LOWERING BLOOD ALCOHOL CONTENT LEVELS TO SAVE LIVES: THE EUROPEAN EXPERIENCE

by Daniel Albalate.

Research Unit of Public Policy and Economic Regulation (GPPRE-IREA), University of Barcelona, Department of Economic Policy and World Economics. Diagonal 690, 08034 Barcelona, Spain; email: albalate@ub.edu

Abstract: Road safety has become an increasing concern in developed countries due to the significant amount of mortal victims and the economic losses derived. Only in 2005 these losses rose to 200.000 million euros, a significant amount – approximately the 2% of its GDP- that easily justifies any public intervention. One tool used by governments to face this challenge is the enactment of stricter policies and regulations. Since drunk driving is one of the most important concerns of public authorities on this field, several European countries decided to lower their illegal Blood Alcohol Content levels to 0.5 mg/ml during the last decade. This study evaluates for the first time the effectiveness of this transition using European panel-based data (CARE) for the period 1991-2003 using the Differences-in-Differences method in a fixed effects estimation that allows for any pattern of correlation (Cluster-Robust). My results show the existence of positive impacts on certain groups of road users and for the whole population when the policy is accompanied by some enforcement interventions. Moreover, a time lag of more than two years is found in that effectiveness. Finally, I also assert the importance of controlling for serial correlation in the evaluation of this kind of policies.

Keywords: Road Safety; Policy Evaluation; Differences-in-Differences; Drunk Driving; Illegal Blood Alcohol Content Levels (BAC).

JEL codes: I18; H73; K32; R41.

Acknowledgements: I wish to thank Marcos Vera-Hernández for his useful advice and support and to the rest of the Economics Department in the University College London. I am also thankful for comments received from my colleagues in the Research Unit of Public Policy and Economic Regulation, in particular to Germà Bel, Xavier Fageda and Laura Fernández. Finally, I would like to express my gratitude to Rosa Vidal and David López-Rodríguez for their suggestions over the last months. All errors are my own.

1. Introduction.

In the programme to promote road safety in 1997 the European Commission estimated yearly losses related with road accidents in 45.000 million euros.[1] This estimation increased after the EU enlargement to 200.000 million - approximately the 2% of its GDP- in 2005.[2] Two thirds of this quantity are spent in medical care, police intervention and vehicle repairing costs. The rest represents a waste of economic production caused by deaths and injuries. Thus, this estimation gives a strong argument to consider the reduction of road accidents as an economic objective for governments and justifies the implementation of costly measures.

It is already proved and socially accepted that alcohol consumption has a dramatic impact on driver's ability to drive. The European Commission considered in 2003 that at least 10.000 road users died every year in alcohol-related accidents costing about 10.000 million euros in social value.[3] For that reason governments try to discourage drunk driving using specific regulations worldwide.

One common policy implemented in developed countries has been setting or lowering Blood Alcohol Content (BAC) illegal limits.[4] Especially in Europe, this policy has a long tradition and recently has lived an imperfect process of homogenisation since 1994.[5] From that year on, most former EU15 countries lowered their illegal BAC limits, usually set at the level of 0.8 mg/ml, to the level already established in other few countries: a BAC limit of 0.5 mg/ml. Since this process is almost completed, I consider that it is time to evaluate its results. Therefore, the objective of this study is the evaluation of the effectiveness of lowering illegal Blood Alcohol Content limits to 0.5 mg/ml as a way to fight against road fatalities in Europe.

This study contributes to the literature in several ways. Firstly, as far as I know, this is the first evaluation of BAC policies that uses international panel-based data for the former

[1] COM (97) 131**.** Promotion of road safety in the European Union 1997-2001.
[2] More than 41.000 lives were lost and 1.9 million were injured that year, some of them severely according to the Directorate-general for Energy and Transport of the European Commission.
[3] This estimation comes from the one million euros rule established in the European programme on road safety (1997), where it was agreed that one life had the social value of one million euros.
[4] A BAC level is the number of grams of ethanol per litre of blood.
[5] We call it imperfect process of homogenization because some countries never lowered that limit and still have an illegal BAC limit of 0.8 mg/ml.

EU15 countries. Secondly, this research aspire to fill another gap, since few studies evaluate the transition from higher BAC limits to the 0.5 mg/ml level.[6] Finally, the most recent and technically accurate studies which used Differences-in-Differences in panel-based data to evaluate BAC changes – Dee (2001) and Eisenberg (2003) -, did not consider serial correlation problems. This absence can generate a downward bias in standard errors that could overestimate the effectiveness of lowering BAC levels. Therefore, the last contribution comes from solving this problem by taking into account not only the heterogeneity caused by dealing with different countries, but also the existence of serial correlation.

Our main results show how lowering illegal BAC limits to 0.5 mg/ml has been an effective policy to save lives in particular road user groups in Europe. From these groups we can emphasize the case of males, to whom it has been especially effective in urban areas, and the case of all drivers between 20 and 49 years old. However, 0.5 mg/ml illegal BAC limits are not found statistically significant for the whole population unless it is accompanied by specific enforcement activities as random checks on the road. Moreover, I find an important time lag longer than two years in the effectiveness of the policy.

This study is organised as follows. In section 2 I describe the evolution of the legislative process that leaded to the homogenisation in BAC limits, emphasizing the role taken by national and European institutions. In section 3 I introduce the related literature that has studied the effectiveness of setting and lowering BAC levels focusing our attention on the most recent and accurate studies that used panel-based data and Differences-in-Differences as a method of evaluation. In sections 4 and 5 I explain the methods, data and variables employed. In section 6 I provide the main results while in section 7 I assert the importance of controling by serial correlation in the evaluation of this policy. Finally, some concluding remarks are reported in section 8.

2. European and national legislations on BAC limits.

In Europe, the illegal Blood Alcohol Content (BAC) levels have always been established by national legislations. However, the European institutions have not remained

[6] The literature was mainly focused in the American experience where several states lowered their illegal BAC levels to 0.8 mg/ml by the end of 1998. None of them established a lower limit.

impassive and their concern pushed the European Commission (EC) to propose a draft Directive in 1988 in order to harmonise illegal BAC limits at the level of 0.5 mg/ml in all member states.[7] In that moment only Finland, Netherlands, Portugal and Sweden already had this limit in their national legislations. The Commission's proposal was thought to send a clear and coherent message to the drivers in the whole Community but did not succeed because several member states denied the competence of the European legislation.[8] Although the Directive did not prosper, many member states having higher BAC limits decided to accommodate them to the level recommended during the following decade as I show in **Table 1**. Despite of this, thinking that their decision was only taken because of this frustrated Directive would be too naive, especially if we take into account that the first reforms were not undertaken until 1994. However, it is fair to consider the Commission's proposal as the first important attempt to claim for a general reduction of BAC limits to the level of 0.5 mg/ml across Europe.

Table 1. Changes Adopted in the Illegal BAC Limits. EU15 (1991-2003).

Country	Changes in illegal BAC limits during 1991-2003	BAC limit (mg/ml) in 2006
Austria	January 1998	0.5
Belgium	December 1994	0.5
Denmark	March 1998	0.5
France	July 1994 / August 1995	0.5
Finland	-	0.5
Germany	April 1998	0.5
Greece	March 1999	0.5
Luxembourg	-	0.8
Ireland	April 1994	0.8
Italy	July 2002	0.5
Netherlands	-	0.5
Portugal	-	0.5
Spain	May 1999	0.5
Sweden	-	0.2
United Kingdom	-	0.8

Source: Self-construction.

Belgium and France were the first two countries that decided to reduce their BAC limits to 0.5 mg/ml in 1994 and 1995, respectively. Later, in April 1997, the EC launched a

[7] COM (88) 707. The Commission explains that this level was chosen after some studies and investigations and took into account the public acceptance that the new limit would have and the effectiveness of the reduction.

