of counties in the other 15 federal states.

Figure 1b displays the development in the number of quarterly hospitalizations due to alcohol intoxication based on information from our large health insurance fund. Similar to the previous figure, there is an upward trend in alcohol-related hospital admissions before the introduction of the ban on alcohol sales in both the treatment and comparison group, with, on average, higher levels in the treatment state. While in the pre-intervention period, the treatment group tends to exhibit higher rates of hospitalization, this gap closes after the intervention, with the treatment group showing lower hospitalization rates in many quarters.

Figure 1c shows the development of doctor visits due to alcohol intoxication. There are considerably fewer outpatient cases per 100,000 inhabitants aged 15–24 compared to hospitalizations, and we observe lower levels in the treatment than in the comparison group during quarters 12–20 and for most quarters in the post-treatment period, where the difference between treatment and comparison group appears slightly larger in the post-treatment period. Figure 1d shows the trends in hospital admissions due to alcohol intoxication during the daytime, that is, between 8 a.m. and 10 p.m., according to the hospital diagnosis data. The trends in both groups are very similar before and after the implementation of the ban. Figure 1d provides the first suggestive evidence that the late-night alcohol sales ban is unlikely to have an impact on hospitalizations during the day (our placebo outcome), at hours during which the alcohol sales ban was not in place. Finally, Figure 1e displays the development in the average number of individuals involved in alcohol-related traffic accidents during the night. Across all years, we observe quite similar numbers of cases in the treatment and the comparison group.

In sum, Figures 1a–1e show that the trends in the outcome variables prior to the implementation of the ban on alcohol sales in March 2010 are quite similar, but not perfectly parallel. Hence, there is the concern that the crucial assumption according to the difference-in-differences estimation of the common trend of the outcome variables in the absence of the policy might be violated. To address this, we also present results based on a SCG. This is shown in Figures 2a–2e For the time period prior to the introduction of the late-night alcohol sales ban, by construction, the development in the outcome measures is identical for the treatment and comparison group. However, as Figures 2a–2c show, after the introduction of the ban, the treatment and control group deviate, with higher rates of hospitalization and more doctor visits due to alcohol intoxication in the SCG, suggesting that the ban reduced these hospitalizations and doctor visits in the treatment state of Baden-Württemberg. In contrast, Figure 2d shows that Baden-Württemberg and its synthetic version exhibit similar developments of the placebo outcome, hospitalizations due to alcohol intoxication during the day. Similarly, Figure 2e also shows no clear differences in the development of alcohol-related road casualties between the treatment and comparison group after the introduction of the late-night alcohol sales ban in March 2010.

4.2 | Difference-in-differences

Table 2 reports the results for the baseline DiD (column 1), two-way-fixed effects DiD (column 2), and SCG DiD (SCG-DiD). Panel A shows the estimated results for alcohol-related hospitalizations during the night based on the DRG-Statistik, and Panel B displays the findings for alcohol-related hospitalizations taken from the information provided by our large health insurance fund. In Panel C of Table 2, we report the results for alcohol-related doctor visits. Panel D reports the estimates for alcohol-related hospitalizations during the day, when there was no off-premise alcohol sales ban in place. Panel E shows the empirical findings for alcohol-related road casualties during the night. Each column represents a separate DiD specification, and in each panel we present the key DiD estimates (i.e., on the "alcban" indicator from Equations (1) and (2), respectively) and standard errors.

The results in Table 2 provide evidence that the ban on late-night alcohol sales significantly reduces doctor visits and alcohol-related hospital admissions during the night, but not alcohol-related road casualties. The baseline DiD estimates in column (1) indicate that there are around 10 (Panel A; DRG-Statistik) to 12 (Panel B; SHI data) fewer admissions per 100,000 inhabitants aged 15–24 per quarter as a result of the late-night alcohol sales ban, with the point estimates being precisely estimated at the 5% significance level. This corresponds to a reduction of around 10 (13) percent, based on the counterfactual outcome mean in the treatment group. These findings on hospital admissions due to alcohol intoxication are consistent with earlier work by Marcus and Siedler (2015). The results in Panel C further suggest that the ban on alcohol sales significantly reduces doctor visits due to alcohol intoxication, by around five visits in each quarter per 100,000 individuals aged 15–24, or about 17%. The results in Panel D of Table 2 provide no evidence that the late-night alcohol sales ban significantly reduces alcohol-related hospital admissions during the daytime.[22] This is to be expected, given that the law prohibited the sales of alcoholic beverages between 10 p.m. and 5 a.m. in supermarkets, kiosks, and gas stations. We interpret the null finding on the placebo outcome as supportive evidence that the reduction in hospital (doctor) visits during the night is unlikely to be driven by confounding factors that might drive differences between the treatment state and control states after March 2010. Finally,

TABLE 2 Effect of the ban on late-night alcohol sales: Main results

	Basic DiD (1)	Two-way fixed effects DiD (2)	Synthetic control (3)
Panel A: Hospital admissions, night only (population, DRG)			
Ban on late-night alcohol sales	−9.62**	−8.37**	−10.52***
	(3.35)	(3.12)	(2.73)
R^2	0.06	0.62	0.58
% Change	−9.63	−8.48	−10.41
Panel B: Hospital admissions (sample, SHI)			
Ban on late-night alcohol sales	−12.04***	−11.53***	−12.14***
	(2.84)	(3.10)	(3.05)
R^2	0.03	0.18	0.13
% Change	−13.08	−12.59	−13.15
Panel C: Doctor visits (sample, SHI)			
Ban on late-night alcohol sales	−4.74**	−5.35**	−4.74***
	(1.99)	(2.19)	(1.39)
R^2	0.01	0.17	0.10
% Change	−17.49	−19.31	−17.67
Panel D: Hospital admissions, day only (population, DRG)			
Ban on late-night alcohol sales	−0.50	−0.33	−0.60
	(0.81)	(0.77)	(0.69)
R^2	0.01	0.28	0.31
% Change	−2.90	−1.94	−3.41
Panel E: Traffic accidents (population, RTAS)			
Ban on late-night alcohol sales	−0.52	−0.85	0.40
	(0.79)	(0.70)	(0.94)
R^2	0.07	0.35	0.34
% Change	−2.54	−4.03	2.01

Note: The dependent variables measure quarterly numbers per 100,000 15–24-year-olds. Each estimated coefficient (standard error) comes from a different regression. Panels A and D report results from the DRG-Statistik, and Panels B and C report findings from the health insurance fund data. The number of observations is 16,080 (402 counties × 10 years × 4 quarters).

Abbreviation: DRG, diagnosis related groups.

$^{**}p < 0.05$, $^{***}p < 0.01$.

the estimates in Panel E of Table 2 do not show a significant reduction in the number of alcohol-related road casualties during the night.

The findings are very similar for the two-way-fixed effects models in column (2) and the synthetic control method in column (3). The ban on late-night off-premise alcohol sales seems to reduce the number of hospital admissions and doctor visits due to alcohol intoxication, but not alcohol-related road casualties during the night. The reduction in hospital admissions mainly comes from a decline in the number of admissions during the night, but not during the day.

