Do Laws to Reduce Dangerous Driving Reduce Traffic Accidents?

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1 Introduction

Road crashes are one of the most significant causes of premature death in Canada. However, as the OECD points out, many deaths and injuries attributable to transport accidents are preventable: they are attributable to drowsy driving, the use of drugs or alcohol by motorists, or driver errors in judgment.[1] This suggests that a strategy to reduce road accidents should target changing the behaviour of drivers. Federal and provincial government regulations play a key role in influencing driver behavior. Both levels of government have particularly targeted drunk driving.

A federal law makes it a criminal offence to drive a car with a Blood Alcohol Concentration (BAC) above 80 mg of alcohol per 100 ml of blood. The federal Minister of Justice is reportedly that is considering lowering the driving limit from 80 to 50 mg of alcohol per 100 ml of blood ("the "CTV" Television and Publishing Channel in a publication dated August 08, 2017").[2] However, most provincial governments have already enacted legislation that lowers the BAC unit to 50 mg of alcohol per 100 ml of blood. Many researchers have presented evidence to support the claim that these BAC laws (federal and provincial) have helped to significantly reduce alcohol-related accidents.

Considered to be particularly at risk, young drivers have been, for some time, the main subjects of government policies in the fight against road accidents. Many provinces have put in place a Graduated Driver Licensing (GDL) program to help new drivers gain road-safety experience. This GDL system involves lengthening the time required to obtain a driver's licence and imposes restrictions on driving behaviour that does not apply to drivers who hold a full licence.

Several studies have examined the impact of the GDL system on the youth accident rate and have found evidence of a change in behaviour. However, since there is an average of two cars in an accident, a change in behaviour among novice drivers affects the accident rate for other categories of drivers and, in particular, experienced drivers. This observation seems to be neglected in the evaluation of the impact of this program on accident rates. Also, studies conducted by various academic and non academic researchers to evaluate the effectiveness of GDL in Canada provided mixed support for this new observation. Studies conducted by provincial and government ministries show that introducing GDL program leads to a reduction in the accident rate, whereas a recent academic study covering all of Canada's provinces argued that the GDL system has not had a significant impact. The effectiveness of the GDL system to reduce dangerous accidents involving new drivers, therefore, merits further study.

Surprisingly, although there has been sustained academic interest in the examination of, on the

[1] OECD (2015), "Mortality from transport accidents", in Health at a Glance 2015: OECD Indicators, OECD Publishing, Paris, p. 60.

[2] https://www.ctvnews.ca/canada/federal-justice-minister-seeks-to-decrease-alcohol-levels-for-drivers-1.3537232

one hand, the impact of the changes in BAC law on the accident rates and, in parallel, the impact of GDL law on accident rates for young drivers, there has been no examination of the effect of these laws on accident rates for the population as a whole. Another weakness of the literature is that it neglected the problem of endogeneity that may arise between these laws (BAC, GDL) and accident rates. An endogeneity problem may arise because BAC and GDL laws are often strengthened or implemented after the authorities have observed high rates of road accidents, especially those involving young drivers or those driving while impaired.

In this study, I pursue three primary objectives. The first objective is to investigate how the implementation of, or changes in BAC and GDL laws, both independently and jointly, influence the rate of traffic accidents for drivers of different ages. Secondly, this study aims to consider a broad set of measures of traffic accidents (fatalities and injuries, fatalities and major injuries, fatalities, injuries, major injuries and minor injuries). The existing literature concentrates mostly on fatalities. Finally, the present work is also intended to consider and deal with the question of endogeneity that may exist between accident rates and laws (BAC, GDL).

To achieve these objectives, I undertake an econometric analysis of the impact of changes in BAC and GDL legislation on injury and fatality rates. My analysis draws on collision data from the provinces of Alberta, Ontario, Quebec, and Saskatchewan. These microdata provide detailed information about collisions, and detailed information regarding all persons involved in the accident. I aggregate the data at the age-group-month-municipality level. I consider all drivers aged 16 to 90 years old, novices drivers aged 16 to 24 years old, experienced drivers aged 25 to 90 years old, as well as sub groups of novices drivers aged 16 to 19 years old and 20 to 24 years old, and sub groups of experienced drivers aged 25 to 34 years old, 35 to 44 years old, 45 to 64 years old, 55 to 64 years old and 65 to 90 years old. I calculate, for these different age groups, by municipality and by month, the rate of accidents resulting in deaths and injuries, in deaths, in deaths and major injuries, in injuries, in major injuries, and in minor injuries.

Data on the design and application of provincial laws regulating BAC and GDL are drawn from the Canadian Council of Motor Transport Administrators (CCMTA) and the Traffic Injury Research Foundation (TIRF) on Best Practices for Progressive Licensing in Canada. There is considerable interprovincial variation in the timing of the application of these laws, and this is the basis for identification of the impact of regulatory changes on accident rates.

I first use Ordinary Least Squares (OLS) regressions to assess the impact of BAC and GDL laws on accident rates for different driver age groups, and also to examine the joint effect of the BAC-GDL interaction on accident rates. Subsequently, I use an instrumental variable model to deal with the endogeneity problem. A natural candidate for my instrumental variables are the

BAC and GDL laws in neighboring provinces; the ideology of the governing party in each province is also used as a potential third candidate for the instrumental variable role. The choice of the last instrument is motivated by the fact that the ideological preferences of the party in power can influence certain political, economic and social decisions. These ideological preferences and the resulting decisions reflect the party norms and traditions, general political orientations, and the preferences and interests of voters in different constituencies.

My results reveal that there is considerable heterogeneity in the influence of the two laws, taken individually and jointly; both when considering the degree of severity of the accident and also the age group of the drivers. For example, without taking into account the potential interaction effect of BAC and GDL, BAC does not seem to affect the fatality-injury rate, the injury rate and the minor injury rate involving all drivers whereas it significantly reduces these rates involving novice drivers. However, in the absence of the GDL law, the BAC law does not prevent accident rates (such as the number of accidents, the fatalities-major injuries rate and the major injuries rate involving all drivers or only novice or experienced drivers) from rising. Furthermore, without the interaction term, the GDL law leads to the decline of almost all accident rates. Results suggest that GDL law can significantly and depending on the degree of injury, reduce accident rates such as the fatality-injury rate, the fatalities-major injuries rate, the injury rate, the major injuries rate and the minor injury rate involving all drivers as well as novices and experienced drivers. More specifically, when BAC law is not in force, the GDL law leads to the decline of the fatality-major rate and the major rate involving novice and experienced drivers aged 16 to 19, 55 to 64 years, and 65 to 90 years; the fatality rate involving novice and experienced drivers aged 16 to 19 and 45 to 54 years. Considering all drivers or only novice or experienced drivers, I note that the interaction term significantly reduces the expected effect of each of the laws (BAC, GDL) on the number of accidents, the fatalities-major injuries rate and the major injuries rate. The interaction term also reduces the expected effect of BAC or GDL on the fatality rate involving only experienced drivers especially those aged 45 and over. Most importantly, I note that the interaction term makes the effect of BAC law on rates such as the accidents number, the fatalities-major injuries rate and the major injuries rate very inaccurate. Indeed, one can notice a significant variation in the standard deviation of the estimated coefficient of BAC when GDL is in force or not. Finally, it should be noted that neither of the two laws, even their interaction has a significant effect on the fatality-injury rate, the fatalities-major injuries rate, the fatalities rate, the injury rate, the major injuries rate and the minor injury rate involving drivers aged 25 to 34.

The outline of this paper is as follows. Section 2 presents the legislative framework for BAC and GDL laws. Section 3 reviews the literature examining the impact of changes in BAC and GDL laws on accident rates. Sections 4 and 5 describe the data used and the econometric methodology. Section 6 presents my results and Section 7 concludes.

2 Legislation

Canada is a federal system whose powers of government are divided between the federal and the provincial (territorial) governments. The federal government's power to regulate dangerous driving is to set the maximum BAC limit in the Criminal Code. In contrast, it has no direct control over driver licensing. Provincial governments can legislate on BAC limits and GDL programs in their jurisdictions. These laws only impose administrative sanctions for violations that can include fines.

2.1 Blood Alcohol Concentration (BAC) laws

There are two types of impaired driving laws in Canada: a federal or legal BAC law and provincial BAC laws. The federal BAC law is a criminal code that prohibits driving a motor vehicle with a blood-alcohol level greater than 80 milligrams of alcohol per 100 millilitres of blood (80mg/100ml) since 1969. The provinces and territories also impose sanctions against anyone driving a vehicle impaired with a blood-alcohol level more than 80mg/100ml or with a drug impairment. These penalties range from a mere licence suspension to car seizure. These measures vary from province to province. The provincial BAC laws impose a legal limit lower than that federal stipulated by the criminal code; the details of this provincial BAC law are presented in Table A.1, Appendix A.

In the remainder of the document, BAC law will designate the provincial law regulating the blood alcohol level to 50 milligrams of alcohol in 100 millilitres of blood (50mg/100ml). BAC law violations often result in a period of suspension of the driver's licences. Ontario's BAC limit was at 50mg/100ml throughout the period of study; administrative sanctions in Ontario were strengthened once during this period. Saskatchewan and Alberta introduced a 50mg/100ml and 40mg/100ml limit respectively during the study.[3] Both provinces also introduced stronger administrative penalties at a later date. Quebec does not have a 50mg/100ml limit; only the federal law applies.

2.2 Graduated Driver Licensing (GDL) program

Graduated Drivers Licensing (GDL) is a three-stage program designed by the provinces and territories to provide to young or new drivers the knowledge and skills they need to improve road safety when they drive a motor vehicle. The three stages of GDL are described in the following

[3] In the rest of the paper, I consider the BAC limit at 50mg/100ml for the province of Saskatchewan.

way. The first stage is the supervised learning period where a young driver or new drivers, after passing a qualifying test, is granted a learner's permit. A novice driver is allowed to drive only with a supervising adult (who has a driver's licence) in the car for a given period or a minimum number of hours before earning an intermediate licence.

The intermediate licence represents the second stage. At this stage, the driver has earned a licence and no longer needs supervision to drive, but is subject to restrictions, such as a curfew, no cell phone, or the number of passengers allowed in the car. Restrictions vary from province to province. The last stage is a full licence where the driver meets the age and any other requirements to earn an unrestricted drivers licence.