[8] This proposal was rejected by the Council of Transport Ministers in 1989 where the member states that were against the proposal (United Kingdom, Netherlands and Germany) claimed that there was no Community competence to act and no soundly justification.

new programme to promote road safety which included the revival of the 1988 draft.[9] Again, the programme claimed for a reduction in illegal BAC but the responsibility was left to the national legislation.[10] This programme was more successful than the 1988 draft because five countries (Austria, Denmark, Germany, Spain and Greece) decided to join to the 0.5 mg/ml group during the first two active years of the programme, making clear an important convergence towards a common prohibited BAC level.

The last effort arrived in 2001 when, still in the last year of the same programme, the EC published a Recommendation that pursued the same objectives and included the reduction of illegal BAC limits as one of the most important measures to promote road safety. In that Recommendation the EC established the recommended BAC limit for the European Union in 0.5 mg/ml.[11] The EC asked to the countries that already had the recommended level to continue the tendency reducing this limit as low as possible. On the other hand, the Commission invited the rest of members to join at least to the group of 0.5 mg/ml. As a consequence, Italy was the only remaining member that reduced its illegal BAC limit after the Commission's Recommendation while Ireland, Luxemburg and United Kingdom preferred to keep the 0.8 mg/ml BAC limit.[12]

As a result of the process above, 12 member states of the former EU15 have a permitted BAC level equal or lower than 0.5 mg/ml at the moment.[13] Three countries already fulfilled this condition before 1991 and 8 changed their national legislation between that year and 2003 to enjoy the same situation.

Finally, it is worth noting that besides of the European Commission's activity and the national objectives, a regional peer expansion of policy enactment seems to have occurred if we focus our attention on the chronology reported in **Table 1**. Belgium and France lowered

[9] Promotion of road safety in the European Union 1997-2001. COM(97)131.
[10] Probably the Commission was aware of the opposition of some members to pass a Directive again.
[11] European Comission's Recommendation 2001. Official diary L 43 de 14.2.2001.
[12] Looking at Table 1, the reader can notice a change occurred in Ireland twelve years ago. Ireland had a higher illegal BAC level before 1994 and decided to lower it to the level of 0.8 mg/ml. Although there is some discussion in the country about the convenience of lowering it again, no decision has been undertaken yet.
[13] The unique country that established a lower BAC limit is Sweden who having already 0.5 mg/ml since 1957, decided that was time to decrease it again to 0.2 mg/ml in 1990. Portugal also passed a reduction in 2001 to force zero consumption but after one year they returned to the 0.5 mg/ml. level because of economic pressures and no significant effectiveness.

their limits between 1994 and 1996 to 0.5 mg/ml while Netherlands already had this limit. On the other hand, Austria, Germany and Denmark also homogenised their limits during the same year. Finally, the Mediterranean countries - Greece, Spain and Italy - have been the last group to reduce and set the common BAC limit since 1999.[14] United Kingdom and Ireland never reduced their limits to the recommended one, while on the contrary, Sweden and Finland have kept a strict policy with low BAC limits for a long time before 1991.

In conclusion, we have seen how the European countries have individually decided to harmonise their illegal BAC limit to 0.5 mg/ml using their national legislation but inspired by the European Commission's activity. A peer effect based on regions seems to have been relevant as well. This process, which started in the middle of the last decade, is almost finished and only three countries remain out of it.

3. Related literature.

The economic literature has been interested in road accidents for a long time. Recent studies usually attempt to evaluate the effectiveness of public policies and regulations against road fatalities. Mandatory seat belt devices, vehicle safety inspections or speed limits are some recurrent examples. However, we are interested in those policies and regulations aimed for reducing alcohol-related road fatalities.

It is socially accepted that alcohol consumption is one of the main determinants of road crashes. Economic and medical literatures also support this idea. Levitt and Porter (1999), Moskowitz and Fiorentino (2000), Zador et al. (2000), Compton et al (2002) and Keall et al. (2004) are just some recent examples of scientific studies and medical reviews that prove the negative effects of alcohol consumption on driver's skills. As a consequence, policies that were designed to fight against drunk driving have been of great relevance in the last two decades, becoming a favourite target for policy evaluators.

Some researchers analysed several alcohol-related laws and facts. Baughman et al. (2001) and McCarthy (2003), for example, devoted their work to the importance of alcohol

[14] Spain and Greece also lowered their illegal BAC limit within the same year 1999 to 0.5 mg/ml. Portugal and France already had this limit.

availability and alcohol access laws on road safety outputs. Saffer (1997) studied the role of alcohol advertising as a contributing factor of road fatalities while alcohol taxes have also been studied by Ruhm (1996) and Benson et al. (1999). Finally, Chaloupka and Saffer (1989) turned to breath testing as a deterrent instrument against drunk driving.

Apart from the mentioned above, the Minimum Legal Drinking Age (MLDA) laws and the illegal BAC limits have been the two most treated regulations by the literature. The concern caused by the huge amount of alcohol-related accidents suffered by young drivers and recent regulatory changes undertaken in USA could explain the particular relevance that these regulations recently enjoy.[15]

The literature on the effectiveness of BAC changes has shown mixed results. As Eisenberg (2003) points out, this is not surprising because of the limitations and varying levels of accuracy carried out in those studies.[16] **Table 2** shows some of these interesting previous studies. Most of them based their analyses on weak research design, small samples, comparison problems and limited data, making impossible to get solid conclusions. Others present too short post-policy periods or do not control for simultaneous policies that can confound the real effectiveness of lowering illegal BAC levels. In addition, few studies tried to control for unobserved characteristics that can vary from one state to another by using a wide set of explanatory variables. However, it is not possible to capture all the heterogeneity by adding a large number of covariates. Therefore, none of them achieves a robust evaluation due to at least one of these briefly exposed problems.

On the contrary, Dee (2001) and Eisenberg (2003) do not suffer the drawbacks above mentioned and represent, as far as I know, the most technically rigorous and accurate studies published so far. They use a large panel of annual state-level data covering the period 1982-2000 for USA federal states and introduce fixed effects to capture the unobserved heterogeneity.[17] Moreover, several concurrent policies (Minimum legal drinking age, seatbelt

---

[15] Cook and Tauchen (1984), Asch and Levy (1990), DuMouchell et al. (1987), Saffer and Grossman (1987), Wagenaar (1993) are just some interesting studies and reviews of the evaluation of changes in MLDA in USA. Results usually support the implementation of higher MLDA.

[16] See Fell and Voas (2003) for a literature review on the evidence of lowering BAC laws.

[17] Cook and Tauschen (1984) and Evans and Graham (1988), as far as we know, are probably the first studies that introduced fixed effects in the road safety literature. Ruhm (1996), for example, shows the goodness of this methology in the evaluation of road safety measures.

laws, administrative license revocation, etc.) are introduced in the analyses to avoid confounding factors that could bias the estimates. Other time varying covariates like unemployment and vehicle-miles driven are also used. In both studies results seem to support the effectiveness of lowering illegal BAC levels to 0.8 mg/ml in USA.[18] Dee (2001), for instance, finds a reduction in the total fatality rate of 7.2% associated with the new illegal BAC level, while Eisenberg (2003) finds a reduction rate of 3.1% in the fatal crash rate. In particular, the policy seems to be especially effective in the reduction of young fatalities, on weekends and during the night time. The last contribution offered by Eisenberg (2003) was the timing effects evaluation. He found an important delay of 6 years in achieving that effectiveness that do not strictly contradict the main result but introduces some doubts about how the policy works.

Despite of being the most relevant studies published so far from our point of view, Dee (2001) and Eisenberg (2003) did not take into account the possible serial correlation that can arise using Differences-in-Differences methods with a large panel and a highly time correlated dependent variable. For that reason, their estimates could be downwards biased, as it is explained in Bertrand et al. (2004), overestimating the effectiveness of the policy. Later in this research I try to solve this drawback by allowing for any pattern of correlation.