There are several potential explanations for why we do not find robust empirical evidence for a reduction in alcohol-related road casualties following the ban. Marcus and Siedler (2015) point out that one reason why the ban might be effective in reducing alcohol consumption is that it suppresses the spontaneous purchase of alcoholic beverages at off-premise outlets. However, this temporal interruption in legal alcohol supply might be less relevant for drivers than for non-drivers. Second, while Germany has a lower minimum legal drinking age than the US (Kamalow & Siedler, 2019), legal blood alcohol concentration (BAC) limits when driving are very strict for young and novice drivers. In fact, Germany has a zero tolerance BAC policy for young and novice drivers (World Health Organization, 2018a). Third, there might be offsetting effects in the sense that the ban reduced drunk driving related to off-premises consumption, which, however, was offset by an increase in drunk driving related to on-premises consumption. Unfortunately, we do not have data to examine this explanation empirically. Fourth, the level of alcohol-related road injuries and alcohol-related traffic fatalities is relatively low (Vissers et al., 2017). In 2010, for example, around 10% of road fatalities in Germany were alcohol-related, compared to around 30% in the US (Vissers et al., 2017).[23]

5 | ROBUSTNESS CHECKS

In Table 3 we examine the sensitivity of our main DiD findings based on the two-way-fixed effects DiD model in column (2) of Table 2. We present the corresponding robustness checks for the SCG-DiD method in Table A1 in the Appendix.

As first robustness checks, we re-estimated our preferred DiD model for the years 2007–2014 and 2007–2011. These two sample selections provide us with time periods that are more similar (identical) to those in Marcus and Siedler (2015). Second, in column (3), we examine the short-term effects of the late-night alcohol sales ban, as we only use observations for the years

TABLE 3 Effect of the ban on late-night alcohol sales: Robustness of DiD estimations

		Observation window			Control states				
	Main DiD	2007–2014	2007–2011	2009–2010	West Germany	w/o Bavaria	Time trend	w/o 2010Q1	County-quarter
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: Hospital admissions, night only (population, DRG)									
Ban on late-night alcohol sales	−8.37**	−8.83***	−4.82*	−5.02**	−11.48***	−5.08**	−3.66*	−7.82**	−7.63**
	(3.12)	(2.65)	(2.69)	(1.82)	(3.33)	(1.82)	(1.96)	(3.18)	(3.07)
N	16,080	12,864	8,040	3,216	13,000	12,240	16,080	15,678	16,080
R^2	0.62	0.62	0.63	0.69	0.60	0.60	0.62	0.62	0.65
Panel B: Hospital admissions (sample, SHI)									
Ban on late-night alcohol sales	−11.53***	−10.76***	−8.03***	−11.84***	−14.00***	−8.61***	−8.76***	−10.96***	−10.38***
	(3.10)	(3.17)	(2.25)	(3.12)	(3.73)	(1.73)	(2.00)	(3.27)	(3.12)
N	16,080	12,864	8,040	3,216	13,000	12,240	16,080	15,678	16,080
R^2	0.18	0.19	0.17	0.24	0.16	0.17	0.18	0.18	0.25
Panel C: Doctor visits (sample, SHI)									
Ban on late-night alcohol sales	−5.35**	−4.41**	−5.76**	−6.28***	−4.93	−7.21***	−3.01*	−5.31**	−5.06**
	(2.19)	(1.89)	(2.17)	(1.38)	(2.75)	(1.87)	(1.60)	(2.39)	(2.25)
N	16,080	12,864	8,040	3,216	13,000	12,240	16,080	15,678	16,080
R^2	0.17	0.20	0.20	0.27	0.16	0.20	0.17	0.17	0.24
Panel D: Hospital admissions, day only (population, DRG)									
Ban on late-night alcohol sales	−0.33	−0.03	0.07	−0.97	−0.75	0.46	0.07	−0.22	−0.12
	(0.77)	(0.82)	(0.83)	(1.36)	(0.92)	(0.38)	(0.81)	(0.75)	(0.72)
N	16,080	12,864	8,040	3,216	13,000	12,240	16,080	15,678	16,080
R^2	0.28	0.29	0.30	0.36	0.29	0.29	0.28	0.28	0.46
Panel E: Traffic accidents (population, RTAS)									
Ban on late-night alcohol sales	−0.85	−0.17	−1.04**	−1.50***	−1.48*	−0.70	0.03	−0.86	−0.89
	(0.70)	(0.58)	(0.42)	(0.47)	(0.67)	(0.88)	(0.39)	(0.73)	(0.73)
N	16,080	12,864	8,040	3,216	13,000	12,240	16,080	15,678	16,080
R^2	0.35	0.33	0.33	0.36	0.32	0.37	0.35	0.35	0.40

Note: The dependent variables measure quarterly numbers per 100,000 15–24-year-olds. Each estimated coefficient (standard error) comes from a different regression.

Abbreviation: DRG, diagnosis related groups.

$*p < 0.1$, $**p < 0.05$, $***p < 0.01$.

TABLE 4 Robustness of DiD results: Other ways of inference

	Cluster			Wild cluster bootstrap		
	State	County	State & time	Rademacher	Mammen	Webb
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Hospital admissions, night only (population, DRG)						
Ban on late-night alcohol sales	−8.37	−8.37	−8.37	−8.37	−8.37	−8.37
p-value	0.001	0.001	0.021	0.001	0.001	0.004
Panel B: Hospital admissions (sample, SHI)						
Ban on late-night alcohol sales	−11.53	−11.53	−11.53	−11.53	−11.53	−11.53
p-value	0.000	0.002	0.004	0.000	0.000	0.000
Panel C: Doctor visits (sample, SHI)						
Ban on late-night alcohol sales	−5.35	−5.35	−5.35	−5.35	−5.35	−5.35
p-value	0.000	0.017	0.028	0.000	0.000	0.003
Panel D: Hospital admissions, day only (population, DRG)						
Ban on late-night alcohol sales	−0.33	−0.33	−0.33	−0.33	−0.33	−0.33
p-value	0.829	0.593	0.662	0.796	0.734	0.795
Panel E: Traffic accidents (population, RTAS)						
Ban on late-night alcohol sales	−0.85	−0.85	−0.85	−0.85	−0.85	−0.85
p-value	0.349	0.104	0.262	0.361	0.327	0.371

Note: The dependent variables measure quarterly numbers per 100,000 15–24-year-olds. Each estimated coefficient (*p*-value) comes from a different regression. The number of observations is 16,080 (402 counties × 10 years × 4 quarters).

Abbreviation: DRG, diagnosis related groups.

2009 and 2010. Next, we change the definition of our control group and only use counties in western Germany in column (5), and only counties outside of Bavaria in column (6) as a control group. The reason for the first robustness check is that western federal states might be a more appropriate control group, and the reason for excluding Bavaria is that some gas stations in Bavaria voluntarily subscribed to a ban on late-night alcohol sales in 2012 (Zierer, 2012).