Table A.2 (Appendix A) summarizes the specific features each of the provincial GDL program in the four provinces of my study. Table A.2 indicates that in 1994, the Ministry of Transportation for Ontario introduced the first graduated licence system in Canada followed by Quebec in 1997, Alberta in 2003 and Saskatchewan in 2005. Except for Alberta, the minimum age to start the GDL program is 16 years. Table A.2 also shows that on September 1, 2005, a new restriction is introduced in the GDL program in Ontario. Modifications to the GDL program included a restriction on passengers prohibiting drivers aged 19 and under from carrying more than one passenger aged 19 or under during the first six months of the intermediate stage (see Table A.3, Appendix A). In the province of Quebec, driving course became mandatory for obtaining a passenger vehicle licence in 2010.

3 Literature Review

Considerable academic effort has been directed to evaluate the impact of the laws governing BAC or GDL. Most of the existing research focuses either on the impact of changes in BAC or GDL laws, separately, on fatalities rate for novice drivers. Some attention has been paid to other measures of accident rates. Little attention is paid to other drivers age groups. This section provides an overview of key research findings related to these topics.

3.1 BAC Laws

Studies evaluating the implementation of administrative laws governing the BAC can be grouped into two categories: those dealing with the lowering of the legal limit of the BAC law and those concerning the illegal limit of the BAC law. Legal limit refers to the federal law on the BAC: exceeding the limit level is a criminal offence. The illegal limit designates the BAC law of each state (or province): exceeding the illegal limit, if the legal limit is not exceeded, gives rise only to administrative sanctions. This paper's review focusses on studies that evaluate effect of lowering the BAC limit from 80 mg to 50 mg. This focus is motivated by the fact that the Federal limit was set at 80 mg throughout the period of this study, and provincial governments introduced a 50 mg limit during this time (or reinforced administrative sanctions relative to the 50 mg limit).

Although there are very few studies that provide empirical evidence regarding the potential impact of lowering BAC limit from 80 to 50 mg/100ml on accident rates (Blais et al. (2015), there is a general consensus in the research literature that this change in the BAC limit is likely to reduce the number of alcohol-related injuries and deaths (Fell and Voas (2014)). Blais et al. (2015) conducted a recent study on the effectiveness of administrative BAC law in Canada. Blais et al. (2015) used data on the number of drivers fatally-injured in motor vehicle collisions and the percentage of the victims of the traffic from the Traffic Injury Research Foundation (TIRF) for all ten Canadian provinces for the period of 1987 to 2010. They also considered data on the number of fatally-injured drivers in motor vehicle crashes and the percentage who had been drinking to estimate the effects of administrative law on alcohol-related crashes. By applying regression models for longitudinal data, Blais et al. (2015) estimated the effect of administrative BAC law on the percentage of fatally-injured drivers with higher BAC levels at 50, 80 and 150 mg/100ml. Their results indicate that the Canadian administrative blood alcohol law has reduced the percentage of fatally-injured drivers for drivers with a BAC level of 50 mg/100ml or more. In this study, the main limit rests in the fact that the issue of reverse causality that there may be between BAC law and accident rates is not being taken into account. Another limitation of this study is that it considers only fatally-injured drivers, while a given accident may involve others who are seriously or fatally-injured.

Albalate (2008) takes a different approach because he focuses on the impact of the BAC law on victims of different age group. Albalate (2008) evaluates the impact of the BAC limit at 50mg/100ml on alcohol-related fatality rate according to the different age group of the victims for the period of 1991 to 2003 in 15 European countries. Using the difference-in-differences method and European panel-based data (CARE), he showed the existence of positive impacts of the law governing the BAC on certain groups of road users. Albalate (2008) found that lowering the blood alcohol level to 50 mg/100ml reduces alcohol-related mortality rates among young drivers aged 18 to 25 years. Also, the adoption of this law led to a reduction in the number of motor-related deaths among men of all ages and all origins. Finally, Albalate (2008) points out that the effects of the law limiting BAC level to 50 mg/100ml in Europe was evident after two years of its implementation and increased over time.

Zador et al. (2000) focuses on the relative risk of fatal accidents by age/sex and a blood-alcohol content of drivers involved in a fatal accident and fatally-injured drivers in an accident. The specificity of this study is to calculate accident rates according to the drivers involved in an accident. However, although this study does not evaluate the impact of the BAC law on accident rates, authors find that lowering the BAC limit reduces accident. Although there is a consensus in the literature studying the impact of lowering the BAC limit from 80 to 50 mg what has been neglected by these authors is the interaction between the BAC laws and other laws regulating driving. On this study, I will explicitly examine the interaction between BAC and GDL laws.

3.2 GDL Program

There is also important literature that examines the impact of the law governing the Graduated Driver Licensing Program (GDL). Here, I will discuss the literature which has evaluated the introduction of GDL program and not the studies that evaluate the effectiveness of individual GDL components. Unlike the literature on lowering the BAC limit, there is no consensus on the impact of introducing on the impact of introducing a GDL program.

The majority of these studies focuses on assessing the impact of GDL on the driver accident rates such as a fatality, major injury, fatal accidents, and accidents caused by drinking-driving involving adolescent drivers per capita or licensed drivers or per kilometre driven. Substantial reductions in the number of collisions, fatal accidents or accidents caused by drinking and driving involving adolescent drivers were found after the implementation of the GDL programs, according to several authors who use different sources of accident data on the one hand and, on the other hand, different approaches and methods of evaluation (Boase and Tasca (1998) in Ontario, Bouchard et al. (2000) in Quebec, Mayhew et al. (2003) in Nova Scotia, Rice et al. (2004) in California, Morrisey et al. (2006) in US states). However, other studies have concluded that the GDL program has no impact on accident rates such as fatal accidents, fatal and/or injured drivers per capita or licensed drivers or per kilometre driven. Examples include studies carried out by Masten and Hagge (2004) and Males (2006) in California, Hay (2010) in Canada.

The lack of consensus in the literature may be explained by the fact that many of these studies have serious limitations. For example, most of these studies cover post-policy periods that are too short or that do not control simultaneous policies that could compromise the real effectiveness of accident rates reduction. In addition, few of these studies have attempted to control unobserved characteristics that may vary from province (state) to province (state). This includes, for example, studies undertaken by Boase and Tasca (1998), Bouchard et al. (2000), Rice et al. (2004) and Masten and Hagge (2004).

However, studies carried out by Hay (2010) in Canada, Dee et al. (2005), (Williams et al. (2005)), Morrisey et al. (2006) in United States do not suffer from the identified weaknesses noted above. Indeed, these studies, in addition to using a large panel of annual state/provincial-level data over a longer period after the implementation of GDL, they also introduce fixed effects to capture unobserved heterogeneity. Furthermore, other policies such as the legal age of alcohol consumption, blood alcohol concentration, seatbelt laws, administrative revocation put in place by the authorities for road safety are introduced in the analyses.

Hay (2010)'s study is the only study that covers all the provinces of Canada. Hay (2010) used data on fatality rates from the Traffic Injury Research Foundation for all provinces to assess the effect of the law governing graduated driver licensing in Canada on fatal motor vehicle collisions. Hay (2010) estimated the effects of GDL on fatal collisions (fatal traffic accidents in a province during the year per 100,000 licensed drivers) of drivers aged 15 to 24, and 25 years and over. Her findings led him to conclude that GDL does not influence the reduction of fatal motor vehicle collisions in Canada.

A striking weakness of the existing literature is that, with the potential exception of Hay (2010) it does not consider the impact of introducing a GDL program on accident rates for experienced drivers. Moreover, it does not consider the interaction between BAC laws and GDL laws. Additionally, the literature does not consider the potential endogeneity of changes in the regulation regime: in jurisdictions with upward trending accident rates, the introduction of BAC or GDL laws may not reduce accident rates leading to the conclusion that they were ineffective, but in their absence, accident rates may have risen higher. In this study, I seek to address these concerns.

4 Conceptual Framework: Can BAC and GDL Laws Affect Accident Rates?

This proposed theoretical framework focuses on the mechanism by which BAC and GDL laws can affect accident rates. This section provides drivers' behavioral responses to the implementation of each of the two laws and how this can affect crash rates.

4.1 Expected Behavioral Reactions to Safety Policy: BAC Law

Since the alcohol level is zero for all young drivers who are subject to the GDL program, then BAC law does not involve drivers who are on the GDL program but rather drivers who have completed the process. For drivers not under GDL, BAC law limits the amount of alcohol that drivers can consume before driving. If BAC law reduces the mobility and thus the movement of drunk drivers, then I can hope that it will reduce the accident rate, the fatalities rate, the major and minors injuries rates since the decrease in mobility and the movement of drivers will result in a reduction of accident rates.

4.2 Expected Behavioral Reactions to Safety Policy: GDL Program

The GDL program imposes the following restrictions on the latter: (minimum age to obtain a learner permit, mandatory minimum period for the learner permit, minimum number of hours of supervised driving during the learner permit internship-both daytime and nighttime, minimum age to obtain an intermediate license, nighttime driving restrictions during the intermediate stage, passenger restrictions during the intermediate stage, minimum age for full licensing). There are other restrictions on young drivers such as cell phone bans, texting bans, seat belt requirements, zero tolerance for driving under the influence of drugs or alcohol. According to Williams (2005), these GDL program conditions described above are a way to limit youth mobility during a given training period and seem to be successful in reducing the risk of accidents. Apart from restrictions on the GDL program, Noland (2013) also argues that a progressive licensing program increases both the cost of learning to drive and therefore discourages young people from driving. All of this makes licensing less attractive for some young drivers, who choose alternative transportation: public buses.

If the GDL program decreases the presence of young drivers on the roads, their mobility and their risk related to driving a car, then I can hope that the number of road accidents involving young drivers will, therefore, decrease so expect fatalities accident rate, major injuries rate and minor injuries rate can reduce over time. For older drivers, the GDL program has provided them with experience to be able to drive more safely on the roads and to take less risk when driving. If the experience gained by older drivers allows them to drive more cautiously on the roads and make less risky decisions on the roads, then the GDL program can be expected to reduce accident rates and thereby fatalities rate, major and minor injuries rates involving them. Finally, if both GDL and BAC laws reduce mobility and travel, and the risks of driving then I can expect that the two laws taken simultaneously reduce more roads accident.