All studies described above are focused on the reduction of illegal BAC limits to the level of 0.8 mg/ml. This study attempts to evaluate the next step: the transition to 0.5 mg/ml%. Unfortunately, the literature on 0.5 BAC limits is much more scarcer. Basically, a major part of these works are just national or regional reports that support the reduction of illegal BAC limits by comparing pre-post statistical data. Other scientific studies just present the same technical limitations mentioned before in the description of the 0.8 literature. From this group of 0.5 BAC studies I can mention Henstridge et al. (1997) for Australia, Bartl and Esberger (2000) for Austria, Bernhoft (2003) for Denmark, Mercier-Guyon (1998) in the case of France, and finally Noordzij (1994) for Netherlands. None of these works uses an international European panel to study this transition, meaning that the current research can fill another relevant space in the evaluation of such an interesting policy.

[18] They also find statistically effective the implementation of 1.0 BAC limits in places where no BAC legislation existed before. Eisenberg (2003) finds a higher effect associated with the 0.8 BAC level.

To conclude this section, I want to highlight the main contributions of this study to the literature, which is twofold: first, this research is the first one to estimate the effect of lowering illegal BAC limits in Europe using panel-based data from former EU15 countries and fixed effects; and second, it is the first one that takes into account serial correlation in estimating the effect of changes in illegal BAC limits, avoiding the usual overestimation suffered by previous works.[19]

Table 2. Previous Literature on 0.8 BAC Limits Evaluation.

Study	Location	Results
NHTSA (1991)	State of California (USA)	12% decline in alcohol related fatalities
NHTSA (1994)	Five States (USA)	Significant reductions in alcohol involvement
Johnson and Fell (1995)	Five States (USA)	Significant reductions in alcohol-related fatal crashes in 4 states
Rogers (1995)	State of California (USA)	Mixed Results
OTS (1995)	State of California (USA)	Mixed results
Hingson et al. (1996)	Five States (USA)	Reduction in alcohol involvement
Foss et al. (1998)	State of North Carolin (USA)	No clear effects
Apsler et al. (1999)	11 States (USA)	Significant reduction in alcohol involvement only in two states
Hingson et al. (2000)	Six States (USA)	6% decline in alcohol-related fatal crashes
Voas et al. (2000)	50 States and District of Columbia (USA)	Decrease in the alcohol involvement
Shults et al. (2001)	50 States (USA)	7% reduction in measures of alcohol-related
Dee (2001)	48 States (USA)	7.2% decline in the total fatality rate
Eisenberg (2003)	50 States and District of Columbia (USA)	3.1% reduction in fatal crash rate

Source: Table adapted from Fell and Voas (2003). NHTS: National Highway Traffic Safety Administration (USA).

4. Empirical strategy.

This study uses several fatality rates for the former EU15 countries for the period 1991-2003 to evaluate the impact of the reduction of illegal BAC limits that some countries

[19] However, this is not the first study that controls for serial correlation in the road safety literature. Dee and Sela (2003) was, as far as we know, the first study that started this estimation strategy in evaluating speed limit changes in USA.

undertook during that time interval. The method chosen is a slight extension of the Differences-in-Differences estimation procedure specified as a two way fixed effects model that takes the following form:

$$Y_{st} = X_{st}\beta + \delta Z_{st} + w_s + v_t + \varepsilon_{st} \qquad \textbf{(1)}$$

where $\boldsymbol{Y_{st}}$ is the chosen dependent variable (Fatality rate), $\boldsymbol{X_{st}}$ contains the vector of time-varying control covariates and $\boldsymbol{Z_{st}}$ is the policy dummy variable that I am evaluating. As usual, $\boldsymbol{w_s}$ and $\boldsymbol{v_t}$ are state-specific and year-specific fixed effects and ε_{st} is a mean-zero random error. State fixed effects control for time-invariant state-specific omitted variables and year dummies control for national trends. The key element of this Difference-in-Difference model is the parameter $\boldsymbol{\delta}$ which measures the difference between the average change in the fatality rates of the treatment group (countries that have a BAC level of 0.5 mg/ml or lower at some point during the period studied) and the average change in the fatality rates of the control group (those countries that kept a higher BAC level).

Specifically,

$$\delta = [\, E(Y_A / G = 1) - E(Y_B / G = 1)] - [\, E(Y_A / G = 0) - E(Y_B / G = 0)] \qquad \textbf{(2)}$$

where $\boldsymbol{Y_B}$ and $\boldsymbol{Y_A}$ denote the road fatality rate before and after the reform and $\boldsymbol{G = 1}$ and $\boldsymbol{G = 0}$ denote treatment and control group observations, respectively.

One of the most basic assumptions of Differences-in-Differences models is that the temporal effect in the two groups of states is the same in the absence of intervention. This is called the *fundamental identifying assumption* and it is described as the equality between average changes in the two groups in the absence of intervention. As Galiani, Gertler and Schargrosdky (2005), I test for the equality between average changes in the two groups in the pre-treatment period to assess the plausibility of the fundamental identifying assumption. This kind of tests are as important as forgotten in the Differences-in-Differences applied literature.

The strategy consists on considering only the pre-treatment years from each treated country, excluding observations from treated years. In addition, I add the observations from each control country for the whole period.[20] Once I have the observations of interest I estimate equation **(1)** but now with two important changes. First, I use separate time dummies for treatment and control countries because it allows us to check whether the time trends in the pre-treatment period were the same; and second, I drop out the policy dummy variable.

The results of the test tell us that we cannot statistically reject the hypothesis of having the same time trends in the pre-treatment period for control and treatment groups, and according to Heckman and Hotz (1989), this validates the main Differences-in-Differences identifying assumption. Results of this test can be found in the appendix (**A1**).

Another concern in using Differences-in-Differences to evaluate the impact of any policy across heterogeneous individuals is to make sure that I do not have endogeneity problems that biases the policy effects. Bertrand et al. (2004) points out that Differences-in-Differences models can avoid many of these endogeneity problems but they can still be one important limitation. As Besley and Case (2000) states, policy change is purposeful action and can rarely be treated as experimental data. Therefore, further research is needed to understand what drives policy makers in each case of study.

In our case I cannot test a policy equation but I can try to find whether any pattern on the evolution of fatality rates and the decision of lowering BAC levels exists. One could reasonably think that those countries who undertook the policy might have observed a bad shock in fatalities in their recent past.

The rates of variation constructed taking into account the last pre-treatment years for each treated country and reported in **Table 3,** reveal that we cannot clearly identify this pattern. Actually, only few countries passed new illegal BAC levels after suffering positive rates of variation in the last pre-treatment years. However, it is true that the rate of change observed for the last pre-treatment year is slightly lower than the annual average change since 1991 for most of the countries. In spite of this, all countries except Spain and Greece, show good results for the last two years, making unlikely that governments considered what

[20] We can use the whole period for the control countries because some countries that still keep high BAC limits (United Kingdom, Ireland and Luxembourg) never changed the law during the period considered.

happened in the latest period an important trend change. Moreover, only Austria and Spain suffered a really important growth in the fatality rate in the last pre-treatment year. For these reasons seems too strict to believe that BAC limits were lowered generally because of bad shocks in the short past.

Table 3. Rates of Change in the Fatality Rate Before the 0.5 BAC Limit Enactment (Treated Countries).

Country	Change Last Year[1]	Change Last Two Years[2]	Annual Average Change since 1991[3]
Austria	7%	-9%	-6%
Belgium	-1%	-12%	-6%
Denmark	-5%	-17%	-4%
Germany	-3%	-10%	-5%
Greece	3%	1%	0%
Spain	6%	8%	-5%
France	-2%	-10%	-5%
Italy	0%	5%	-2%

1. Change in the fatality rate suffered in the last year before setting the 0.5 BAC limit.
2. Change in the fatality rate observed in the last two years before setting the 0.5 BAC limit.
3. Average rate of variation in the fatality rate since 1991 until the enactment year.

Other two possible explanations are the peer effect expansion and the role of the European Union in its fight against road fatalities. The detailed description of the legal chronology exposed in the previous section show how regions seem to have relevance in the enactment process of illegal BAC limits. At the same time, we cannot forget the implication of the European Commission and the programme launched to promote road safety in 1997, which recommended the 0.5 BAC limit and was followed by several countries. Both explanations did not represent any endogeneity problem and cannot promote misleading conclusions.