In column (7) of Table 3, we examine the robustness with respect to the inclusion of linear state-specific time trends (i.e., interacting a linear time variable with state dummy variables). In column (8), we re-estimated the specifications excluding the first quarter of 2010 from the estimation sample. In our main specification, this quarter is assigned to the pre-treatment period although it includes March 2010, which is the month the ban came into effect. Finally, column (9) presents the DiD results when controlling for a maximum set of county-quarter fixed effects (i.e., including 1203 dummy variables (401 counties × 3 quarters)). All these robustness checks confirm our conclusion that the ban reduced both hospitalizations and doctor visits due to alcohol intoxication, while the late-night ban had no effect on alcohol-related road casualties during the night or on our placebo outcome, hospital admissions during the day.[24]

Next we conduct robustness checks with respect to cluster-robust inference. Table 4 reports the results. While in our main specification, we cluster standard errors at the state level (column 1), column (2) clusters standard errors at the county level. Column (3) applies two-way-clustering, that is, clustering at the state and at the year level. Columns (4)–(6) present standard errors using different Wild cluster bootstrap procedures based on state-level clustering. We report the point estimates from our preferred DiD specification, together with p-values. As we can see, using alternative ways of inference does not change our conclusions. Irrespective of the defined within-cluster correlation, there is always significant and negative impact of the late-night alcohol sales ban on alcohol-related doctor visits and hospitalizations during the night, with p-values between 0.000 and 0.004 in Panels A–C of Table 4. In stark contrast, the p-values for the placebo outcome and alcohol-related road casualties are very large, suggesting that none of these regressions show a significant reduction.[25]

Table 5 presents results for robustness tests specific to the SCG-DiD. While the main SCG-specification constructs the SCG based on outcome values for all 21 available pre-intervention quarters, it is not clear whether taking all lags is preferable to taking fewer lags. To empirically derive the optimal number of lags, we apply a cross-validation technique similar to Abadie et al. (2015) where we restrict the sample to the pre-intervention period and divide this period into a training and a validation period. We then construct different synthetic Baden-Württembergs based on the training period and different numbers of lags and compare the observed outcomes in Baden-Württemberg and its synthetic counterpart in the validation period. More specifically, we assume that the treatment took place in Baden-Württemberg in quarter t, $t \in [2, 16]$, construct a SCG based

TABLE 5 Synthetic control group method: Robustness

		Lags					
	Main DiD	All	Three	Six	Eight	Nine	Abadie et al. (2010)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A: Hospital admissions, night only (population, DRG)							
Ban on late-night alcohol sales	−8.37**	−10.52***	−10.01**	−8.85**	−8.82**	−9.65**	−13.01***
	(3.12)	(2.73)	(3.70)	(3.25)	(3.19)	(3.37)	(4.58)
R^2	0.62	0.58	0.56	0.58	0.58	0.58	0.54
Panel B: Hospital admissions (sample, SHI)							
Ban on late-night alcohol sales	−11.53***	−12.14***	−10.45***	−9.62***	−9.46***	−9.53***	−18.99***
	(3.10)	(3.05)	(2.93)	(2.12)	(2.16)	(2.18)	(3.97)
R^2	0.18	0.13	0.13	0.13	0.14	0.13	0.10
Panel C: Doctor visits (sample, SHI)							
Ban on late-night alcohol sales	−5.35**	−4.74***	−5.20*	−5.10*	−4.85**	−4.71**	−3.91**
	(2.19)	(1.39)	(2.48)	(2.44)	(1.78)	(1.78)	(1.89)
R^2	0.17	0.10	0.14	0.13	0.12	0.12	0.11
Panel D: Hospital admissions, day only (population, DRG)							
Ban on late-night alcohol sales	−0.33	−0.60	−0.38	−0.43	−0.48	−0.48	−0.96
	(0.77)	(0.69)	(0.71)	(0.72)	(0.70)	(0.74)	(0.87)
R^2	0.28	0.31	0.30	0.30	0.30	0.30	0.35
Panel E: Traffic accidents (population, RTAS)							
Ban on late-night alcohol sales	−0.85	0.40	0.68	0.70	0.40	0.28	—
	(0.70)	(0.94)	(0.91)	(0.97)	(0.90)	(0.89)	
R^2	0.35	0.34	0.35	0.35	0.35	0.35	

Note: The dependent variables measure quarterly numbers per 100,000 15–24-year-olds. Each estimated coefficient (standard error) comes from a different regression. The number of observations is 16,080 (402 counties × 10 years × 4 quarters).

Abbreviation: DRG, diagnosis related groups.

$^*p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

on the $t - 1$ lags (training period), and compute the outcome difference between the observed Baden-Württemberg and the synthetic Baden-Württemberg in the following four pre-intervention quarters (validation period). In this setting, the preferred lag length is the one with the lowest mean squared prediction error (MSPE).[26]

It proves to be the case that the MSPE is smallest at different lag lengths—depending on the outcome. In Table 5, we show the SCG-DiD results for the four different lag lengths, which minimize the MSPE of one of the outcome variables according to the procedure described above. While the SCG-DiD model in column (3) of Table 2 (repeated in column (2) of Table 5 for ease of comparison) used all available lagged dependent variables for the construction of the SCG, the models in columns (3)–(6) of Table 5 rely on smaller numbers of lagged dependent variables. The results in Table 5 confirm the empirical evidence from the main DiD models: the estimated coefficients in Panels A–C are negative, of comparable magnitude to the main DiD estimates, and precisely estimated at the 5% significance level. In contrast, none of the point estimates in Panel E suggests that there were fewer alcohol-related road casualties in the post-intervention period in Baden-Württemberg than in the synthetic counterpart regions. Furthermore, there is no empirical evidence that the ban reduces the number of hospital admissions due to alcohol intoxication during the day (Panel D in Table 5). Using a different number of included lags of the dependent variables for constructing the SCG does not change the results substantially. In sum, the point estimates are very similar when different numbers of included lags of the dependent variables are used for constructing the SCG, suggesting that the decision about the optimal number of lags is not a crucial one in the present case.

While the construction of the SCG relies on weights based on entropy balancing in all these specifications, in the last robustness test, we apply an alternative method to generate the weights. More specifically, we apply the weighting scheme proposed by Abadie et al. (2010), which does not match the pre-treatment trend as exactly as entropy balancing and assumes a single treated unit.[27] The last column in Table 5 shows that the qualitative results are similar when using this alternative weighting scheme. The point estimates for hospital admissions are even slightly larger in absolute terms.[28]

6 | ADDITIONAL EVIDENCE

In this section, we explore the dynamic effects of the late-night off-premise alcohol sales ban and also study heterogeneous effects by gender using the main two-way-fixed effects DiD estimation strategy.[29]

6.1 | Dynamic effects

We start by presenting an event study analysis, estimating the following models:

$$Y_{cst} = \sum_{k=2004}^{2008} \beta_k \cdot alcban_{stk} + \sum_{k=2010}^{2014} \beta_k \cdot alcban_{stk} + \gamma_c + \delta_t + \varepsilon_{cst}, \quad (3)$$

where Y_{cst}, γ_c, δ_t, and ε_{cst} are defined as before and $alcban_{stk}$ is an indicator for different years before and after the introduction of the ban in 2010. This specification is helpful in two aspects. First, it allows us to investigate whether there are differential trends between the treatment and control group before the implementation of the ban. Ideally, we would like all coefficients that relate to the years prior to 2010 to be small and statistically indistinguishable from zero and for there to be no evidence of diverging trends in the pre-period. Second, rather than estimating one main DiD coefficient, as in Table 2, this specification allows us to examine how the treatment effect develops over time. The graphs in Figure 3 show the estimated β_k-coefficients from the event study analyses based on Equation (3). The event studies use 2009 as the reference period. Hence, the ban coefficient for this year is set to zero.[30]