4.3 Research Hypotheses

Considering all the above, my study focuses on the following three empirical hypotheses:

Hypothesis 1: The GDL program does not reduce roads accident rates (fatalities, major injuries, minor injuries).

Hypothesis 2: BAC does not reduce accident rates (fatalities, major injuries, minor injuries).

Hypothesis 3: The the interaction of BAC and GDL laws do not reduce accident rates (fatalities, major injuries, minor injuries).

5 Data and Descriptive Statistics

This study is based on collision data from Alberta, Ontario, Quebec, and Saskatchewan. It covers the period from 1992 to 2013.[4] These are administrative data provided by provincial departments in charge of collecting and managing them. More than 2,000,000 accidents occurred in these provinces over this period. Each observation represents an individual involved in a collision. For each individual involved in an accident, the data includes the following information: an accident identification number, the date, the place of the accident (municipality name, province name), the total number of deaths, the total number of cars involved in the accident, the age, the sex, the severity of injury (death, serious or minor injury, no injury) and the status (driver, passenger, pedestrian).[5]

My study is restricted to accidents which involve injuries or fatalities. Fatal injuries include all individuals who died as a result of a reported traffic collision.[6]

Whereas the existing literature focuses almost exclusively on the impact of regulatory changes on accident rates for novice drivers, a contribution of this paper is to investigate the impact of these changes on the entire driver population. In this context, an important methodological challenge is to determine how to assign the total number of fatalities and total number of persons injured across the drivers involved in an accident. The appropriate methodology depends critically on the question that is being asked. In particular, it is important to understand the difference between the following two questions: What is the probability that a driver in a certain age group is involved in an accident resulting in death or injury? And, what is the probability that a driver in a certain age group causes an accident resulting in death or injury? The first approach assigns all fatalities

[4] This study was originally intended to cover all provinces in Canada. However, data were obtained only from the four provinces of Alberta, Ontario, Quebec, and Saskatchewan.

[5] Everyone involved in a given accident is identified by a unique registration ID number (accident identifier). Similarly, all information about the persons involved is collected by the police officer legally required to report when a moving vehicle is involved in an accident.

[6] Note that fatal injuries or fatalities include all individuals who died as a result of a reported traffic collision within 30 days of its occurrence except in Quebec where eight days are considered. In this study, I make no distinction between fatalities occurring within 8 days (Quebec) or within 30 days (other provinces) because, all things equal elsewhere, this difference may cause a difference in accident rates without affecting the impact that laws should have on accidents causing fatalities or major injuries. Indeed, this difference in the number of days within which provinces declare a fatal accident can lead to a higher number of major injuries in Quebec compared to other provinces or a higher number of deaths in other provinces compared to Quebec. Major injuries include persons admitted to hospital for treatment or observation due to, for example, fracture or permanent loss of use of a body organ. The provinces of Alberta and Saskatchewan report two subtypes of major injuries such as major incapacity and major unconsciousness. In this study, these two subcategories were grouped into major injuries. Minor injuries include wounds such as sprain, strain, bruising, or laceration. In Alberta, Ontario, and Saskatchewan, minor injuries are subdivided into two sub-categories such as minor and moderate non-incapacitated injuries. In this study, these two sub-categories are grouped into minor injuries.

and injuries to each age group of all the drivers involved; each fatality and injury may therefore be counted multiple times. The second approach identifies and assigns the number of deaths and injuries in an accident to the age group of the at-fault driver; each fatality and injury is therefore counted only once.[7] In this study, I am interested in discerning the impact of BAC and GDL laws on accident rates for drivers of different age groups, and therefore am interested in the first question.

In calculating accident rates, I use data on municipality populations by age group as the denominator.[8] Ideally, when calculating accident rates for each age group of drivers, the denominator in the calculation would be the number of licensed drivers in each age group in each municipality. However, this data is not available. Assuming however, that the proportion of the population with a driver's licence does not vary from city to city, using of the population of each age group in each municipality as the denominator to calculate accident rates is a good proxy. To obtain the population of each municipality, I used the 1991, 1996, 2001, 2006 and 2011 censuses, as well as the annual growth rates and intercensal estimates for the population by age group.[9]

In the collision data from the provinces of Ontario and Quebec, accidents are recorded by the geographic code of each municipality (Table A.4). The registration by geographic code allows me to observe the evolution of the population in the territory associated with it despite the mergers between municipalities that took place between 1992 and 2013.[10] I initially merged collision data with files containing the geographic code and the name of the municipality provided by these provinces to identify the name of the corresponding municipality.

I then linked the different names of municipalities in the four provinces to the generic term "census subdivision (CSD)" used by Statistics Canada. Indeed, Statistics Canada uses census subdivision to refer to municipalities or territories considered to be municipal equivalents for statistical purposes. Thus, the municipality in this study corresponds to Statistics Canada's census subdivision. It is defined as the administration of a community-type territorial entity that may be represented by a single city. Finally, populations of each municipality are subdivided into different age groups: 16 to 19 years old, 20 to 24 years old, 16 to 24 years old, 25 to 34 years old, 35 to 44 years old 45 to 54 years, 55 to 64 years old, 65 to 90 years, 25 to 90 years, and 16 to 90 years.

By using the data presented above, I generated per capita accident rates by following the steps

[7] Data used for this study does not provide any information on who is responsible and what is the cause of each accident.

[8] Different data are used at the denominator to calculate accident rates. This may include the total number of kilometers traveled by drivers in the same age group, the number of registered motorcycles, the number of licensed drivers, census data on the population by age and/or by sex. Ideally, the denominator should be the total number of licensed drivers (McKnight and Peck (2002)) or the total number of kilometers traveled by drivers in the same age group (Tefft (2017)).

[9] I interpolated to obtain the monthly growth rates of the population using the annual rates estimated by Statistics Canada.

[10] For example, in the collision data, Vanier and, Orleans differ from the city of Ottawa in Ontario; Montreal East and, Montreal North are distinct from the city of Montreal in Quebec.

described below.[11] I use the information describing the persons involved in each accident to calculate the total number of major and minor injuries associated with each accident. Tables B.1 and B.2 in Appendix B present a fictitious case. These tables indicate that the accident for which the identifier is 10000103 involves three drivers aged 33, 35 and 29 respectively.

The second task is to associate each accident with the total number of deaths and injuries, deaths and major injuries, deaths, injuries, major injuries and minor injuries to do the analysis. I merge the database from the first step with collision data by accident identifier, per month, per year and per municipality. At the end of this second step, I was able to build datasets for different age groups of drivers. For example, Table B.3 (Appendix B) shows that all the people involved in the accident identified by the number 10000103 (example step 1) are associated the same numbers of dead, and those with injuries (major and minor).

Thirdly, I initially create three different age groups of drivers: all drivers (16 to 90 years old), novice drivers (16 to 24 years old) and experienced drivers (25 to 90 years). Novice drivers were subsequently subdivided into two subgroups (16 to 19 and 20 to 24 years old) and experienced drivers into five subgroups (25 to 34, 35 to 44, 45 to 54, 55 to 64 and 65 to 90 years old) subgroups. Tables B.3.1, B.3.2 and B.3.3 (Appendix B) report the accidents by the age groups of drivers aged 16 to 90, 16 to 24 and 25 to 90. Thus, Table B.3.2 indicates that only one novice driver is involved in the accident identified by the number 10000106, while B.3.3 reports that three drivers over the age of 25 are involved in the same accident.

The fourth step consists in eliminating the double counting of fatalities and injuries when there are two or more drivers *in the same age group*. If the same accident identifier is assocated with more than one driver, the total number of fatalities and injuries with a specific identifier is divided by the number of drivers attached to that accident.[12] Continuing with the preceding example, the elimination of double counting of accidents is carried out through Tables B.4.1, B.4.2, and B.4.3 of Appendix B representing the 3 groups previously listed. Thus, the accident number 10000103 of Table B.3.1 involving 3 drivers of the same age group (16 to 90) is counted once in Table B.4.1. Similarly, in Table B.3.3 reporting the number of deaths and injuries involving experienced drivers, the accident identified by the number 10000103 which had 3 lines, is reduced to one line in Table B.4.2. However, considering Table B.3.2 for novice drivers, it can be noted that Table B.4.2 did not change because there is only one driver aged 16 to 24 involved in the accident identified by the number 10000106. To finish this fourth step, I immediately created after calculating the total number of deaths or injuries per accident, the variable "number of accidents" which takes the value

[11] Accident rates refer to fatality and injury rate, fatality and major injury rate, fatality rate, injury rate, major injury rate and minor injury rate.

[12] The same approach is used for fatality and major injuries, fatality, injuries, major injuries and minor injuries.

1.

At the fifth step, within each group, I have taken the sum of the total number of accidents, of fatalities and major injuries, of deaths, of injuries, of major injuries and of minor injuries per municipality, per month and per year. Table B.5.1 (Appendix B) indicates that the total number of fatalities, of major injuries, of minor injuries and of accidents involving drivers aged 16 to 90 per month is 0, 0, 1 and 1 for the municipality named AAAAA; 1, 1, 1 and 2 for the municipality named BBBBB; and 2, 2 0 and 1 for the municipality named CCCCC. It can also be noted that the total number of fatalities, of major injuries, of minor injuries and accidents involving novice drivers per month are respectively 2, 2, 0 and 1 for the municipality named CCCCC (Table B.5.2). According to my example on fictitious accidents, novice drivers are not involved in any accident in municipalities named AAAAA and BBBBB. However, Table B.5.3 for experienced drivers indicates that the total number of fatalities, of major injuries, of minor injuries and of accidents per month is 0, 0, 1 and 1 respectively for the municipality named AAAAA; 1, 1, 1 and 2 respectively for the municipality named BBBBB; and 2, 2 0 and 1 respectively for the municipality named CCCCC.