In the last effort to overcome the endogeneity concern, I follow the strategy of Eisenberg (2003) and check the time pattern of policy effects with respect to the date of adoption. Our goal is to address unobserved factors like attitude shifts that can be partly responsible for the enactment of stricter policies. This test consists on the same basic model **(1)** introduced earlier but now using binary variables related to the time distance respect to the adoption year instead of the policy dummy. Results of the test can be found in the appendix **(A2)** and they tell us that no significant time patterns are found before the enactment.

Finally, Bertrand et al. (2004) find that most papers that employ Differences-in-Differences estimation ignore serial correlation problems even when they use many years of data and dependent variables likely to be serially correlated.[21] We cannot forget that the estimated effect of the policy is the common OLS estimate. This generates standard errors that severely understate the standard deviation of Differences-in-Differences estimator in the presence of serial correlation. In order to correct this bias Bertrand et al. (2004) propose different solutions that apply depending on sample characteristics. Given the number of states I have in this study the method that performs better according with their Montecarlo simulations is allowing for an arbitrary variance-covariance matrix.[22] For that reason, the results exposed below take into account not only heteroskedasticity but also serial correlation within states, and this represents one important difference between this study and the most advanced literature focused in the evaluation of BAC laws.[23] As it is well known, this method is based on the estimation of the variance-covariance matrix allowing for all arbitrary of correlation. The estimator used takes the following form:

$$V = (X'X)^{-1} \left(\sum_{i=1}^{N} u_i' u_i\right) (X'X)^{-1} \qquad \textbf{(3)}$$

$$u_i = \sum_{t=1}^{T} e_{it} \, x_{it}$$

where V represents the variance-covariance estimator, X the matrix of independent variables and N the number of groups (states). On the other hand, e_{it} is the state-year specific residual and x_{it} the vector of independent variables.[24, 25]

[21] Three causing factors are found in Bertrand et al. (2004): Long time series, serial correlated dependent variables and a treatment variable that changes itself very little within a state over time.

[22] See Bertrand et al. (2004) to check a summary of their Montecarlo simulations for different number of states.

[23] The same strategy is used by Dee and Sela (2003) in the evaluation of changes in speed limits as we mentioned in note 15.

[24] In fact, this is known as the White-like formula to compute standard errors (White, 1984). Also see Arellano (1987) for a deeper understanding.

[25] Since this method is only valid assimptotcally, we apply the finite sample adjustment used by STATA: N-1/(N-k) * M/(M-1), where N is the number of observations, k the number of regressors including the constant and M the number of clusters.

5. Data and variables employed.

This research is based on the European database CARE (*Community database on Accidents on the Roads in Europe*), which started collecting data in 1993 and provides information on annual road casualties reported by the countries that form the EU25.[26] The Council created this Community database on road safety outputs (Fatality Rates, Total Fatalities, Total Injuries, etc.) in order to make possible to identify and quantify road safety problems in the continent.[27] Thus, CARE contains state-level data since 1991 until 2004 for the EU25. However, we are interested in the homogenisation in illegal BAC limits occurred during the last decade, just before the EU enlargement. For that reason I use only data related to the former EU15 countries. In addition, I only use data up to 2003 because the rest of variables are not always available for that last year. As a consequence, I have a sample based on 15 countries during 13 years for the Total Fatality Rates (195 observations).

The best characteristic of this database is that CARE allows exploiting its high level of disaggregation, making possible the use of different fatality rates depending on several victim groups. The available groups are divided by gender, age, zone and kind of road user. Unfortunately, for some reason CARE does not contain disaggregated data for Germany. Therefore, I use 14 countries in the analysis of disaggregated dependent variables (182 observations).

The rest of variables are found in international databases like Eurostat, WHO Europe, World Bank Development Indicators and the World Road Statistics. The policy variables used are found in national and European reports. In **Table 4** I show the explanatory variables used in this research and their descriptive statistics for the whole sample.

Several dependent variables are used depending on the age group and gender of the victims, and on the areas where they were killed. These dependent variables are just the fatality rates per 100.000 inhabitants of each population group or the fatality rate per 100.000

[26] This database can be consulted on-line http://ec.europa.eu/transport/roadsafety.
[27] Council Decision 93/704/EC.

Km driven.[28] Unfortunately, CARE does not contain the latter. To cover this lack and compare both rates, at least for the aggregated rates, I use data available in the WHO database for Europe.[29]

Table 4. Explanatory Variables. Definitions and Descriptive Statistics

Explanatory variables	Description	Mean	S.D.
Unemployment Rate	Unemployment Rate in %.	8.748	4.296
Growth Rate	Rate of change (%) of the Real GDP, PPP$ per capita.	2.750	2.617
Motorization	Number of passenger cars per 1000 inhabitants.	418.536	93.768
Vehicle-Km driven	Annual number passenger cars-Km expressed in 1000 million km and weighted by the national population.	9.146	2.452
Upper secondary Education	% Population between 16-64 years-old with upper secondary education.	55.911	18.270
Motorways	Proportion in % of Motorways (km) over the total road network.	1.312	0.935
National Roads	Proportion in % of National Roads (km) over the total road network.	8.942	5.105
Minimum Legal Drinking Age	Binary variable: **1** for purpose and non-purpose minimum legal drinking age for all beverages. **0** Otherwise.	0.592	0.491
Points License	Binary variable: **1** for countries with driving license that depends on a system based on points. **0** Otherwise.	0.174	0.377
Random Checks	Binary variable: **1** for countries that allow the realization of random breath or Blood tests on the road. **0** Otherwise.	0.779	0.416
BAC05	Binary variable: **1** Countries with an illegal BAC limit of 0.5 mg/ml or lower. **0** for higher illegal BAC limits.	0.504	0.495
BAC05 + Random Checks	Binary variable: **1** for countries that allow random checks and keep an illegal BAC level of 0.5 mg/ml. **0** Otherwise.	0.496	0.497

[28] According to Eisenberg (2003), the literature traditionally uses as output measures these fatality rates because of their accuracy and relevance for policy makers.
[29] World Health Organization Regional Office for Europe (HFA-DB Database).

Before describing the control variables it is worth noting that including a large list of socioeconomic covariates avoids confounding factors that can bias the impact of the policy by keeping them constant and can also give us a better understanding of which factors may influence road fatalities in Europe.

In Ruhm (1996) we saw that macroeconomic variables can help us to improve our estimation because road fatalities and alcohol consumption are usually prociclycal.[30] For that reason I include unemployment and economic growth rates to account for economic cycle.

Besides of macroeconomic variables, I also add some covariates more related with transportation and the use of vehicles. These variables are Motorization and Vehicle-Km. I also include infrastructure variables to catch the possible effect that quality and road characteristics can have on driving. These variables are Motorways and National Roads (% of the total network) and are not usually included in the literature. The educational background of the population between 15 and 64 years old is also taken into account as an additional socioeconomic covariate.

The regulatory binary variables form the last group of covariates. Ruhm (1996), Dee (2001) and Eisenberg (2003) show that it is important to introduce different laws related with road fatalities to avoid confounding effects that may arise in the evaluation of a particular policy if other legal reforms were undertaken simultaneously. For that reason the Minimum Legal Drinking Age (MLDA) and the Points License are introduced as potentially simultaneous policies. The first one takes value 1 for states in years when they have a clear Minimum Legal Drinking Age for purpose and non-purpose drinking and for all alcoholic beverages, and 0 otherwise. The second one takes value one in state-years in which this system of driving license based on points is in effect and 0 otherwise. Although I could use other potentially relevant policies, it is important to preserve degrees of freedom. The choice of these two policies is arbitrary but follows the criteria of being comparable across states, manageable given the differences across national legislations, and the presence of within group variation in some countries for the period studied. Additionally, I avoid those policies that the literature agreed to have no impact on road fatalities or present mixed results. The use of Points License as a concurrent policy variable is especially interesting because it is

[30] See Evans and Graham (1988) and Ruhm (1995) for a deeper discussion on these relationships.

mainly an European policy that has been recently undertaken in some countries and has not been deeply studied so far.