Regarding the coefficients in the pre-period, Panel A of Figure 3 (Hospitalizations during the night) shows that before the ban, all estimated coefficients are close to zero and statistically insignificant, supporting the assumption of parallel trends between the treatment and control group. This pattern in Panel B is very similar.[31] For the outcome doctor visits (Panel C) it appears as though there is a downward trend in the coefficients in the pre-period. This optical impression is mostly driven by the first observation (i.e., the coefficient for 5 years before the ban) and excluding this year does not change the results.[32] In Panels D and E, there is little evidence that the treatment and control groups are on linearly diverging trends.[33]

Regarding the coefficients for the post-period, we observe a negative effect of the ban on late-night alcohol sales in all years after its implementation for the three outcome variables in Panels A–C, with 10 out of 15 point estimates being precisely estimated at the 5% significance level. The negative impact increases in size (and significance) over time for alcohol-related hospitalizations during the night (Panel A), and is more volatile in magnitude for the outcomes alcohol-related hospitalizations (Panel B) and doctor visits (Panel C). Reassuringly, we observe no significant effects for the placebo outcome, alcohol-related hospitalization for any time period during the day (Panel D). This suggests that the variation driving our results is very likely to be due to the late-night alcohol sales ban rather than concurrent changes. The estimates in the last panel of Figure 3 might suggest a short-term decline in alcohol-related road casualties in the first and second year after the ban was introduced, with around 1.5 fewer accidents per 100,000 population, on average. However, these estimates are of similar magnitude as the (placebo) effect 2 years before indicating that there is no structural break around the time of the introduction of the ban. Moreover, none of these coefficients is statistically significant in the corresponding SCG specification (Figure A1). There is also no evidence of a longer-term reduction as the point estimates decline considerably and we do not observe any significant reductions after three or more years in alcohol-related road casualties.

6.2 | Gender-specific effects

Table 6 reports separate two-way-fixed effects DiD results for women and men. One might expect stronger effects for men because binge-drinking is more common among men than women and young men might also be more likely to drink in public in front of gas stations or supermarkets.[34] The findings in Table 6 show that there are no large differences in the effect of the ban on the number of alcohol-related hospitalizations for males and females, with around eight fewer admissions per 100,000 population during the night (Panel A). However, due to differences in the levels of hospitalization during the night, the relative reduction is larger in magnitude for women (13%) than men (7%). In Panel B, we observe a larger reduction in magnitude for men (17 fewer admissions per 100,000 population) than women (nine fewer admissions per 100,000 population). In relative terms, both point estimates correspond to a reduction in hospital admissions of around 14%. The findings in Panel C suggest that the ban on alcohol sales reduces doctor visits due to alcohol intoxication by around three visits (15%) among women

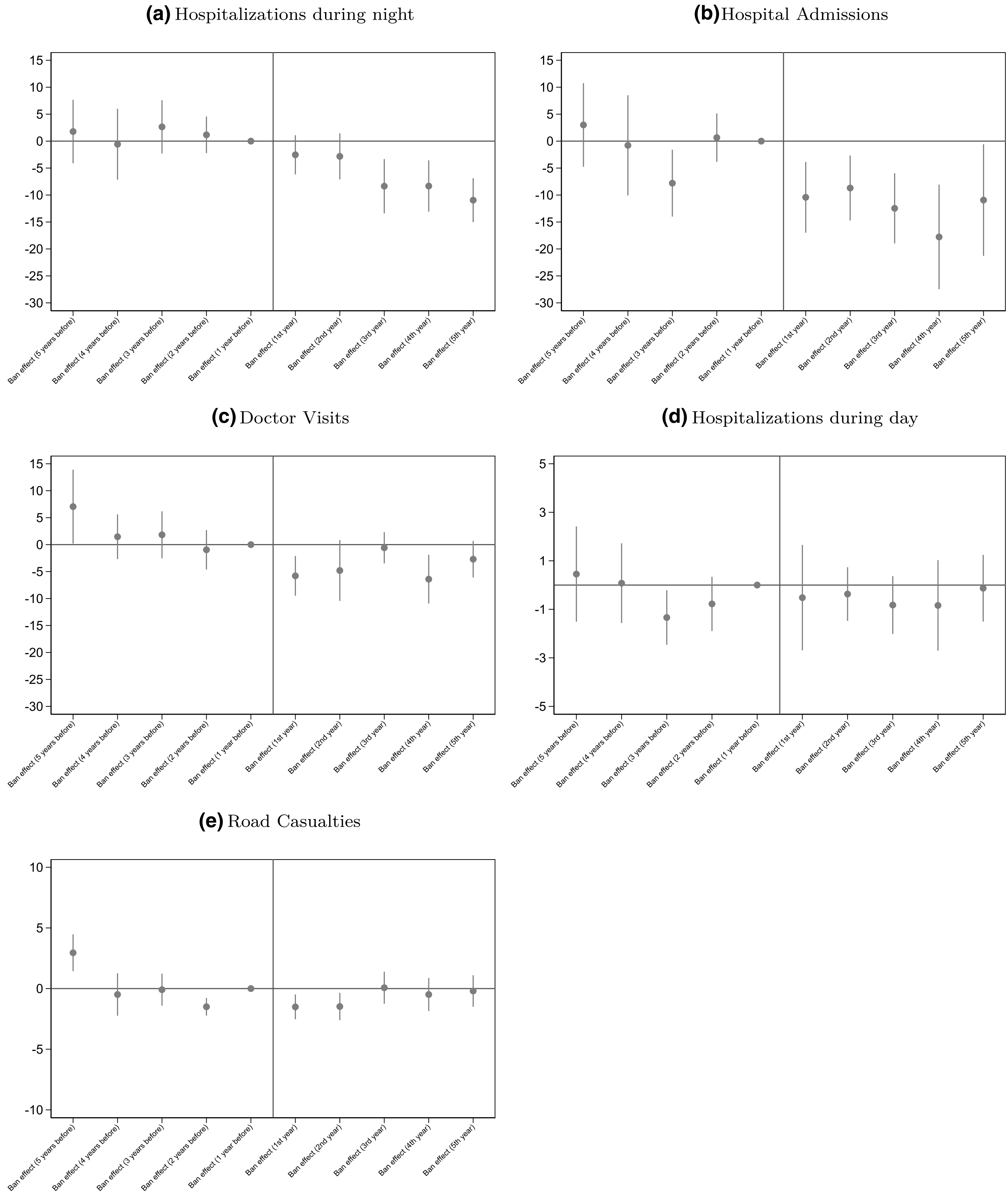

FIGURE 3 Event Study Analysis (DiD Estimations): The dependent variables measure quarterly numbers per 100,000 15-24-year-olds. All estimated coefficients and the displayed 95%-confidence intervals in each panel come from one regression. Panels (a) and (d) report results from the diagnosis related groups-Statistik, and panels (b) and (c) report findings from the health insurance fund data, while panel (e) relates to the Road Traffic Accident Statistics (RTAS). The reference period includes all observations from 2009, the year before the ban.