In the last step, I used on the one hand, the respective sum of the total number of accidents, of fatalities and major injuries, of deaths, of injuries, of major injuries and of minor injuries previously calculated, and the populations of the municipalities on the other to obtain accident rates by exploiting the formulas presented in the sixth step of Appendix B using. For example, using Table B.6.1, the fatality rate for all drivers is 0 for the municipality named AAAAA; 0.5 for the municipality named BBBBB and 0.8 for the municipality named CCCCC. This same rate calculated from Tables B.6.2 and B.6.3 is respectively for novice drivers and experienced drivers 2.63 and 1.15 in the municipality named CCCCC. It should be noted that the rate per age group calculated in this way has led to the fact that the accident rates (fatality rate) for novice and experienced drivers in this example is higher than that obtained for all drivers. This is due to the fact that the numerators are almost the same for example for the age group of all drivers (16 to 90) and experienced drivers (25 to 90) while the denominator of the population aged 16 to 90 is higher than that of drivers aged 25 to 90.

I make two restrictions to the data used (see Table A.5). First, using the population estimates between two censuses of the year 1992, I restricted my analysis to municipalities with more than 10,000 inhabitants because I noticed that in localities with a small population size, accident frequency is very low: in most months, there are no accidents observed. This reduces the key source of variation in the data which is essential to identifying the impact of changes in BAC and GDL laws on accident rates.[13] Before limiting my study to cities with more than 10,000 inhabitants, the pop-

[13]The accident rates refers to the accident number rate, the accident rate with fatalities and injuries, the accident rate with fatalities

ulations of Alberta, Ontario, Quebec and Saskatchewan respectively represent 12.40; 49.15; 33.61 and 4.81% of the total population of these four provinces. After removing municipalities with less than 10,000 inhabitants in each of the four provinces, the new proportions are 12.27, 53.92, 30.63 and 3.16% respectively for Alberta, Ontario, Quebec and Saskatchewan. Compared to the pre-removal proportion, the province of Ontario is overrepresented while the provinces of Quebec and Saskatchewan are under-represented. Table A.5 reports the number of municipalities per province covered by my study. Thus, this study covers 13 municipalities in Alberta, 105 municipalities in Ontario, 69 municipalities in Quebec and 7 municipalities in Saskatchewan. The second restriction is to exclude drivers who are under 16 years of age.[14]

Finally, the dataset on BAC legislation for this study was extracted from reports published by the Canadian Council of Motor Transport Administrators (CCMTA) in 2011 and 2013 (see Table A.1). Data on the implementation or modification dates of the GDL programs were extracted from the reports of the Traffic Injury Research Foundation (TIRF) on Best Practices for Progressive Licensing in Canada (see Tables A.2 and A.3). Data from CCMTA and TIRF serve me to create my regressors of interest BAC, GDL laws and their interaction term (GDLxBAC). Beside BAC and GDL laws, I have also used municipality, month and year as fixed effects.

Table 1 shows that on average, GDL is implemented for 87% of my observations at a given period of my study. Indeed, in 1992, none of the provinces under this study had yet implemented GDL. Between 1994 and 2005, these provinces successively implemented GDL in their territory. Furthermore, Table 1 reports that, on average, BAC is implemented for 62% of my observations at a time during the period of my study. This low rate of BAC compared to that of GDL is because Quebec does not regulate BAC.

and major injuries, the accident rate with fatalities, the accident rate with injuries (major and minor), the accident rate with major injuries and the accident rate with minor injuries. Other papers report this measure as follows: alcohol-related driving death rate, traffic injuries and fatalities, driver injury rate, driver crash rate, per capita crash rate, per capita causality crash rate, motor vehicle collisions fatalities, per capita serious casualty accidents, per miles driven fatal crash rate.

[14]The average age to begin the GDL program in the provinces in my study is 16.

Table 1: Descriptive statistics for BAC law, GDL program, number of drivers and vehicles by accident, municipality size

Variables	Mean	SD
Blood Alcohol Concentration Levels (BAC)	0.62	0.48
Graduated Driver Licensing Law (GDL)	0.87	0.32
(GDL)times(BAC)	0.59	0.49
Number of driver by accident[a]	1.92	2.63
Number of vehicle by accident[b]	2.12[c]	2.90
Municipality size	81,839	164,172
Observations	51,216	

[a] This is a ratio of total number of drivers involved in a road accidents to the total number of road accidents (per month and per municipality). [b] This is a ratio of total number of vehicles involved in a road accidents to the total number of road accidents (per month and per municipality). [c] The number of cars is larger than the number of drivers, I remove drivers under 16 years, and some accidents take place with parked vehicles .

Table 2 shows that, on average per 10,000 inhabitants per month and per municipality, drivers aged 16 to 90 are involved in 21.01 accidents with 0.27 deaths and 21.49 injuries, of which 1.60 major injuries and 19.89 minor injuries. Among these drivers, novices are involved in 14.81 accidents per 10,000 inhabitants per month and per municipality, resulting in 0.41 deaths and 22.26 injuries, of which 2.10 are major and 20.16 are minor.

Table 2: Descriptive statistics: Accident rates by drivers age group

	16-90		16-24		25-90	
Rate	Mean	SD	Mean	SD	Mean	SD
Accident number[a]	21.01	12.17	14.81	10.65	21.41	10.36
Fatalities-Injuries[b]	21.76	12.98	22.67	12.50	21.37	11.08
Fatalities-Major Injuries[c]	1.87	1.80	2.51	1.70	1.48	1.64
Fatalities[d]	0.27	0.22	0.41	0.18	0.22	0.19
Injuries[e]	21.49	12.88	22.26	11.55	21.15	11.45
Major injuries[f]	1.60	1.75	2.10	1.63	1.25	1.61
Minor injuries[g]	19.89	12.47	20.16	11.30	19.90	11.25

[a]Accident number rate is a ratio of the total number of road accidents (per month and per municipality) to the total population of the municipality. [b]Fatalities and injuries rate is a ratio of the total number of deaths and injuries of traffic accidents (per month and per municipality) to the total population of the municipality. [c]Fatalities and major injuries rate is the ratio of the total number of deaths and major injuries of traffic accidents (per month and per municipality) to the total population of the municipality. [d]Fatalities rate is a ratio of the total number of deaths of traffic accidents (per month and per municipality) to the total population of the municipality. [e]Injuries (major & minor) rate is a ratio of the total number of injury of traffic accidents (per month and per municipality) to the total population of the municipality. [f]Major injuries rate is a ratio of the total number of major injuries of traffic accidents (per month and per municipality) to the total population of the municipality. [g]Minor injuries rate is a ratio of the total number of minor injuries of traffic accidents (per month and per municipality) to the total population of the municipality. All ratios are multiplied by 10,000.

Table 3 provides more insight into how more insight into how accident rates being by age group. What is striking is that fatality rates, for example, are higher for drivers ages 20-24 than for drivers aged 16-19. Drivers aged 45-54 have the second highest fatality rates. Also, the accident rate is highest for drivers aged 25-34, and this age group has the highest rate of accidents leading to fatalities and major injuries. The data presented in this table shows the importance of BAC and GDL laws on accident rates for the entire driver population.

Table 3: Descriptive statistics: Accident rates by drivers age subgroup

	16-19		20-24		25-34		35-44		45-54		55-64		65-90	
Rates	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Accident number	14.44	10.1	17.80	12.05	22.25	10.11	21.13	12.35	20.58	12.23	7.88	7.70	5.60	6.20
Fatalities-Injuries	20.95	15.88	25.49	20.38	22.73	18.16	23.43	14.64	22.10	16.05	8.67	13.23	6.39	6.81
Fatalities-Major Injuries	1.7	1.34	3.05	1.56	1.66	1.10	1.46	0.96	1.42	0.94	0.45	0.98	0.45	1.01
Fatalities	0.35	0.46	0.48	0.71	0.34	0.24	0.37	0.34	0.41	0.37	0.07	0.28	0.08	0.46
Injuries	20.6	15.81	25.01	20.3	22.38	18.37	23.05	14.58	21.69	15.97	8.6	13.1	6.31	6.68
Major injuries	1.35	1.21	2.57	1.33	1.31	1.17	1.09	0.83	1.012	0.81	0.38	0.89	0.37	0.84
Minor injuries	19.25	15.35	22.44	19.81	21.07	18.48	21.96	14.24	21.28	15.61	8.22	12.75	5.94	6.34

6 Ordinary Least Squares (OLS) Estimation

6.1 Baseline OLS Specification

In this subsection, I present the main econometric framework to estimate the effect of BAC law and GDL program on different accident rates AR_{tm}. The main regression equation is defined as:

$$AR_{tm} = \alpha BAC_{tm} + \beta GDL_{tm} + \delta BAC_{tm} \times GDL_{tm} + \mu_t + \tau_m + \epsilon_{tm} \tag{1}$$

where AR_{tm} denotes the accident rates experienced in the month and year t, and in the municipality m.[15] The variables of interest are BAC_{tm}, GDL_{tm} and their interaction terms $BAC_{tm} \times GDL_{tm}$. BAC_{tm}, GDL_{tm} are binary variables equal to one if the law is in force in month and year t in municipality m and $zero$ otherwise.[16] α measures the impact of the BAC law on accident rates when GDL is not in force; β measures the effect of a GDL program on accident rates when BAC is not in force; δ measures the additional impact that GDL (BAC) has on accident rates when BAC

[15] In general, empirical studies that assess the effectiveness of road safety laws are conducted using aggregate data at the provincial level. The implicit assumption is that the application of these laws and the influence all of the factors that contribute to the likelihood of accidents are uniform across the province. However, these laws are applied by municipalities, and variation now therefore arise in the strictness with which they are interpreted. Moreover, the congestion rate, which is a key determinant of the accident rate, is higher in large cities than in small towns or villages. Also, when congestion is high, it may involve driving with frequent stops which, other things being equal, should increase accidents but reduce the number of fatalities (Keeler (1994)). This is an important source of variation in the data, and using the municipality as the unit of observation, therefore, will lead to a more precise estimate of the impact of changes in these laws on accidents. Additionally, by using municipality as the unit of observation rather than the province, this leads to a large number of reasonably homogeneous clusters in term of size, which also contributes to the precision of the estimated effects.

[16] Other control variables are also used in the literature. This is the case for example of the regulations on speed limits, seatbelt use that did not change over the period covered by this study in the four provinces. Therefore, they are not included in my regression.