Finally, the expected key policy variable that serves to evaluate the effectiveness of lowering Blood Alcohol Content legal limits is named BAC0.5. This variable takes value 1 in states and years when a country has an illegal BAC limit of 0.5 mg/ml or lower, and 0 when this limit is higher.[31] A fractional correction is applied for cases in which the policy was implemented at some point during the year. Moreover, Dee (2001) explains that it is not only important to control by the policy of evaluation, but also by the level of enforcement that exists. For this purpose I use the variable Random Checks to control for the enforcement of this policy. Random Checks identifies countries that authorise and undertake random breath tests on the road. In addition, I also create a new explanatory binary variable that is formed by the interaction between lowered BAC limits and random checks to capture whether there is a different impact when the policy is accompanied or not by this reasonable enforcement activity.[32]

6. Main results.

The estimation results for the total fatality rates are reported in **Table 5**. Specifications **(1)** and **(2)** show that the coefficients associated with the 0.5 mg/ml BAC limit are not significant neither for the total fatality rate per population nor for the total fatality rate per Km driven. On the contrary, when I use as a key policy variable the interaction between BAC limits and Random Checks in models **(3)** and **(4)** I find an important negative impact even at the 5% level of significance in the latter model. This result suggests that lowering BAC levels does not have a global impact unless this regulation is enforced in practice by random checks on the road. Thus, when these two regulatory measures go together both fatality rates seem to decline substantially. The fatality rate on population declines a 4.3% while the fatality rate on km driven falls a 6.1%.

[31] It is important to point out that Sweden, for example, has a 0.2 mg/ml BAC limit for the whole time series and Portugal presents the same BAC limit in 2001. These facts justifies why we control for BAC levels of 0.5 mg/ml or lower.

[32] Alcohol consumption is not included even knowing its strong impact on road fatalities, because it is directly affected by the regulation I am evaluating. In this direction I discuss later that the success of lowering BAC levels could apply mainly due to the effect that this change have on alcohol consumption in treated states.

Table 5. Least-squares Estimates for Semi-logs Models. Total Fatality Rates.

Independent variables	TFR per 100.000 Population (1)	TFR per 100.000 Km driven (2)	TFR per 100.000 Population (3)	TFR per 100.000 Km driven (4)
BAC0.5	-0.0339 (0.0271)	-0.0429 (0.0338)	-	-
Random Checks	-0.0040 (0.0758)	0.0861 (0.0731)	-	-
BAC0.5 + Random Checks	-	-	-0.0426* (0.0228)	-0.0612** (0.0220)
Points License	0.00556 (0.0411)	-0.0618 (0.0533)	0.0072 (0.0402)	-0.0612 (0.0503)
MLDA	-0.0121 (0.0215)	0.0059 (0.0235)	-0.0102 (0.0197)	0.0064 (0.0197)
Unemployment rate	-0.0032 (0.0030)	0.0009 (0.0039)	-0.0032 (0.0032)	0.0009 (0.0044)
Growth rate	0.0091* (0.0049)	0.0064 (0.0059)	0.0093* (0.0046)	0.0057 (0.0054)
Motorization	-0.0019** (0.0006)	-0.0040*** (0.0003)	-0.0019*** (0.0006)	-0.0041*** (0.0003)
Vehicle-Km	0.0381 (0.0436)	-	0.0381 (0.0433)	-
Upper Sec. Education	0.0046 (0.0030)	0.0065* (0.0036)	0.0045* (0.0024)	0.0072** (0.0032)
Motorways	-0.0478*** (0.0103)	-0.0464*** (0.0124)	-0.0455*** (0.0099)	-0.0372*** (0.0109)
National Roads	0.0033 (0.0023)	0.0040* (0.0021)	0.0032 (0.0022)	0.0032* (0.0017)
R-sq	0.81	0.93	0.80	0.93

Standard errors are reported in parenthesis allowing for clustering by country. Each model also includes time and state fixed effects and a constant term.* Statistically significant at the 10% level; ** at 5% level and *** at 1% level.

Macroeconomic variables do not seem to have a strong role on road fatalities in Europe. Only growth rates seem to have an impact on fatality rates on specifications **(1)** and **(3).** Thus, I cannot reject the procyclical effect of road fatalities but it seems to be weaker than expected.

On the other hand, the coefficient associated with the country motorization is highly significant in all specifications. It is worth noting that the negative sign it shows can be explained by the level of transport development achieved by the country. There is an important negative correlation between development and accidents, since more developed countries usually enjoy better infrastructures, safer cars, more organised regulations and more police interventions. Thus, the number of cars per 1000 inhabitants may be considered as a proxy for the achieved transport development.

Interesting results are obtained regarding the road infrastructure variables. The coefficient associated with Motorways, the best type of road and therefore the safest, is always strongly significant across specifications and presents negative sign. Moreover, National Roads, that are roads of a lower quality than motorways but where users drive still fast, presents positive sign and significant coefficient in models **(2)** and **(4)**. This result suggests that road system's quality and characteristics play a relevant role as well.

Finally, the upper secondary education variable is significant in all models except in specification **(1)** and has positive impact. One possible explanation is that more educated people usually travel more often and enjoy more leisure. This would act as a proxy of income, variable that the literature usually finds positive related with accidents because of the positive correlation that exists between income and both alcohol consumption and vehicle use.

Recent works on road fatalities as Eisenberg (2003), Dee and Sela (2003) and Grabowsky and Morrisey (2004), have studied the impact of road safety measures on different victim groups. I also follow this strategy dividing fatalities into age and gender groups. In addition CARE also allows to include the difference between urban and non-urban fatalities to check where the policy has been more effective. **Table 6** shows the results of applying specifications **(1)** and **(3)** to each age group. Lowering BAC limits seems to be effective for people between 20 and 49 years old. A reduction around 10.5% is found in victims between 20-40 years old and a decline of 8% for the 40-50 age group. Older groups do not seem to be affected by the change in the policy.

Table 6. Least-squares Estimates for Semi-logs Models. Age Group Fatality Rates. (Selected Results)

Independent variables	Age Group 20-29 (5)	Age Group 30-39 (6)	Age Group 40-49 (7)	Age Group 50-59 (8)
BAC0.5	-0.1050* (0.0515)	-0.1043** (0.0400)	-0.0819* (0.0422)	-0.0965 (0.0656)
BAC0.5 + Random Checks	-0.0992* (0.052)	-0.1077** (0.0396)	-0.0823* (0.0417)	-0.0862 (0.0620)

Independent variables	Age Group 60-69 (9)	Age Group 70-79 (10)	Age Group +70 (11)	Age Group + 80 (12)
BAC0.5	0.0153 (0.0638)	0.0378 (0.035)	-0.0767 (0.0968)	-0.0068 (0.0842)
BAC0.5 + Random Checks	0.0170 (0.0651)	0.0424 (0.0332)	-0.0680 (0.0829)	0.0075 (0.0877)

Each model include the rest of explanatory variables, time and state dummy variables and a constant term. Standard errors allowing for clustering by country are reported in parenthesis

In **Table 7** I show the results for gender groups and zones.[33] Males seem to be the gender group affected by the policy causing a decrease of 5.7% in their fatality rate. On the contrary, the policy seems to have no impact on female fatalities, may be because their law fulfilment was already higher.

Once we introduce the area where the accident happened I do not find any difference until I put together gender and zone. Once they joined I observe only one affected group by the policy: Males in urban areas. The reduction estimated is 9.5 or 10.9%, depending on the

[33] Models **(1)** and **(3)** are also applied here but Motorways and national roads are dropped out when we study urban fatalities.

BAC variable used as it is shown in **Table 7**. However, no impact is found in non-urban zones. This result could be explained by the fact that non-urban fatalities can be caused by other problems more related with speed, sleepery and road characteristics. These factors are more likely to be the most relevant in non-urban than in urban driving where the speed is not usually so high and the characteristics of roads are more homogeneous.