TABLE 6 DiD results by gender

	Women	Men
Panel A: Hospital admissions, night only (population, DRG)		
Ban on late-night alcohol sales	−8.28***	−8.41*
	(1.61)	(4.43)
R^2	0.40	0.54
% Change	−13.01	−6.69
Panel B: Hospital admissions (sample, SHI)		
Ban on late-night alcohol sales	−9.04***	−16.50***
	(1.93)	(3.92)
R^2	0.09	0.13
% Change	−14.17	−14.93
Panel C: Doctor visits (sample, SHI)		
Ban on late-night alcohol sales	−3.42	−6.11**
	(2.10)	(2.55)
R^2	0.10	0.11
% Change	−15.33	−18.32
Panel D: Hospital admissions, day only (population, DRG)		
Ban on late-night alcohol sales	−0.41	−0.45
	(0.31)	(1.20)
R^2	0.17	0.23
% Change	−3.83	−2.02
Panel E: Traffic accidents (population, RTAS)		
Ban on late-night alcohol sales	−0.01	−1.71
	(0.25)	(1.23)
R^2	0.10	0.34
%-Change	−0.12	−4.74

Note: Data from the DRG-Statistik. The dependent variables measure quarterly numbers per 100,000 15-24-year-old women and men, respectively. Each estimated coefficient (standard error) comes from a different regression. The number of observations is 16,080 (402 counties × 10 years × 4 quarters).

Abbreviation: DRG, diagnosis related groups.

$^*p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

(though this effect is not statistically significant), and by six visits (18%) among men per 100,000 population. Finally, the results in Panel D and Panel E show that the ban had no effects on hospitalizations during the day and on alcohol-related road casualties for both women and men.[35]

6.3 | Accident-specific results

This section discusses results that are specific to the road accident statistics. The first column of Table 7 repeats the estimated effect from our main specification. The next two new specifications relate to alternative definitions of the outcome variable. The numerator of our main traffic-related outcome variable relies on the number of *15–24-year-olds* who were involved in nighttime traffic accidents that occurred under the influence of alcohol. Instead, the numerator of the outcome variable in column (2) considers the number of nighttime traffic *accidents* that occurred under the influence of alcohol and involved at least one individual between 15 and 24 years of age. Hence, this alternative outcome relates more to the extensive margin of traffic accidents. In contrast, the outcome in column (3) relates to the intensive margin as this outcome considers *all individuals*—i.e., irrespective of their age—who were involved in nighttime traffic accidents that occurred under the influence of alcohol and in which at least one individual between 15 and 24 years of age was involved.[36] Table 7 shows that there is no evidence that the ban affected the number of road casualties or traffic accidents—irrespective of the outcome measure.

TABLE 7 Traffic-specific results

	Alternative outcomes			County heterogeneity			
	Main	Accidents	Individuals	No internal border	Internal border	No border	Any border
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Ban effect	−0.85	−1.06	0.37	−1.22	−0.12	−1.22	−0.47
	(0.70)	(0.65)	(0.40)	(0.70)	(0.70)	(0.70)	(0.70)
N	16,080	16,080	16,080	15,480	14,920	15,200	15,200
R^2	0.35	0.36	0.72	0.35	0.34	0.35	0.35
% Change	−4.03	−5.41	4.66	−5.72	−0.60	−5.98	−2.19

Note: The table presents additional results relating to the Road Traffic Accident Statistics.

Generally, the ban's null effect on accident-related outcomes could be the result of two opposing effects that cancel each other out. The ban could *increase* alcohol-related road casualties among individuals in the treatment state of Baden-Württemberg who live close to the state border, as these individuals might drive to neighboring regions to buy alcohol during the night. Conversely, the ban could *decrease* alcohol-related road casualties among individuals further away from the border as these individuals can no longer purchase alcohol off-premise during the night. To examine this hypothesis more closely, the next four columns of Table 7 analyze whether the effect of the ban differs according to whether the county has a border with neighboring regions outside of Baden-Württemberg. More specifically, the treatment group in column (4) consists only of counties in Baden-Württemberg that have no border with other German states, while the treatment group in column (5) consists only of counties in Baden-Württemberg that do have a border with other German states (Bavaria, Hesse, Rhineland-Palatinate). Similarly, columns (6) and (7) split the treatment group by whether the county has a border with another German state or another country (Switzerland, France). While in absolute terms, the point estimates are slightly larger for counties without borders, none of the estimated treatment effects are statistically significant at conventional levels. Moreover, in the specifications based on the SCG methods (see Table A3 in the Appendix), the point estimates are not only statistically insignificant but also positive for all groups. Hence, we conclude that the ban did not affect the number of individuals involved in alcohol-related traffic accidents.

7 | CONCLUSION

What alcohol control policies successfully reduce excessive drinking and alcohol-related harm? In this paper, we examine the impact of a ban on late-night off-premise alcohol sales on different health-related outcomes among young people aged 15–24 in Germany. In March 2010, the federal state of Baden-Württemberg, in the south-west of Germany, banned off-premise sales of alcohol between 10 p.m. and 5 a.m. We use rich administrative data for the years 2005–2014 from hospital diagnosis data, a large health insurance fund, and road accidents. We apply difference-in-differences and SCG methods and find robust evidence that the ban on late-night off-premise alcohol sales is effective in reducing hospitalizations and doctor visits due to alcohol intoxication. Our preferred specification suggests that alcohol-related hospitalizations decreased by about nine admissions per 100,000 same-age individuals in the years following the implementation of the ban. This corresponds to a decline of around 9% relative to the mean. Similarly, there is a significant reduction in alcohol-related doctor visits of five alcohol-related visits per 100,0000 same-age individuals, which corresponds to a reduction of around 18%. However, there is little empirical evidence that the ban was also successful in reducing the number of individuals involved in alcohol-related traffic accidents. For all outcomes, there is little evidence for effects differences between women and men.

We also document that the reduction is driven by fewer hospitalizations due to alcohol intoxication during the night—when the ban is in place—but not during the daytime. In addition, we conduct several robustness checks with respect to the observation window, comparison group, inference, and time trends. The results from the placebo outcome and the sensitivity checks give us confidence that there is a negative causal effect of the ban on late-night alcohol sales on alcohol-related hospitalizations and doctor visits.