Blood Alcohol Concentration legislation existed in Alberta and Saskatchewan over the entire period of my study. They are the subject of this study. However, laws governing revocation or license suspension underwent changes (reported in Table A.1). I attempted to include this modification to the existing administrative BAC law in my regression. However, there had no significant effect on accident rates. Therefore, I choose not to report these results.

(GDL) laws are already in place.[17]

μ_t denotes month and year fixed effects. I use the month×year fixed effects to allow for variation of the different accident rates that can occur in the year rather than controlling only for the month×year. The month×year fixed-effects control for specific effects such as technological changes (introducing of safer cars, or national campaigns that affect driver behaviour) that was also impact the number of accidents in all municipalities. τ_m designates municipality-fixed effects to capture all unobserved time invariant characteristics, such as population characteristics, general weather conditions, traffic conditions and others. The error term ϵ_{tm} includes all other unobservable shocks to the accident rate. I cluster the error term at the municipality level in order to take into account potential serial-correlation in accident rates within the municipality.[18]

6.2 Baseline Results

In this subsection, I present OLS estimates of the impact of BAC and GDL legislations on motor vehicle collision fatalities and injuries rates. The results from estimating equation (1) are presented in Table 4.

6.2.1 BAC and GDL effect on accident rates involving all, novice, and experienced drivers

i) ***Partial effect of the BAC law on accident rates involving all drivers***

Table 4 below reports two sets of results of the effect of changes in the BAC and GDL laws on the number of accidents and on accident rates for the entire population. The first set of regressions ignores the potential effect of the interaction term between BAC and GDL. The second set sheds light on the importance of the interaction term. Table 4 indicates that the results change depending on whether the interaction term is introduced in the regression or not.

Columns (1) through (7) in Table 4 show that my regression results for my 7 dependent variables. Columns (2), (5) and (7) of Table 4 indicate that BAC, when GDL is not present, does not affect the fatality-injury rate, the fatality rate, the injury rate and the minor-injury rate involving all drivers aged 16 to 90 years old. Indeed, the estimated coefficients of BAC on these rates are negative but non-statistically significant.

[17] The differences between the components of each law across the provinces are not the subject of my study.

[18] The clustering is not done on municipality-year pairs since, for example, the error term for municipality named AAAA in 2001 is likely to be correlated with the error term for the municipality named AAAA in 2000.

Furthermore, the BAC law, when GDL law is not in force, does not prevent the accident-number rate, the fatality-major injury rate and the major-injury rate from rising. Indeed, without the interaction term, the estimated coefficients of the BAC law are positive and statistically significant at five (5) percent level for the accident-number rate, the fatality-major injury rate and the major-injury rate involving all drivers as shown columns (1), (3) and (6) of Table 4. Whether or not GDL law is implemented, the BAC law has no effect on fatality rate involving all drivers aged 16 to 90 years old (column (4), Table 4).

Table 4: Effect of BAC law or GDL program on accident rates[a] involving all drivers (16-90 years old)

		(1)	(2)	(3)	(4)	(5)	(6)	(7)
Variables		Accident number	Fatalities & injuries	Fatalities-Major injuries	Fatalities	Injuries	Major injuries	Minor injuries
without interaction	BAC[b]	3.271**	-0.762	0.139**	0.004	-0.766	0.135**	-0.901
		(0.813)	(0.798)	(0.030)	(0.004)	(0.795)	(0.028)	(0.775)
	GDL[c]	-2.663*	-4.092**	-0.126*	-0.015	-4.077**	-0.11*	-3.966**
		(1.333)	(1.911)	(0.072)	(0.010)	(1.903)	(0.062)	(1.859)
with interaction	BAC	-0.581	-2.261	-0.026	-0.013	-2.248	-0.012	-2.235
		(2.118)	(3.040)	(0.104)	(0.015)	(3.026)	(0.089)	(2.949)
	GDL x BAC	4.825**	1.877	0.206**	0.021	1.856	0.184**	1.671
		(2.030)	(2.034)	(0.100)	(0.015)	(2.910)	(0.086)	(2.840)
	GDL	-4.389*	-4.764*	-0.200**	-0.023	-4.740*	-0.176**	-4.564*
		(1.771)	(2.771)	(0.097)	(0.015)	(2.757)	(0.083)	(2.683)
	F-Statistic and *p*-Values on Joint Hypothesis							
	Ho: $\alpha + \beta + \delta = 0$							
	F-Statistics	0.01	2.98	0.03	1.02	2.99	0.00	3.14
		(0.93)	(0.09)	(0.85)	(0.31)	(0.09)	(0.96)	(0.08)
	Ho: $\alpha + \delta = 0$							
	F-Statistics	59.01	0.88	34.82	7.34	0.92	35.58	1.97
		(0.00)	(0.35)	(0.00)	(0.00)	(0.33)	(0.00)	(0.16)
	Ho: $\beta + \delta = 0$							
	F-Statistics	0.22	4.86	0.04	0.17	4.85	0.07	4.74
		(0.64)	(0.028)	(0.84)	(0.68)	(0.02)	(0.79)	(0.03)
	Weighted average in 1992	20.90	25.00	1.78	0.32	24.68	1.46	23.22
	Observations	51,216	51,216	51,216	51,216	51,216	51,216	51,216
	Municipality FE	YES	YES	YES	YES	YES	YES	YES
	Year x Month FE	YES	YES	YES	YES	YES	YES	YES

Notes: This table reports the results of the effect of BAC law or GDL program on accident rates involving all drivers. All columns include BAC, GDL laws and their interaction term. Columns (1) to (7) use dependent variables such as accident number, fatalities and injuries, fatalities and major injuries, fatalities, injuries, major injuries and minor injuries rates. I controlled month, year and municipality fixed effect. Standard errors clustered at the at the municipality level are reported in parentheses under coefficients, and *p*-values are given in parentheses under F-statistics. Individual coefficients are statistically significant at the *** 1% or ** 5% or * 10% significance level.

[a] In columns (1) to (7), the ratio of the total number of each accident category and total population, is multiplied by 10,000; [b] Restricted Blood Alcohol Concentration law (BAC): BAC law level = 50 milligrams of alcohol in 100 millilitres of blood (50mg/100ml). It takes value one in the municipality m in the month and year t where it is in force; otherwise, BAC law is equal to zero. [c] Graduated Driver Licensing (GDL); it is equal to one if the program already is in force in the municipality m in the month and year t; if not, GDL program takes value zero.

Moreover, and more importantly, when the interaction term is included as an additional control variable, all estimated coefficients of BAC law on accident rates involving all drivers are not statistically significant. A precise estimate of the real effect of BAC law on accident rates depends on the size of the confidence interval. Indeed, the larger the size of the standard error, the more imprecise the estimated effect. However, the results in Table 4 show that the standard errors of the coefficients estimated in the presence of the interaction term are very large compared to those obtained in the absence of the interaction term. On this basis, I can conclude that the estimate of the effect of the BAC law on almost all accident rates is not precise.

The table 4 also indicates that the estimated coefficients of the interaction term are positive and statistically significant at five (5) or 10 percent level for the accident number rate, the fatality-major injury rate and the major injury rate. It indicates that the interaction term reduces the expected effect of BAC law on the accident-number rate, the fatality-major-injury rate and the major-injury rate involving all drivers when GDL law is not in force. These results reveal the impact of BAC law when another law such as GDL program is implemented and therefore appears highly relevant for policy recommendation aiming to reduce the rate of road accidents. The bottom line of this analysis is that the effect of BAC law on accident rates is sensitive to the interaction term since its omission leads to bias estimated results.

Table 4 also reports the joint hypothesis test that the coefficients on BAC law, the interaction term and the GDL program are all zero. This hypothesis is rejected for the fatality-injury rate, the injury rate and the minor injury rate. The rejection of the joint hypothesis indicates that at least one of the BAC or GDL laws affects the fatality-injury rate, the injury rate and the minor injury rate involving all drivers. Moreover, the joint hypothesis that the coefficients of BAC law and the interaction term are both zero is accepted for the fatality-injury rate, the injury rate and the minor injury rate involving all drivers aged 16 to 90 years old. By accepting this hypothesis, it can be deduced that the BAC law does not affect the fatality-injury rate, the injury rate and the minor injury rate when GDL program is also in force. This is consistent with Killoran et al. (2010) who find that there were no significant reductions in fatality or injury among the population as a whole when other concurrent policies were taken account with the BAC law.

However, this last hypothesis test is rejected for the accident number rate, the fatality-major injury rate and the major injury rate. This rejection states that the BAC law affects the accident number rate, the fatality-major injury and the major injury involving all drivers even when GDL is also present. This joint hypothesis is finally rejected for the fatality rate involving all drivers (column (4), Table 4). These results suggest that when BAC law is already in place and it adds

GDL law, the partial effect of BAC law does not prevent the accident number rate, the fatality-major injury and the major injury involving all drivers aged 16 to 90 years from rising.[19] Finally, BAC law has no effect on fatality rate regardless of whether GDL is in effect or not.

ii) ***Partial effect of GDL program on accident rates involving all drivers***

Results in Table 4 show that without the interaction term, the fatality-injury rate, the injury rate and the minor injury rate involving all drivers aged 16 to 90 years old decrease after the implementation of GDL program. For example, columns (2) (5) and (7) in Table 4 report that without the interaction term, the estimated coefficient of GDL program is negative and statistically significant at the 10 percent level for fatality-injury rate, injury rate and the minor injury rate involving all drivers. This result is consistent with Shope and Molnar (2004) who find that fatalities-injuries decrease after the introduction of graduated driver licensing programs in Michigan.

By introducing the interaction term, Table 4 indicates that all estimated coefficients of GDL program are negative and statistically significant at 5 percent level (columns (3), (6)) for the fatality-major injury rate and the major injury rate; and 10 percent level ((columns (1), (2), (5) and (7)) for the accident rate, the fatality-injury rate, the injury rate, and the minor injury rate involving all drivers.