Table 7. Least-squares Estimates for Semi-logs Models. Gender and Zone Fatality Rates. (Selected results)

Independent Variables	Male Total Fatalities (13)	Female Total Fatalities (14)	Non-Urban Total Fatalities (15)	Urban Total Fatalities (16)
BAC0.5	-0.0573* (0.0317)	-0.0250 (0.0407)	-0.0362 (0.0573)	-0.0470 (0.0413)
BAC0.5 + Random Checks	-.0574* (0.0313)	-0.0232 (0.0394)	-0.0310 (0.0425)	-0.0678 (0.0405)

Independent variables	Male Non-Urban Fatalities (17)	Male Urban Fatalities (18)	Female Non-Urban Fatalities (19)	Female Urban Fatalities (20)
BAC0.5	-0.0470 (0.0361)	-.0959** (0.0419)	-0.0362 (0.0573)	-0.0205 (0.0603)
BAC0.5 + Random Checks	-0.0351 (0.0402)	-0.1094** (0.0463)	-0.0240 (0.0601)	-0.0240 (0.0601)

Each model include the rest of explanatory variables, time and state dummy variables and a constant term. Standard errors allowing for clustering by country are reported in parenthesis. The variable Motorways is excluded in the models that treat urban road fatalities.

Finally, I tried a new combination joining age groups and zone but, as it is shown in the appendix (**A3** and **A4**), no stable results are found with the exception of young groups in urban zones where I find an important effect of the policy. In **Table 8** I report results for the young group by zone.

After identifying the affected groups, I am interested in the evaluation of timing effects. Eisenberg (2003) introduced this analysis in this literature and found an important lag of at least 6 years. In our case I replicate the strategy using binary time variables instead of the 0.5 BAC policy. These new dummies are constructed as time intervals that account for the time after the new legislation was adopted. Because of data constraints I construct 2 intervals. The first one, that takes value one in state-years from 0 to 2 years after the enactment and zero otherwise, is thought to identify short time effects. The second, that takes value one from the third year of application and zero otherwise, captures long term effects. Thus, I apply it only to the models where the 0.5 BAC policy was effective in the previous estimations.

Table 8. Least-squares Estimates for Semi-logs Models.
Age 20-29 Group and Zone Fatality Rates. (Selected results)

Independent Variables	Urban Age 20-29 (21)	Non-Urban Age 20-29 (25)
BAC0.5	-0.2830** (0.0972)	-0.0341 (0.0561)
BAC0.5 + Random Checks	-0.2947** (0.1031)	-0.0341 (0.0561)

Two-way fixed effects estimation. The model includes a constant term and the rest of covariates used in previous specifications with the exception of infrastructure variables in the case of urban fatality rate. Cluster-robust standard errors in parenthesis.

Results reported in **Table 9** seem to suggest that lowering BAC levels is not generally effective in the short-run. What I find is that it is necessary to wait more than two years to observe some impact. Only for males in urban areas a short time effect is found, but the coefficient in the long term interval is significantly higher as well. Although I find a significant delay, our result seem to be less surprising than the 6 years delay obtained by Eisenberg (2003). However, I must honestly point out that this result only implies that the effectiveness of the policy could start in the third year but nothing can make sure that the effects do not start later due to the time intervals I have used.

To sum up, we have seen that lowering illegal BAC limits has been an effective policy for the whole population when it is accompanied by random checks on the road. Moreover, in disaggregated cases, we have checked that males and young road users, especially in urban zones, are clearly affected by the policy. The rest of drivers from 30 to 49 years old also receive the positive impact of lowering BAC levels. However, the effectiveness of the policy do not usually apply in the short run. The rest of victim groups do not seem to receive any benefit from the policy.

7. Serial correlation treatment.

In section 5 I argued that scorning serial correlation can lead sometimes to too optimistic estimates on the effectiveness of the policy using Differences-in-Differences methods. For that reason in this section I provide some evidence of this by finding the results I would have obtained forgetting serial correlation and basing our estimation only on heteroskedastic-consistent standard errors like previous studies.

Table 10 presents the results of this estimation that serves to compare with **Table 5**. Now, BAC reductions would have appeared effective even in countries without random checks on the road while we have seen that only when the policy is accompanied by random checks it is actually effective. In addition, the coefficient associated with the low BAC policy becomes more significant, also in those estimations that use the interacted variable that identifies policy and enforcement at the same time (BAC05+Random Checks). The rest of variables do not change very sharply.

When the same strategy is applied to the rest of fatality rates, the ones that appeared affected in section 6 show now even more statistically significant coefficients associated to the BAC policy. However, only urban fatalities changes from not being impacted to being impacted, while I have shown that only males receive the benefits of the policy in these zones. The rest of rates of fatality does not change and provide the same interpretations found in section 6.

These examples make clear the importance of controlling for serial correlation to avoid misleading interpretations in the evaluation of public policies under Differences-in-

Differences in large panels. In our case of study, few mistakes would be inspired by scorning serial correlation but enough to confound some effects.

Table 10. Least-squares Estimates for Semi-logs Models for Total Fatality Rates. White-Robust Estimation. (Selected results)

Independent variables	TFR per 100.000 Population (29)	TFR per 100.000 Km driven (30)	TFR per 100.000 Population (31)	TFR per 100.000 Km driven (32)
BAC0.5	-0.0339* (0.0271)	-0.0429* (0.0338)	-	-
Random Checks	-0.0040 (0.0758)	0.0861 (0.0731)	-	-
BAC0.5 + Random Checks	-	-	-0.0426** (0.0228)	-0.0612*** (0.0220)
R-sq	0.81	0.93	0.81	0.93

Heteroskedastic-consistent standard errors are reported in parenthesis. Each model also includes time and state fixed effects, the rest of covariates and the constant term.

8. Concluding remarks.

Lowering illegal BAC levels to 0.5 mg/ml has been an effective policy in Europe. However, I cannot leave this conclusion without further discussion. As I have shown, the policy is not found effective for all road users unless some enforcement is present in the country, stressing its importance in any policy or regulatory change. Moreover, the effectiveness of the policy is heterogeneous depending on the age, gender and zone of the victim group. Therefore, this can give some advice to policy-makers to understand which groups are more likely to be affected by this and other policies related with drunk driving. However, we have seen that it is usually necessary to wait more than two years in order to obtain the positive influence of the policy, ruling out a short-run effect. Further research is needed to understand this time lag.[34]

[34] See Eisenberg (2003).

It is also important to point out that although I find positive effects in the enactment of the policy, a cost-benefit analysis is absolutely necessary to conclude whether this policy can be recommended from an economic point of view. We can not forget that changing the behaviour of people in this case can generate a negative impact on several sectors (alcoholic beverages industry, bars and restaurants, discotheques, etc.).[35] Thus, we should make sure that predicted costs do not exceed the economic benefits obtained by the policy before recommending this tool to the countries that still keep higher illegal BAC limits in Europe. This analysis is left for future research.

We have seen the importance of allowing for any pattern of correlation in this kind of estimation to avoid possible misleading interpretations that could affect the degree of effectiveness derived from the analysis. For that reason, I give strong arguments and some evidence to come under review the estimates found by the previous literature on BAC policies.[36] Overcoming this problem in this research adds another interesting contribution to the literature.

Finally, I consider that a preliminary debate on the pathways used by the policy against drunk driving needs to be launched. Behind this research, there was the assumption that lowering BAC levels could reduce drunk driving through discouraging alcohol consumption.[37] However, this might not be the only possible pathway covered by the policy against drunk driving. Another reasonable consequence could imply the reduction of Km travelled. This pathway could arise through an increase of public transport use or by changing leisure habits (less journeys, more home meetings, walking distances, etc.). In the appendix (**A5**) I present a preliminary test that seems to support that people reduce their alcohol consumption when this policy comes into force. However, these preliminary results are not conclusive and consequently more robust analyses are needed to achieve a confirmation.

[35] This negative impact can be translated in a lower alcohol consumption and therefore in lower income and probable employment losses.

[36] As far as we know Dee and Sela (2003) were the first authors using Differences-in-Differences to consider serial correlation in their evaluation of the effectiveness of changing speed limits in USA.