There are several potential explanations as to why the ban is effective in reducing alcohol-related hospitalizations and doctor visits. One explanation is that the ban makes individuals more aware of the dangers of heavy alcohol consumption. Another explanation is that the ban does not raise awareness but rather works by making it more difficult for people to spontaneously access alcoholic beverages. This explanation is particularly relevant if individuals who already started to drink early in the evening continue to drink (excessively) after 10 p.m. if it is easy to obtain more alcohol, but stop drinking if the alcohol supply chain is interrupted and more effort is needed to obtain more alcohol. Unfortunately, there is no data available that allow us to distinguish between these alternative explanations. However, given the fact that there have been several nationwide alcohol awareness campaigns specifically targeting young people,[37] it seems less likely that the ban operates through increasing awareness of the dangers of alcohol. Moreover, our online survey provides some additional suggestive evidence on young people's attitudes toward the ban. We asked participants in whether they find the late-night alcohol sales ban reasonable. A total of 48% of young people living in Baden-Württemberg found the law reasonable, compared to 40% of those living outside Baden-Württemberg. In a second step, we asked respondents why they found the ban reasonable. Respondents could rank the following reasons (with rank 1 being the most important reason, rank 2 the second most important, etc.). Less noise during the night; less binge drinking; less violence and crime; improved public safety; and other reasons. Among those survey participants who felt that the late-night alcohol sales ban was reasonable, as the main reason for their response, 46% gave "less binge drinking", 22% said it was because there is less violence and crime, 24% indicated an improvement in public safety, and 10% an improvement in health.

Taken together, our empirical findings and previous work by Marcus and Siedler (2015) and Baumann et al. (2019) suggest that, when thinking about appropriate policy initiatives to reduce extreme drinking and alcohol-related harm among young people, policymakers should keep in mind that the introduction of a ban on late-night off-premise alcohol sales might be a useful policy initiative. A law of this type is relatively easy to implement and is more of a "light touch" regulation compared to other legislation (e.g., minimum legal drinking ages which exclude entire demographic groups from legally drinking). While young people can easily and legally circumvent the ban on late-night off-premise alcohol sales by buying alcohol earlier (i.e., before 10 p.m.) and/or by drinking in bars, restaurants, and clubs after 10 p.m., we document a robust and significant decline in alcohol-related hospitalizations and doctor visits.

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CONFLICT OF INTEREST

The author declares that there is no conflict of interest that could be perceived as prejudicing the impartiality of the research reported.

DATA AVAILABILITY STATEMENT

The data used in this study are proprietary and cannot be shared by us directly. Two of the three used data sets are official German government data sets (German DRG-Statistik, RTAS), while the third data set comes from a large SHI fund. All data sets can be accessed for research purposes.

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ENDNOTES

1 See, for example, Ruhm (1996); Dee (1999); Markowitz and Grossman (2000); Wagenaar and Toomey (2002); Carpenter (2005); Young and Bielinska-Kwapisz (2006); Carpenter et al. (2007); Carpenter and Dobkin (2009); Lovenheim and Slemrod (2010); Wagenaar et al. (2010); Carpenter and Dobkin (2011); Cawley and Ruhm (2012); Conover and Scrimgeour (2013); Yörük and Yörük (2013); Johansson et al. (2014); Hansen (2015); Boes and Stillman (2017); Carpenter and Dobkin (2017); Hansen and Waddell (2018); Ahammer et al. (2022).

2 Marcus and Siedler (2015) could only study the short-term effects of the ban (up to 2011).

3 Generally, it is not clear whether the effect of the ban is expected to increase or decrease over time. Progress in learning how to avoid the ban suggests declining effectiveness. However, it might also be the case that individuals stop excessive alcohol consumption as a result of the ban and, consequently, change their overall drinking behavior. Similarly, some off-premise outlets might completely stop trading (in particular, kiosks and gas stations that generated high profits by selling alcohol at night).

4 Our treatment state Baden-Württemberg is located in the south-west of Germany (bordering France, Switzerland, and the federal states of Bavaria, Hesse, and Rhineland-Palatinate) and has around 11 million inhabitants. It is the third largest federal state in terms of number of inhabitants and area.

[5] There are two minimum legal drinking age thresholds in Germany. At age 16, individuals are allowed to buy and consume beer, wine, and sparkling wine. Once they reach their 18th birthday and the age of majority, young adults can buy and consume all types of alcoholic beverage. See, for example, Kamalow and Siedler (2019).

[6] Individuals were invited to participate in this survey through ads on Facebook. While about 14,700 individuals participated, the participants are not a random sample of the population and we oversampled young people in Baden-Württemberg.

[7] The main reasons reported by the media were the encroachment on individual liberties and the economic burden for gas stations, which often generated substantial revenues by selling alcohol at night (Allgoewer, 2016).

[8] Note that we cannot investigate the abolition of the ban because we only have data available until the end of 2014.

[9] In addition, the majority of hospital admissions due to alcohol poisoning among young people occur late in the evening and at night.

[10] Several alcohol-related campaigns were implemented in our observation period. All of them were implemented across all German states, including "Don't drink too much - Stay Gold" in 2008, which was directed explicitly at excessive youth alcohol consumption and relied on informational videos and posters.

[11] In Germany, young people are allowed to drive certain types of light motorcycles from the age of 16 and regular cars from the age of 18.

[12] Due to data confidentiality regulations, we are not allowed to name the health insurance fund.

[13] For example, if an accident occurred as a result of a pedestrian (or cyclist) being drunk and causing a car to crash, we classify this accident as alcohol-related, even though the driver of the car was not under the influence of alcohol. Generally, individuals are recorded by the police as under the influence of alcohol if their blood alcohol concentration is found to exceed 0.3 (Kamalow & Siedler, 2019).

[14] Our conclusions do not change when admissions from 10 p.m. to 5 a.m. are considered, see Section 5.

[15] Across all age groups, acute alcohol intoxication (F10.0) makes up about 30 percent of all cases with the F10 code ("Mental and behavioral disorders due to use of alcohol") in the German DRG-Statistik. The share of hospitalizations with F10.0 in all F10 cases is higher for younger age groups (up to 90 percent) and lower for older age groups.

[16] This lowers the precision of the estimators, if the measurement error is completely unrelated to the ban. If, however, this measurement error, is, for whatever reason, related to the ban, this will even induce bias. The greater the extent of measurement error, the larger the efficiency loss and bias, respectively.

[17] This means we can, for instance, also include individuals who were concussed due to drunk driving but whose primary diagnosis was related to the concussion. When F10.0 is one of the secondary diagnoses, the top primary diagnoses are S06.0 (concussion), S00.95 (superficial injury of head), and S00.85 (unspecified injury of head), while E87.6 (hypokalemia), T68 (hypothermia), and R11 (nausea and vomiting) are the top secondary diagnoses when acute alcohol intoxication (F10.0) is the primary diagnosis.

[18] Here, we define night as the time between 10 p.m. and 6 a.m., that is, the time the ban was effective plus 1 hour to take into account that there might be a time lag between drinking alcohol and being involved in a road accident. Note that the definition of night in the RTAS data differs slightly from the definition used in the DRG-Statistik. While our results for both data sets are robust to using either definition, we think that it makes sense to use a smaller post-ban window for the road casualties than for the hospitalization data as in the hospital data there might be an additional time lag between arriving at hospital and receiving the time stamp for inpatient admission.

[19] The second quarter of 2010 is the first observation in the post-treatment period. This means that we assign March 2010, the first month, when the ban was effective, to the control group as we rely on quarterly data. Dropping the first quarter of 2010 from the analysis or assigning it to the post-treatment period does not change our conclusions (see Section 5).