Table 4 also reports the joint hypothesis that the coefficients of the GDL program and the interaction term are both zero is rejected for the fatality-injury rate, the injury rate, and minor injury rate. This result suggests that when GDL program is already in place and BAC law is introduced, the fatality-injury rate, the injury rate and the minor injury rate involving all drivers decrease. Indeed, the sign of the partial effect of GDL program on these rates is negative. By omitting the interaction term, results obtained reveal that the GDL program has led to a decrease in accident rate, fatality-injury rate, fatality-major injury rate, major injury rate and minor injury rate involving all drivers. However, when both laws are in effect, one almost cancels the effect of the other as indicated in columns (3) and (6) of Table 4.

In short, it is important to keep in mind that, considering the entire population, I note that the interaction term reduces the expected effect of each of the laws on accident rates, which is reflected mainly in a decrease in their expected effect on the number of accidents, the fatalities-major injuries rate and the major injuries rate involving all drivers. In the next subsection, dividing the driver population into groups of novice and experienced drivers, Tables 9 to 11 allow to observe that the effect of the interaction term varies not only according to injury severity but also the age group of drivers.

[19] The partial effect of BAC (GDL) law is given by the sum of coefficients α or β and δ.

iii) ***Partial effect of the BAC law on accident rates involving novice and experienced drivers***

Columns (1-2) of Tables 9 to 11 indicate that the implementation of the BAC law does not prevent the number of accidents, the fatalities-major injury and the major injury rates involving novice and experienced drivers from rising when the GDL program is not in force. However, column (1) of Tables 9 to 11 reports that without the interaction term, the estimated coefficients of BAC law on fatality-injury rate, injury rate and minor injury rate involving novice drivers are negative and statistically significant at 10 percent level indicating that these rates decrease after the implementation of BAC law. For example, column 1 of Table 9 reveals that BAC law reduces the fatalities-injuries rate involving novice drivers per month and per municipality with 10,000 inhabitants by 1.25.

Moreover, I do not reject for 10 percent the joint hypothesis that the coefficients of BAC law and the interaction term are both zero for the fatality-injury rate, the injury rate and the minor injury rate involving experienced drivers. Therefore, BAC law and GDL program are not jointly significant to reduce these rates involving experienced drivers as indicated column (4) of Tables 9 and 11. However, for novice drivers, the joint hypothesis is rejected for the fatality-injury rate, the injury rate and the minor injury rate involving them as reported in column (4) of Tables 9 and 11. This result stats that the BAC law and GDL program are jointly significant. They affect the fatality-injury rate, the injury rate and the minor injury rate involving novice drivers. The sign of the partial effect of BAC law on these rates is negative indicating that the implementation of BAC law and GDL program leads to a decline in the fatality-injury rate, injury rate and minor injury rate involving young drivers. Finally, the joint implementation of BAC law and GDL program does not prevent the fatality rate involving experienced drivers aged 25 to 90 years old from rising.

iv) ***Partial effect of GDL program on accident rates involving novice and experienced drivers***

Tables 9 to 11 show that without the interaction term, the accident number, the fatality-injury, the fatality-major injury, the injury, the major injury and the minor injury rates involving novice and experienced drivers decrease after the implementation of GDL program as all drivers aged 16 to 90 years old. It is important to note that here the estimated coefficient of the GDL law is negative and significant at the 5 or 10 percent level for fatalities rates involving subgroups of novice and experienced drivers, whereas this was not the case for all drivers (see Table 4). Most importantly, by introducing the interaction term, the estimated coefficients of GDL program are negative and statistically significant at 5 (10) percent level for the fatality rate (columns (3-4), Table 10) involving experienced (young) drivers.

Tables 9 and 11 also report the joint hypothesis that the coefficients of the GDL program and the interaction term are both zero. In short, it is important to point out here that, considering the entire population, the interaction term reduces the expected effect of each of the law on accident rates, which is reflected mainly in a decrease in their expected effect on the number of accidents, the fatalities-major injuries rate and the major injuries rate involving all drivers. A very significant effect can also be seen in reducing the expected impact of each of the laws on the number of accidents, the fatalities-major injuries rate and the major injuries rate involving novice and experienced drivers; the fatalities rate involving only experienced drivers. It thus appears that the partial effect of GDL law can be explained by a small drop in the fatalities-major injuries rate and the major injuries rate involving novice drivers; the fatalities rate involving experienced drivers. However, there is a small increase in the number of accidents involving both groups of drivers.

6.2.2 BAC and GDL effect on accident rates involving all sub-groups of novice and experienced drivers

To have a better understanding of the previous results, I have broken *novice drivers* and *experienced drivers* into different sub-categories. The novices are divided into two age groups (drivers aged 16 to 19 years old and drivers aged 20 to 24 years old) and the experienced drivers in five age groups: experienced drivers aged 25 to 34 years old, 35 to 44 years old, 45 to 54 years old, 55 to 64 years old and 65 to 90 years old. Tables 12 to 14 report the results for the impact of BAC laws, GDL program and their interaction term on accident rates involving all sub groups of novice and experienced drivers.

i) ***Partial effect of the BAC law on accident rates involving all sub-groups of novice drivers (16-19 and 20-24 years old)***

Tables 12 to 14 report the effect of changes in the BAC law on accident rates for the population split into sub groups of novice drivers. Column 1 in Tables 12 to 14 show that without the interaction term, the fatality-injury rate, the injury rate and the minor injury rate involving novice drivers aged 16 to 19 years old decrease after the implementation of BAC law while column (2) reports that only the minor injury rate involving novice drivers aged 20 to 24 years old decrease.

Results indicate that the accident rates increase despite the implementation of BAC law without the GDL program being in force. When the interaction term is included as an additional control variable, the estimated coefficients of BAC law have no significant effect on the accident rates involving the novice drivers. These results confirm my previous conclusion that the estimation of the effect of the BAC law on accident rates is imprecise when the interaction term is introducing into the estimates.

Results suggest that when BAC law is already in place and the GDL program is introduced, the accident number rate, the fatality-major injury rate and the major injury rate (only for novice aged 20 to 24 years) involving the novice drivers increase. These results may be related to the estimated and imprecise effects of BAC law on accident rates when both laws are in force, as mentioned above. Finally, I find that BAC law, when GDL law is not in force, reduces the fatality rate involving novice drivers aged 16 to 19 years old (column 8, Table 13). However, when the BAC law is implemented and GDL program is introduced, the effects of the two laws disappear.

ii) ***Partial effect of GDL program on accident rates involving all sub-groups of novice drivers (16-19 and 20-24 years old)***

Columns (1) and (2) in Tables 12 to 14 report that without the interaction term, the estimated effect of GDL program decreases all accident rates involving novice drivers aged 16 to 19 years old. In addition, the accident-number rate, the fatality-injury rate, the injury rate and the minor injury rate involving novice drivers aged 20 to 24 years old decrease after the implementation. Furthermore, all estimated coefficients of GDL program are negative and statistically significant for the accident rates involving novice drivers after adding the interaction term (columns (8) and (9), Tables 12-14).

Importantly, results reveal that the introduction of the GDL program when BAC is not present, reduces the accident rates, particularly the fatality rate involving young drivers aged between 16 and 19 years old. My findings are consistent with the conclusions of Rios et al. (2006), Margolis et al. (2007), Fohr et al. (2005), Rice et al. (2004), Males (2006) who find that the GDL program reduced the fatality rate involving young drivers aged between 16 and 19 years old.

iii) ***Partial effect of BAC law on accident rates involving sub-groups of experienced drivers (25-34 and 35-44 years old)***

The estimated coefficients of BAC law, when GDL program is not in force are negative and statistically significant for the fatality-injury rate, the injury rate and the minor injury rate involving experienced drivers aged 35 to 44 years old at 10 percent. Similarly, when the interaction term is excluded from the estimation, only the minor injury rate involving experienced drivers aged 25 to 34 years old decreases after the implementation of BAC law (columns (3) and (4), Tables 14). By including the interaction term, I find that the estimated coefficients of BAC law on accident rates involving experienced drivers aged 25 to 34 years old and 35 to 44 years old are negative but are not statistically significant.

The results reveal that when BAC law is already in place and the GDL program is introduced, the fatality-injury rate, the injury rate and the minor injury rate involving experienced drivers aged 25 to 34 years old and 35 to 44 years old, decrease. However, the sign of the partial effect is positive for the accident number rate, the fatality-major injury rate and the major injury rate involving experienced drivers 25 to 34 years old and 35 to 44 years old indicating that the joint implementation of the two laws does not prevent these rates from rising.

iv) ***Partial effect of GDL program on accident rates involving sub-groups of experienced drivers (25-34 and 35-44 years old)***

Column (3) of Tables 12 to 14 reports that without the interaction term, only the accident number rate and minor injury rate involving experienced drivers aged 25 to 34 years old decrease after the implementation of GDL program. However, columns (4) of the same Tables show that all accident rates involving experienced drivers aged 35 to 44 years old are negatively linked to the implementation of GDL program.

When I include the interaction term, columns (10) and (11) of Table 12 show that GDL program decrease all accident rates but the estimated coefficient of GDL program is only statistically significant at 5 percent level for the accident number rate involving experienced drivers aged 25 to 34 years old and 35 to 44 years old.

These results suggest that the effect of GDL program on the fatality-injury rate, the injury rate and the minor injury rate involving experienced drivers aged 25 to 34 years and 35 to 44 years decreases when the two laws are jointly implemented. In addition, the fatality-major injury rate and major injury rate involving only experienced drivers 35 to 44 years increase. Finally, BAC (GDL) law has no effect on fatalities rate involving experienced drivers aged 25 to 34 years old and 35 to 44 years old when GDL (BAC) is in force or not.

v) ***Partial effect of the BAC law on accident rates involving sub-groups of experienced drivers (45-54, 55-64, and 65-90 years old)***

I finally look at the impact of the BAC law on accident rates involving drivers aged 45 to 54, 55 to 64 and 65 to 90 years old. Tables 12 to 14 report the results of the impact of the BAC law on accident rates with or without the implementation of new program such as GDL program. Results suggest that the BAC law does really affect the accident-number rate involving the three age groups by reducing the accident-number rate when the GDL program is introduced.