[37] That is the reason why we did not include alcohol consumption as an explanatory variable in the basic model used to evaluate the effectiveness of BAC policies.

References

Apsler, R., A.R.Char, W.M. Harding, and T.M. Klein (1999) "The effects of 0.08 BAC laws", Washington DC, National Highway Traffic Safety Administration.

Arellano, M. (1987) "Computing Robust Standard Errors for Within-Groups Estimators", Oxford Bulletin of Economics and Statistics, XLIX, pp. 431-434.

Asch, P. and D.T. Levy (1990) "Young Driver Fatalities: The Roles of Drinking Age and Drinking Experience", Southern Economic Journal, pp. 512-520.

Bartl, G. and R. Esberger (2000) Effects of lowering the legal BAC limit in Austria. In H. Laurell & F. Schlyter (Eds.), "Proceedings of the 15th International Converence on Alcohol, Drugs and Traffic Safety", May 22-26, 2000.

Baughman, R., M. Conlin, C., S. Dickert-Conlin and J. Pepper (2001) "Slippery when wet: The effects of local alcohol access laws on highways safety", Journal of Health Economics 20, pp. 1089-1096.

Benson, B.L., B.D Mast and D. Rasmussen (1999) "Beer taxation and alcohol-related traffic fatalities", Southern Economic Journal, Vol. 66, No. 2, pp. 214–249.

Bernhoft, I.M. (2003) "Effect of lowering the alcohol limit in Denmark", Accident analysis and Prevention, Vol. 35, No. 4, pp. 515-25.

Bertrand, M., E. Duflo and S. Mullainathan (2004) "How much should we trust differences-in-differences estimates", The Quarterly Journal of Economics MIT press, Vol. 119, No. 1, pp. 249-275.

Besley, T. and A. Case (2000) "Unnatural experiments: Estimating the incidence of Endogenous Policies", The Economic Journal, Vol. 110, pp. 672-694.

Chaloupka, F. and H. Saffer (1989) "Breath testing and Highway fatality rates", Applied Economics, Vol. 21, pp. 901-912.

Compton, R.P., R.D. Blomberg, H. Moskowitz, M. Burns, R.C. Peck and D. Fiorentiono (2002) "Paper presented at the Proceedings of Alcohol, Drugs & Traffic Safety – T 2002: 16th International Conference on Alcohol, Drugs & Traffic Safety", August 4-9, 2002, Montreal, Canada.

Cook, P.J and G. Tauchen (1984) "The effect of minimum drinking age legislation on youthful auto fatalities, 1970-1979", Journal of Legal Studies, Vol. 13, pp. 169-190.

Dee, T. S. (2001) "Does setting limits save lives? The case of 0.08 BAC laws" Journal of Policy Analysis and Management, Vol. 20, No. 1, pp. 111–118.

Dee, T.S. and R.J. Sela (2003) "The fatality effects of highway speed limits by gender and age", Economic letters, Vol. 79, pp. 401-408.

DuMouchel, W., A.F. Williams and P. Zador (1987) "Raising the alcohol purchase age: Its effects on fatal motor vehicle crashes in twenty-six states", Journal of Legal Studies, Vol. 26, pp. 249-266.

Eisenberg, D. (2003) "Evaluating the effectiveness of policies related to drunk driving", Journal of Policy Analysis and Management, Vol. 22, No.2, pp. 249-274.

Evans, W.N and J.D. Graham (1988) "Traffic safety and the business cycle", Alcohol, Drugs and Driving, Vol. 4, pp. 31-38.

Fell, J., and R. Voas (2003) "The effectiveness of reducing illegal blood alcohol concentration (BAC) Limits for Driving: Evidence for Lowering the Limit to .05 BAC in Canada", Calverton, Md.: Pacific Institute for Research & Evaluation.

Foss, R.D., J.R. Stewart, and D.W. Reinfurt (1998) "Evaluation of the effects of North Carolina's 0.08% BAC law", Washington, DC: National Highway Traffic Safety Administration.

Galiani, S., P. Gertler, and E. Schargrodsky (2005) “Water for Life: The Impact of the Privatization of Water Services on Child Mortality”, Journal of Political Economy, Vol. 113, pp. 83-120.

Grabowsky, D.C, and M.A.Morrisey (2004) “Gasoline price and motor vehicle fatalities”, Journal of Policy Analysis and Management, Vol. 23, No. 3, pp. 575-593.

Heckman, J. and V.J. Hotz (1989) “Choosing among Alternatives Nonexperimental Methods for Estimating the Impact of Social programmes”, Journal of the American Statistical Association, Vol. 84, pp. 862-874.

Henstridge, J., R. Homel, and P. Mackay (1997) “The long-term effects of random breath testing in four Australian states: A time series analysis”, Canberra: Federal Office of Road Safety.

Hingson, R., T. Heeren, and M. Winter (1996) “Lowering state legal blood alcohol limits to 0.08%: The effect on fatal motor vehicle crashes”, American Journal of Public Health, Vol. 86, No. 9, pp. 1297-1299.

Hingson, R., T. Heeren, and M. Winter (2000) “Effects of recent 0.08% legal blood alcohol limits on fatal crash involvement”, Injury Prevention, Vol. 6, pp. 109–114.

Johnson, D., and J.C. Fell (1995) “The impact of lowering the illegal BAC limit to .08 in five states in the U.S., 39th Annual Proceedings for the Association for the Advancement of Automotive Medicine”, October 16-18, Chicago, IL: Association for the Advancement of Automotive Medicine.

Levitt, S.D. and J. Porter (1999) “Estimating the effect of alcohol on driver risk using only fatal accident statistics”, Working Paper 6944. Cambridge, MA: National Bureau of Economic Research.

Keall, M., W. Frith, and T. Patterson (2004) “The influence of alcohol, age and number of passengers on the night-time risk of driver fatal injury in New Zealand”, Accident Analysis and Prevention Vol. 36, pp. 49-61.

McCarthy, P. (2003) “Alcohol-related crashes and alcohol availability in grass roots communities”, Applied Economics, Vol. 35, pp. 1331-1338.

Mercier-Guyon, C. (1998) “Lowering the BAC limit to 0.05: Results of the French experience. Paper presented at the Transportation Research Board 77th Annual Meeting”, January 11-15, Washington, DC.

Moskowitz, H. and D. Fiorentino (2000) “A review of the scientific literature regarding the effects of alcohol on driving-related behavior at blood alcohol concentrations of 0.08 grams per deciliter and lower”, Washington, DC: National Highway Traffic Safety Administration.

National Highway Traffic Safety Administration (NHTSA) (1991) “Alcohol Limits for Drivers: A Report on the Effects of Alcohol and Expected Institutional Responses to New Limits” (DOT HS 807 692), National Highway Traffic Safety Administration.

National Highway Traffic Safety Administration (NHTSA) (1994) “Computing a BAC estimate”, Washington, DC: National Highway Traffic Safety Administration.

Noordzij, P.C. (1994) “Decline in drinking and driving in the Netherlands. Transportation Research Circular, Vol. 422, pp. 44-49.

Office of Traffic Safety (OTS) (1995) “The general deterrent impact of california’s 0.08% blood alcohol concentrarion limit and administrative per se license suspension laws”, Office of Traffic Safety, State of California.

Rogers, P. (1995) “The general deterrent impact of California’s 0.08% blood alcohol concentration limit and administrative per se license suspension laws”, Sacramento, CA: California Department of Motor Vehicles.

Ruhm, C.J. (1995) “Economic conditions and alcohol problems” Journal of Health Economics, Vol. 14, pp. 583-603.

Ruhm, C.J. (1996) “Alcohol policies and highway vehicle fatalities”, Journal of Health Economics, Vol. 15, pp 435-454.

Saffer, H. and M. Grossman (1987) “Drinking Age Laws and Highway Mortality Rates: Cause and Effect”, Economic Inquiry, Vol. 25, No.3, pp. 403-417.

Saffer, H. (1997) “Alcohol advertising and motor vehicle fatalites” The Review of Economics and Statistics. Vol. 79, No. 3, pp. 431-442.