[20] There is a discussion in the literature on the appropriateness of clustered standard errors when the number of clusters is small (Donald & Lang, 2007). In the robustness section, we also report results based on wild cluster bootstrap procedures (Cameron et al., 2008).

[21] We apply Stata's user-written program *ebalance* (Hainmueller & Xu, 2013).

[22] Moreover, we can reject the hypothesis that the placebo estimate is equal to the point estimate of the outcome alcohol-related hospitalization during the night.

[23] The authors also report comparable differences between the two countries for the years 2000 and 2005.

[24] Note that all coefficients in Panels A–C are at least statistically significant at the 10 percent level, except for the coefficient in column (5) for Panel C. This coefficient is of a similar size to the estimate of our main specification but less precisely estimated as this specification relies on a much smaller sample. Moreover, the point estimates in Panel E, columns 3–5, show a significant decline in the number of alcohol-related road casualties in the short-run (columns 3–4) and when the treatment state is compared to states in western Germany only (column 5). We refrain from giving these significant results too much weight, since the other robustness checks and the corresponding results based on the synthetic control provide little evidence of a statistically significant reduction.

[25] Appendix Tables A1 and A2 present similar robustness checks as in Tables 3 and 4, respectively, for the SCG-DiD method. The results of these tables are also very much in line with the results in Table 2.

[26] The MSPE takes the average of the sum of squared differences between observed and synthetic Baden-Württemberg in the validation period.

[27] For this weighting procedure, we use Stata's user-written program *synth* Abadie et al. (2015) and six lags.

[28] Note that we are not able to report the results from the Abadie et al. (2015) estimation procedure for the outcome road casualties as strict data regulations in the research data center of the statistical office did not allow us to install the necessary program.

[29] The corresponding results from the SCG-DiD method are shown in the Appendix.

[30] Note that the level of observations in the event studies is still the same as in the main analysis (quarterly level) and that only the lags and leads summarize the effects at the annual level. We present event-study coefficients at the annual level rather than at the level of half-years or quarters as there is a lot of noise in our outcome variables (see also Figure 1). Event-study coefficients with more granular time units would pick up some of this noise, while the point estimates at the yearly level average out more noise. Note also that the event study estimations exclude the first quarter of 2010 as the ban was introduced in March 2010.

[31] Here, all point estimates in the post-period are statistically significant, but so too is one of the coefficients in the pre-period. However, there is little evidence of a differential linear trend in the pre-period.

[32] Further, the respective graph for the synthetic control group (Figure A1) shows that there is a clear trend break with the introduction of the ban, while the trends in the pre-period are parallel.

[33] The bill to implement the late-night ban was discussed in the state parliament for the first time in summer 2009, while it was approved in November 2009. Hence, it may have been the case that, in anticipation of the ban, some consumers engaged in excessive alcohol consumption in the period before the actual implementation of the ban. However, Figure 3 provides little evidence for such anticipatory behavior. Moreover, the event study graphs show very similar pictures when excluding the year 2009 and using the observations from 2008 as a reference period (results available on request).

[34] It is a common finding in the literature that men engage in excessive alcohol consumption more frequently than women (see, e.g., Conover & Scrimgeour, 2013). This observation is also supported by our data. For all our outcome variables, the mean is substantially higher for men than for women. For instance, for our first outcome (Hospital Admissions, Night Only, DRG), the mean for men is 100.7 hospitalizations per quarter per 100.000 15–24-year-old men, while the respective number for women is 48.3. The differences are also substantial for the other outcomes (e.g., 84.6 vs. 50.2 for Hospital Admissions in the SHI data, and 33.4 vs. 21.6 for doctor visits). In our online survey, we also find that young men are more likely to report binge-drinking than young women.

[35] When we split the sample according to the age of the individuals, we find that the impact of the ban on late-night alcohol sales is stronger among adolescents aged 15–19 years than among those aged 20–24 years.

[36] We normalize the outcomes in columns (1) and (2) by the county's population of 15–24-year-olds, while the outcome in column (3) is a count variable.

[37] These nationwide campaigns include, for instance, “HaLT - Hart am Limit” (https://www.halt.de/) and “Null Alkohol - Voll Power” (https://www.null-alkohol-voll-power.de/), both of which have been running for many years.

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APPENDIX: ROBUSTNESS AND ADDITIONAL EVIDENCE FROM THE SYNTHETIC CONTROL GROUP METHOD