I also look at the impact of the BAC law on other accident rates such as fatality-injury, fatality-major injury, fatality, injury, major injury and minor injury involving aged drivers 45 to 54, 55 to 64 and 65-90 years old when GDL program is present or not. Tables 12 to 14 also show that when the GDL program is in effect, the BAC law has no effect on minor injury rate for age groups 45 to 54 and 65 to 90 years old. It does not prevent the fatality-injury rate, the fatality-major injury rate, the injury rate for age groups 55 to 64 and 65 to 90 years old, the major injury rate involving the three groups, the fatality rate involving drivers age groups 45 to 54 and 64-90 years old rate from rising. This result could be due to the unspecified effect of the BAC law on certain rates mentioned above when GDL program is in effect.

vi) ***Partial effect of GDL program on accident rates involving sub-groups of experienced drivers (45-54, 55-64, and 65-90 years old)***

Here I look at the impact of GDL program on accident rates for the last three age groups (45-54, 55-64, and 65-90 years old). Tables 12 indicates that an implementation of the BAC law to reduce the accident number rate nullifies the effect of GDL program for all the three age groups. Tables 12 to 14 report results regarding the effect of GDL program on other rates such as fatality-injury, fatality-major injury, fatality, injury, major injury and minor injury when the BAC law is introduced to reduce them. I find that when the GDL program is in effect, the fatality-injury rate, the injury rate and the minor injury rate involving the three age groups decrease. However, the effect of GDL program on fatality-major injury rate and major injury rate is nullified after the implementation of the BAC law. This result gives a signal to lawmakers that GDL program, when the BAC law is not in effect, is very important. Indeed, it gives experience to young drivers who will drive more carefully to avoid accidents with high rate of fatality-injury, major injury and minor injury even if it does not affect the accident number rate, fatality-major injury rate and major injury rate.

6.3 Robustness Checks

In this subsection, I consider two robustness checks by examining two different ways of constructing the accident rates. I mainly investigate how the implementation or changes of BAC and GDL laws both independently and jointly influence the rate of traffic accidents for all drivers firstly at the provincial level with population restriction, and secondly at a provincial level without any restriction on the population. The results are reported in Tables 5 and 6. The results in Table 4 are robust to important variations in data: the estimate of accident rates at the provincial level (with or without restriction on the population) whose results are reported in Tables 5 and 6. Results of Tables 5 and 6 report that the effects of BAC (GDL) laws are more precise coefficients relative to OLS.

6.3.1 BAC, GDL laws effects on accident rates involving all drivers 16-90 years old at the provincial level without population restriction

Table 5 reports the results of the BAC, GDL laws effects on accident rates using the sample of observations at the provincial level without population restriction. The results in Table 5 suggest that when BAC (GDL) law is in force whereas GDL (BAC) is not present, the results in Table 4 are robust to different samples. It is important to mention that all the coefficients in Table 5 are significant and almost superior (lower) to those obtained in Table 4 when BAC (GDL) is in place while GDL (BAC) is absent. Moreover, when the term interaction is introduced, I note that the results related to the effect of GDL on the accident number rate, fatalities and major injuries rate, the fatalities rate and major injuries rate are robust. These results suggest that GDL does not prevent the accident number rate, the fatalities-major injuries rate, the fatalities rate and the major injuries rate from increasing when BAC is also implemented.

Table 5: Effect of BAC law or GDL program on accident rates[a] involving all drivers without population restriction(16 to 90 years old)

		(1)	(2)	(3)	(4)	(5)	(6)	(7)
Variables		Accident number	Fatalities-Injuries	Fatalities-Major injuries	Fatalities	Injuries	Major injuries	Minor injuries
without interaction	BAC[b]	5.220***	-0.872***	0.141***	0.016***	-0.888***	0.125***	-1.013***
		(0.911)	(0.170)	(0.015)	(0.003)	(0.169)	(0.013)	(0.166)
	GDL[c]	-1.806***	-0.484***	-0.025**	-0.003	-0.481***	-0.022**	-0.458***
		(0.668)	(0.124)	(0.011)	(0.002)	(0.124)	(0.009)	(0.122)
with interaction	BAC	1.263	-0.058	0.118***	0.011***	-0.047	0.107***	-0.059
		(0.911)	(0.161)	(0.016)	(0.004)	(0.160)	(0.014)	(0.156)
	GDL x BAC	10.04***	-2.360***	0.058***	0.012***	-2.372***	0.045***	-2.418***
		(0.874)	(0.154)	(0.015)	(0.003)	(0.153)	(0.013)	(0.149)
	GDL	-3.847***	-0.845***	-0.0582***	-0.010***	-0.855***	-0.047***	-0.903***
		(0.791)	(0.140)	(0.014)	(0.003)	(0.139)	(0.012)	(0.135)
	F-Statistic and p-Values on Joint Hypothesis							
	Ho: $\alpha+\ \delta=0$							
	F-Statistics	128.67	47.66	11.37	76.17	48.54	92.24	60.31
		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
	Ho: $\beta+\delta=0$							
	F-Statistics	139.42	0.00	0.53	141.4	0.05	148.75	72.5
		(0.00)	(0.97)	(0.46)	(0.00)	(0.81)	(0.00)	(0.00)
	Observations	1,056	1,056	1,056	1,056	1,056	1,056	1,056
	Province FE	YES	YES	YES	YES	YES	YES	YES
	Year x Month FE	YES	YES	YES	YES	YES	YES	YES

Notes: This table reports the results of the effect of BAC law or GDL program on accident rates involving all drivers without population restriction(16 to 90 years old). All columns include BAC, GDL laws and their interaction term. Columns (1) to (7) use dependent variables such as accident number, fatalities and injuries, fatalities and major injuries, fatalities, injuries, major injuries and minor injuries rates. I controlled month, year and province fixed effect. Standard errors clustered at the at the municipality level are reported in parentheses under coefficients, and p-values are given in parentheses under F-statistics. Individual coefficients are statistically significant at the *** 1% or ** 5% or * 10% significance level.

[a] In columns (1) to (7), the ratio of the total number of each accident category and total population, is multiplied by 10,000; [b] Restricted Blood Alcohol Concentration law (BAC): BAC law level = 50 milligrams of alcohol in 100 millilitres of blood (50mg/100ml). It takes value one in the province p in month and year t where it is in force; otherwise, BAC law is equal to zero. [c] Graduated Driver Licensing (GDL); it is equal to one if the program already is in force in the province p in month and year t; if not, GDL program takes value zero.

6.3.2 BAC, GDL laws effects on accident rates involving all drivers 16-90 years at provincial level with population restriction

Table 6 reports the results of the BAC, GDL laws effects on accident rates using the sample of observations at provincial level with population restriction. The conclusions are the same as those obtained in Table 5 with the only difference that the effect of GDL when BAC also is in effect is relatively lower almost on all rates. Regarding the effect of BAC when GDL is also in effect, the results in Tables 5 and 6 confirm the imprecision of the effect of BAC obtained in Table 4 when both laws are in force.

Table 6: Effect of BAC law or GDL program on all accident rates[a] involving all drivers with population restriction(16 to 90 years old)

		(1)	(2)	(3)	(4)	(5)	(6)	(7)
Variables		Accident number	Fatalities-Injuries	Fatalities-Major injuries	Fatalities	Injuries	Major injuries	Minor injuries
without interaction	BAC[b]	3.525***	-0.485***	0.186***	0.0146***	-0.500***	0.171***	-0.671***
		(0.557)	(0.142)	(0.00977)	(0.00200)	(0.141)	(0.00872)	(0.139)
	GDL[c]	-0.586	-0.463***	-0.000488	-0.000512	-0.463***	-0.00100	-0.464***
		(0.409)	(0.104)	(0.00717)	(0.00147)	(0.104)	(0.00640)	(0.102)
with interaction	BAC	1.068*	-0.361***	0.203***	0.0192***	-0.342***	0.184***	-0.159
		(0.556)	(0.131)	(0.0104)	(0.00212)	(0.131)	(0.00936)	(0.128)
	GDL x BAC	6.233***	-2.147***	0.0426***	0.0118***	-2.135***	0.0308***	-2.105***
		(0.533)	(0.126)	(0.0100)	(0.00203)	(0.125)	(0.00897)	(0.123)
	GDL	-2.924***	-0.746***	-0.0245***	-0.00614***	-0.740***	-0.0184**	-0.721***
		(0.482)	(0.114)	(0.00906)	(0.00184)	(0.113)	(0.00812)	(0.111)
	F-Statistic and p-Values on Joint Hypothesis							
	Ho: $\alpha+\ \delta=0$							
	F-Statistics	155.21	196.92	10.3	157.84	222.99	193.42	144.5
		(0.00)	(0.00)	(0.0014)	(0.00)	(0.00)	(0.00)	(0.00)
	Ho: $\beta+\delta=0$							
	F-Statistics	179.4	4.74	11.28	179.47	2.79	183.53	55.73
		(0.00)	(0.0297)	(0.0008)	(0.00)	(0.0952)	(0.00)	(0.00)
	Observations	1,056	1,056	1,056	1,056	1,056	1,056	1,056
	Province FE	YES	YES	YES	YES	YES	YES	YES
	Year x Month FE	YES	YES	YES	YES	YES	YES	YES

Notes: This table reports the results of the effect of BAC law or GDL program on all accident rates involving all drivers with population restriction(16 to 90 years old). All columns include BAC, GDL laws and their interaction term. Columns (1) to (7) use dependent variables such as accident number, fatalities and injuries, fatalities and major injuries, fatalities, injuries, major injuries and minor injuries rates. I controlled month, year and province fixed effect. Standard errors clustered at the at the municipality level are reported in parentheses under coefficients, and p-values are given in parentheses under F-statistics. Individual coefficients are statistically significant at the *** 1% or ** 5% or * 10% significance level.

[a] In columns (1) to (7), the ratio of the total number of each accident category and total population, is multiplied by 10,000; [b] Restricted Blood Alcohol Concentration law (BAC): BAC law level = 50 milligrams of alcohol in 100 millilitres of blood (50mg/100ml). It takes value one in the province p in month and year t where it is in force; otherwise, BAC law is equal to zero. [c] Graduated Driver Licensing (GDL); it is equal to one if the program already is in force in the province p in month and year t; if not, GDL program takes value zero.