Shults, R. A., R.W. Elder, D.A. Sleet, J.L. Nichols, M.O. Alao, V.G. Carande-Kulis, S. Zaza, D.M. Sosin, R.S. Thompson and Task Force on Community Preventive Services (2001) “Reviews of evidence regarding interventions to reduce alcohol- impaired driving”, American Journal of Preventive Medicine, Vol. 21, No. 4, pp. 66-88.

Voas, R.B., E. Taylor, T. Kelley Baker and A.S. Tippetts (2000) “Effectiveness of the Illinois .08 law”, (DOT HS 809 186). Washington, DC: Department of Transportation, National Highway Traffic Safety Administration.

Wagenaar, A.C. (1993) “Minimum drinking age and alcohol availability to youth: Issues and research needs”, in M. Hilton and G. Bloss, eds., Economics and the prevention of alcohol-related problems, US Department of Health and Human Services. Rockville, MD, 175-200.

White, H. (1984) “Asymptotic Theory for Econometricians”, Academic Press, San Diego CA.

Zador, P., S. Krawchuk and R. Voas, (2000) “Alcohol related relative risk of driver fatalities and driver involvement in fatal crashes in relation to driver age and gender: An update using 1996 data”, Journal of Studies of Alcohol, Vol. 61, No. 3, pp. 387-395.

APPENDIX

A1.a. Identifying assumption test. Estimation Results.

ln Rate fat.	Coef.	Robust Std. Err.	t	P>|t|
Random checks	0.0143	.0888	0.16	0.874
Mlda	0.0126	.0332	-0.38	0.709
Points License	0.0159	.04312	0.37	0.717
Unemployment	-0.0045	.0034	-1.35	0.199
Growth rate	0.0090	.0062	1.44	0.172
Motorization	0.0021	.0008	-2.70	0.017
Vehicle-Km	0.0341	.0437	0.78	0.447
Education	0.0066	.0029	2.26	0.040
Motorways	-0.0521	.0129	-4.03	0.001
National Roads	0.0046	.0030	1.53	0.148
yeartreated~1991	**0.3544**	**.0632**	**5.61**	**0.000**
yearcontrol~1991	**0.1585**	**.1783**	**0.89**	**0.389**
yeartreated~1992	**0.2957**	**.0496**	**5.97**	**0.000**
yearcontrol~1992	**0.1847**	**.1563**	**1.18**	**0.257**
yeartreated~1993	**0.2662**	**.0598**	**4.45**	**0.001**
yearcontrol~1993	**0.1229**	**.1372**	**0.90**	**0.386**
yeartreated~1994	**0.1853**	**.0482**	**3.84**	**0.002**
yearcontrol~1994	**0.0522**	**.1159**	**0.45**	**0.659**
yeartreated~1995	**0.1868**	**.0637**	**2.93**	**0.011**
yearcontrol~1995	**0.0891**	**.0755**	**1.18**	**0.258**
yeartreated~1996	**0.1473**	**.0590**	**2.50**	**0.026**
yearcontrol~1996	**0.0960**	**.0523**	**1.84**	**0.087**
yeartreated~1997	**0.1221**	**.0461**	**2.65**	**0.019**
yearcontrol~1997	**0.0834**	**.0464**	**1.80**	**0.094**
yeartreated~1998	**0.1275**	**.0433**	**2.94**	**0.011**
yearcontrol~1998	**0.0158**	**.0435**	**0.36**	**0.723**
yeartreated~1999	**0.1060**	**.0345**	**3.07**	**0.008**
yearcontrol~1999	**0.0698**	**.0435**	**1.61**	**0.131**
yeartreated~2000	**0.1047**	**.0447**	**2.34**	**0.035**
yearcontrol~2000	**0.0449**	**.0449**	**1.00**	**0.334**
yeartreated~2001	**0.0999**	**.0359**	**2.78**	**0.015**
yearcontrol~2001	**0.0260**	**.0556**	**0.47**	**0.646**
yeartreated~2002	**0.0561**	**.0203**	**2.75**	**0.016**
yearcontrol~2002	**0.0262**	**.0325**	**0.81**	**0.434**
constant	4.9012	.3542	13.84	0.000

A1.b. Identifying assumption test. Testing Hypothesis.

H_0 : yeartreated i + yearcontrol $i = 0$

H_1 : yeartreated i + yearcontrol $i \neq 0$

Year	F-Stat. (1 , 14)	Prob > F. Stat	H_0 vs. H_1
1991	**1.58**	**0.2299**	**H_0**
1992	**0.73**	**04066**	**H_0**
1993	**1.82**	**0.1993**	**H_0**
1994	**2.24**	**0.1569**	**H_0**
1995	**3.06**	**0.1021**	**H_0**
1996	**1.04**	**0.3255**	**H_0**
1997	**0.66**	**0.4286**	**H_0**
1998	**4.74**	**0.0471**	**H_1**
1999	**0.53**	**0.4775**	**H_0**
2000	**1.12**	**0.3070**	**H_0**
2001	**1.12**	**0.3079**	**H_0**
2002	**0.59**	**0.4538**	**H_0**

A2. Pre-treatment time pattern test results.

ln Rate fat.	**Coef.**	**Robust Std. Err.**	**t**	**P>|t|**
Unemployment	-0.0032	0.0027	-1.16	0.266
Growth rate	0.0089	0.0051	1.73	0.105
Motorization	-0.0018	0.0007	-2.57	0.022
Vehicle-Km	0.0377	0.0452	0.83	0.418
Education	0.0049	0.0030	1.64	0.123
Motorways	-0.0508	0.0110	-4.63	0.000
National Roads	0.0036	0.0023	1.59	0.134
MLDA	-0.0117	0.0253	-0.46	0.650
Points License	-0.0002	0.0384	-0.01	0.996
Random	-0.0034	0.0758	-0.05	0.965
Before02	**0.0145**	**0.0240**	**0.61**	**0.554**
Before+3	**0.0159**	**0.0362**	**0.44**	**0.667**

This model also uses year-specific national fixed effects and state-specific fixed effects. Cluster robust standard errors are presented.

A3. Least-squares Estimates for Semi-logs Models. Age Group and Urban Fatality Rates. (Selected results)

Independent Variables	Urban Age 20-29 (21)	Urban Age 30-39 (22)	Urban Age 40-49 (23)	Urban Age 50-59 (24)
BAC0.5	-0.2830**	-0.0370	-0.1074	-0.1319
	(0.0972)	(0.1196)	(0.0724)	(0.0763)
BAC0.5 + Random Checks	-0.2947**	-0.0531	-0.1246*	-0.1310
	(0.1031)	(0.1167)	(0.0677)	(0.0750)

The same two-way fixed effects model is applied to these groups of victims. Cluster-robust standard errors in parenthesis.

A4. Least-squares Estimates for Semi-logs Models. Age Group and Non-Urban Fatality Rates. (Selected results)

Independent Variables	Non-Urban Age 20-29 (25)	Non-Urban Age 30-39 (26)	Non-Urban Age 40-49 (27)	Non-Urban Age 50-59 (28)
BAC0.5	-0.0341	-0.1200*	-0.0124	-0.0883
	(0.0561)	(0.0635)	(0.0467)	(0.0908)
BAC0.5 + Random Checks	-0.0341	-0.1014	0.0007	-0.0883
	(0.0561)	(0.0584)	(0.0511)	(0.0908)

The same two-way fixed effects model is applied to these groups of victims. Cluster-robust standard errors in parenthesis.

A5. Least-squares estimates, semi-log model. Alcohol Consumption.

Independent variables	**Alcohol Consumption (33)**
BAC0.5	-0.0656**
	(0.0297)
Points License	0.0338*
	(0.0174)
MLDA	-0.0687
	(0.0615)
Unemployment rate	-0.0164***
	(0.0038)
Growth rate	0.0033
	(0.0023)
R-sq	0.50

Two way fixed effect model for alcohol consumption. Standard errors allowing clustering by country are reported in parenthesis.