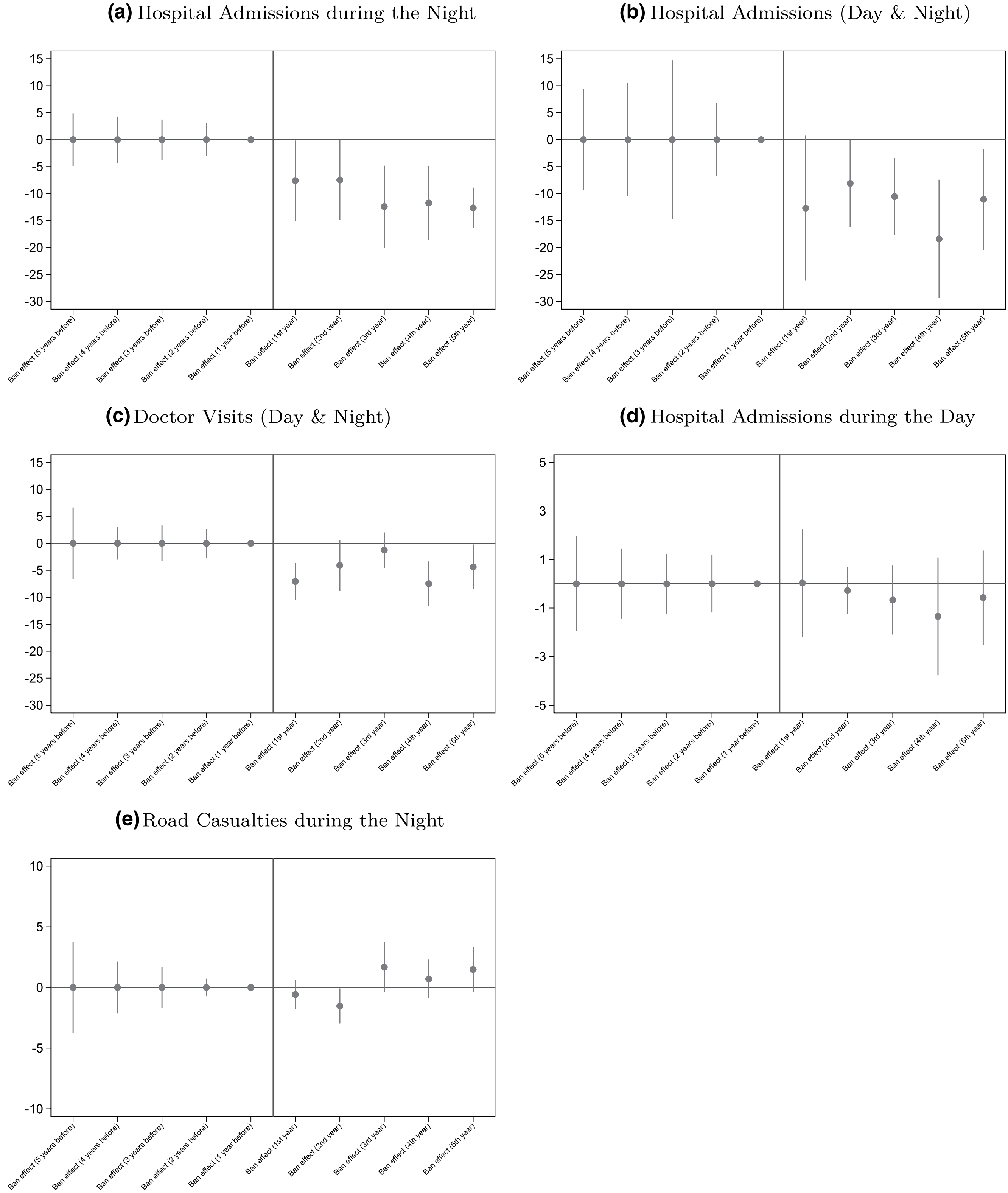

FIGURE A1 Event Study Analysis (Synthetic control). The dependent variables measure quarterly numbers per 100,000 15-24-year-olds. All estimated coefficients and the displayed 95%-confidence intervals in each panel come from one regression. Panels (a) and (d) report results from the diagnosis related groups-Statistik, and panels (b) and (c) report findings from the health insurance fund data, while panel (e) relates to the Road Traffic Accident Statistics (RTAS). The reference period includes all observations more than 2 years before the ban.

TABLE A1 Synthetic control: Robustness

	Main DiD	Observation window 2007–2014	Observation window 2007–2011	Observation window 2009–2010	Control states West Germany	Control states w/o Bavaria	Time trend	w/o 2010Q1	County-quarter
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: Hospital admissions, night only (population, DRG)									
Ban on late-night alcohol sales	−10.52***	−10.52***	−7.53**	−7.60**	−12.87***	−6.95***	−6.88**	−10.52***	−10.19***
	(2.73)	(2.33)	(2.83)	(2.92)	(2.38)	(2.10)	(3.19)	(2.88)	(2.78)
N	16,080	12,864	8040	3216	13,000	12,240	16,080	15,678	16,080
R^2	0.58	0.60	0.61	0.67	0.56	0.58	0.58	0.58	0.62
Panel B: Hospital admissions (sample, SHI)									
Ban on late-night alcohol sales	−12.14***	−12.14**	−10.08*	−12.70*	−13.60***	−8.48***	−9.88**	−12.14***	−11.48***
	(3.05)	(4.47)	(4.74)	(6.02)	(3.20)	(1.55)	(4.55)	(3.19)	(2.93)
N	16,080	12,864	8040	3216	13,000	12,240	16,080	15,678	16,080
R^2	0.13	0.15	0.14	0.23	0.12	0.11	0.13	0.13	0.20
Panel C: Doctor visits (sample, SHI)									
Ban on late-night alcohol sales	−4.74***	−4.73***	−5.37***	−7.07***	−4.30**	−6.04***	−4.54*	−4.74***	−4.61***
	(1.39)	(1.55)	(1.81)	(1.33)	(1.62)	(1.02)	(2.28)	(1.52)	(1.48)
N	16,080	12,864	8040	3216	13,000	12,240	16,080	15,678	16,080
R^2	0.10	0.13	0.13	0.23	0.10	0.11	0.10	0.10	0.18
Panel D: Hospital admissions, day only (population, DRG)									
Ban on late-night alcohol sales	−0.60	−0.60	−0.14	0.03	−0.96	0.05	0.17	−0.60	−0.48
	(0.69)	(0.77)	(0.60)	(1.38)	(0.79)	(0.48)	(0.71)	(0.71)	(0.70)
N	16,080	12,864	8040	3216	13,000	12,240	16,080	15,678	16,080
R^2	0.31	0.32	0.34	0.42	0.32	0.31	0.31	0.30	0.47
Panel E: Traffic accidents (population, RTAS)									
Ban on late-night alcohol sales	0.40	0.40	−1.12**	−0.58	−0.27	0.70	−0.95	0.40	0.41
	(0.94)	(0.67)	(0.43)	(0.59)	(0.91)	(1.20)	(0.72)	(0.99)	(0.99)
N	16,080	12,864	8040	3216	13,000	12,240	16,080	15,678	16,080
R^2	0.34	0.32	0.33	0.33	0.34	0.36	0.35	0.35	0.40

Note: The dependent variables measure quarterly numbers per 100,000 15–24-year-olds. Each estimated coefficient (standard error) comes from a different SCG-DiD model.

Abbreviation: DRG, diagnosis related groups.

$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

TABLE A2 Synthetic control: Other ways of inference

	Cluster			Wild cluster bootstrap		
	State	**County**	**State & time**	**Rade-macher**	**Mammen**	**Webb**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Panel A: Hospital admissions, night only (population, DRG)						
Ban on late-night alcohol sales	−10.52	−10.52	−10.52	−10.52	−10.52	−10.52
p-value	0.024	0.003	0.003	0.015	0.002	0.015
Panel B: Hospital admissions (sample, SHI)						
Ban on late-night alcohol sales	−12.14	−12.14	−12.14	−12.14	−12.14	−12.14
p-value	0.015	0.002	0.004	0.014	0.006	0.015
Panel C: Doctor visits (sample, SHI)						
Ban on late-night alcohol sales	−4.74	−4.74	−4.74	−4.74	−4.74	−4.74
p-value	0.000	0.019	0.005	0.000	0.000	0.000
Panel D: Hospital admissions, day only (population, DRG)						
Ban on late-night alcohol sales	−0.60	−0.60	−0.60	−0.60	−0.60	−0.60
p-value	0.504	0.359	0.398	0.526	0.460	0.499
Panel E: Traffic accidents (population, RTAS)						
Ban on late-night alcohol sales	0.40	0.40	0.40	0.40	0.40	0.40
p-value	0.714	0.565	0.684	0.693	0.685	0.700

Note: The dependent variables measure quarterly numbers per 100,000 15–24-year-olds. Each estimated coefficient (*p*-value) comes from a different regression. The number of observations is 16,080 (402 counties × 10 years × 4 quarters).

Abbreviation: DRG, diagnosis related groups.

TABLE A3 Traffic-specific results (Synthetic control)

	Alternative outcomes			County heterogeneity			
	Main	**Accidents**	**Individuals**	**No internal border**	**Internal border**	**No border**	**Any border**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
Ban effect	−0.85	−1.06	0.37	0.03	1.10	0.03	0.76
	(0.70)	(0.65)	(0.40)	(0.94)	(0.94)	(0.94)	(0.94)
N	16,080	16,080	16,080	15,480	14,920	15,200	15,200
R^2	0.35	0.36	0.72	0.35	0.33	0.35	0.34
%-Change	−4.03	−5.41	4.66	0.14	5.78	0.13	3.74

Note: The table presents additional results relating to the Road Traffic Accident Statistics, based on the synthetic control method.