7 Endogeneity Issues

One endogeneity issue faced by the ordinary least squares estimations is the potential reverse causality problem between laws and accident rates. Indeed, after observing an increase in the road-accident rate, a given province can react through the implementation or strengthening of law. For example, in Ontario, on December 10, 1981, when provincial BAC legislation was passed, the Honorable McMurtry, one of the members who supported its passage, stated:[20]

"*... I do not intend to discuss in great detail what must be an obvious fact to all members of the legislature, that is, the very tragic statistics we are aware of on a day-to-day basis about the carnage on our highways... Without doubt many of these tragedies are, as we all know, related to alcohol abuse on the highway... I would think any future civilization, looking back on ours and seeing the number of lives that were either lost or destroyed, the mutilation that occurs every day on the highway, will reflect with some degree of wonderment on why we demonstrated the relative degree of tolerance we do demonstrate to such a critical problem.*" (See also section C.1 and C.2 in Appendix C for more details on the arguments)

All of the preceding results suggest that the legislators' decision to implement or strengthen BAC law or GDL program to reduce the high level of accident rates involving young, new drivers and those caused by impaired drivers, is based on the previous evolution of these accident rates. This may justify the existence of the potential reverse causality problem in estimating the effect of BAC law and GDL program on accident rates.

7.1 IV Strategy

To address this endogeneity problem, two natural candidates as instrumental variables are identified: BAC law and the GDL program in neighboring provinces. The ideology of the ruling parties in each of the provinces of my study can also be used as a potential third candidate for the instrumental variable role.

I construct the two first of these variables based on the theory of contagion and of imitation of peers (see, e.g., Pritsker (2001), Leeson and Dean (2009), Acemoglu et al. (2015)). I argue that the implementation of BAC law and GDL program can be the result of imitation of the policies adopted by the neighboring provinces.[21] To do this, I assume that a given province, by observing the effectiveness of implementing of BAC law and GDL program to reduce accident rates in neighboring provinces, may be encouraged to emulate them.

7.1.1 Average BAC law and GDL program values in neighboring provinces

To construct the variable measuring the average BAC and GDL of neighboring provinces, I assume that a given province "p" has "n_p" neighbours. My hypothesis is that the probability a province p introduces a law based on the one set up by the province that is close to it, is higher than the probability that it imitates a non-neighboring province. In this context, the BAC law and the GDL program in the neighboring

[20] http://ontla.on.ca/web/house-proceedings/house_detail.do?locale=en&Date=1981-12-10&Parl=32&Sess=1&detailPage=/house-proceedings/transcripts/files_html/10-DEC-1981_L126.htm

[21] The geographical neighbors are not limited to the provinces included in the study. For example, Alberta has British Columbia and Saskatchewan as neighboring provinces; Ontario has Manitoba and Quebec as neighboring provinces.

The neighboring provinces of Alberta, Ontario, Quebec, and Saskatchewan are summarized in Table A.6 of Appendix A. Note, however, that I considered only the neighboring provinces and not the territories.

provinces are codified in the same way as the provinces that cover my study. The BAC law and the GDL program are two dichotomous variables that take the value of *one* if they are enforced in the same month and year t as in the neighboring provinces. Otherwise, the BAC law and the GDL program take the value *zero*. The neighboring provinces of Alberta, Ontario, Quebec and Saskatchewan are summarized in Table A.6 of *Appendix A*. Table A.7 in the *Appendix A* also reports the date of GDL and BAC implementations in neighboring provinces.

I include in the calculation of average BAC and GDL laws values, the role of the population in the voting process of a law in any representative democracy. Thus, the average of BAC and GDL laws is weighted by the population of each province j as shown equations 2 to 4. Indeed, in a representative democracy, the division of the territory (province, municipality) for electoral purposes is of great importance because it allows, in conjunction with the electoral system, to ensure the effective representation of the population and the transposition of the will of the people to the national assembly. The role of populations is exercised through the legislators who represent them. The values of BAC and GDL laws, and of their interaction term in neighboring provinces are obtained as follows:

$$BAC_{-pt} = \sum_{j=1}^{n_p} \frac{Pop_j \times BAC_{-pjt}}{\sum_{j=1}^{n_p} Pop_j} \tag{2}$$

$$GDL_{-pt} = \sum_{j=1}^{n_p} \frac{Pop_j \times GDL_{-pjt}}{\sum_{j=1}^{n_p} Pop_j} \tag{3}$$

$$BAC_{-pt} \times GDL_{-pt} = (\sum_{j=1}^{n_p} \frac{Pop_j \times BAC_{-pjt}}{\sum_{j=1}^{n_p} Pop_j}) \times (\sum_{j=1}^{n_p} \frac{Pop_j \times GDL_{-pjt}}{\sum_{j=1}^{n_p} Pop_j}) \tag{4}$$

where BAC_{-pt} and GDL_{-pt} are the average of BAC law and GDL program values in the month and year t in all neighboring provinces (-p); BAC_{-pjt} and GDL_{-pjt} are BAC and GDL laws values in the month and year t in jth neighboring province. Pop_j is the population of province j.

7.1.2 Ideology of the party in power in each province

This type of instrument is already used in the literature (see, e.g., Brochu and Green (2013), Green and Harrison (2010)). For example, Green and Harrison (2010) examines the establishment of minimum wages, explaining that they can be understood as reflecting the notion of voter equity. This study shows that the minimum wage is strongly and positively related to the unqualified median wage whether a left-wing government is in power. This conclusion leads Green and Harrison (2010) to assume that the average minimum wage in the other provinces is probably an endogenous variable. To overcome the problem of endogeneity between the average minimum wage and the left government in power, Green and Harrison (2010) argued that the ideological positions of the governments of other provinces can be used as instruments.

In general, the choice of this type of instrument is motivated by the fact that the ideological preferences of the party in power can influence certain political, economic and social decisions. These ideological preferences and the resulting decisions reflect, on the one hand, party norms and traditions, general political orientations and, on the other hand, the preferences and interests of voters in different constituencies (Swank (1988)). Thereby, the support provided by a political party to the vote of law in the assembly depends on the ideology to which it belongs. In the case where a law does not meet the fundamental principles of the party, then I should expect negative correlation between law and ideology.

To build this instrument, I replicated Brochu and Green (2013) and Green and Harrison (2010) approach. Green and Harrison (2010) identified 3 distinct groups of political party: left, right and center. As such, Brochu and Green (2013) had a dummy for left and for right. Table A.8 in the *Appendix A* reports the government party in power when BAC and GDL laws are implemented or changed in the four provinces. As such, I define a dichotomous variable that represents the party in power in each of the four provinces of study in a given year. This dummy takes the value one when the ideology of the political party is left and zero if the ideology of the political party is right. The corresponding equation I estimate is given by:

$$\begin{aligned} BAC_{tm} = \phi_1 BAC_{-pt} + \vartheta_1 GDL_{-pt} + \Lambda_1 BAC_{-pt} \times GDL_{-pt} \\ + \Omega_1 LEFTH_{tp} + \psi_t + \Gamma_m + \Theta_{tm} \end{aligned} \tag{5}$$

$$\begin{aligned} GDL_{tm} = \phi_2 BAC_{-pt} + \vartheta_2 GDL_{-pt} + \Lambda_2 BAC_{-pt} \times GDL_{-pt} \\ + \Omega_2 LEFTH_{tp} + \theta_t + \kappa_m + \xi_{tm} \end{aligned} \tag{6}$$

$$\begin{aligned} BAC_{tm} \times GDL_{tm} = \phi_3 BAC_{-pt} + \vartheta_3 GDL_{-pt} + \Lambda_3 BAC_{-pt} \times GDL_{-pt} \\ + \Omega_3 LEFTH_{tp} + \varsigma_t + \varpi_m + \varrho_{tm} \end{aligned} \tag{7}$$

As shown equations 5, 6 and 7, I treat BAC law, GDL program as endogenous variables. I instrument BAC_{tm}, GDL_{tm}, $BAC_{tm} \times GDL_{tm}$ using BAC_{-pt}, GDL_{-pt}, $BAC_{-pt} \times GDL_{-pt}$ and $LEFTH_{tp}$. My exclusion restriction is that, the BAC law (BAC_{-pt}), the GDL program (GDL_{-pt}) in the neighboring provinces and the ideology party ($LEFTH_{tp}$) in each province under this study have has no direct impact on accidents occurring in Alberta, Ontario, Quebec and Saskatchewan. However, BAC_{-pt} and GDL_{-pt} are the channels by which BAC_{tm}, GDL_{tm} laws can affect accident rates in these provinces. Also, the ideology of the party in power in the provinces under this study is the channel through which the interaction term between BAC_{tm}, GDL_{tm} laws in force can influence accident rates. Tables 7 and 8 report the IV results.

7.2 First-Stage and 2SLS Estimates

To gauge the validity of my instrumental variables, I use the first-stage regression results for each of the three endogenous terms presented in Table 7. This includes the F statistic from a joint significance test of the excluded instruments, the Sanderson-Windmeijer (SW) F statistic, the Kleibergen-Paap rk LM statistic and the Anderson-Rubin Wald test. Based on the univariate F-test of excluded instruments, I am able to reject the null hypothesis that the coefficients on the excluded instruments are jointly zero. Also, the SW multivariate F test indicates that my instruments are relevant. Additionally, the Anderson-Rubin Wald test lead to rejecting the null hypothesis that the coefficients of the endogenous regressors in the structural equation are jointly equal to zero and thereby confirms that my instruments are relevant. Furthermore, Table 7 reports that the Kleibergen-Paap rk LM statistic test fails to reject at the 5% level of confidence that the excluded instruments are not correlated with the endogenous regressors (i.e. the equation is under-identified). This suggests that even for over-identification with the order condition, the instruments may be inadequate to identify the equation. The results of the second stage reported in Table 8 indicate that GDL and BAC individually reduce all accident rates. Also, columns (1) to (7) report that the estimated coefficients of the interaction term between BAC, GDL laws are positive for all rates. However, the negative estimated coefficient of BAC law is only significant for the effect of this law on the major injury rate (column (6), Table 8). Similarly, columns (1), (3) and (6) of Table 8 indicate that the estimated coefficients of GDL program are negative and significant for the accident number rate, the fatality-major injury rate and major injury rate.

Comparing the results of the second stage of Table 8 with those of OLS in Table 4 when the interaction term is taken into account, I observe that the signs of the coefficients of the BAC, and GDL laws are the same in both tables. However, there is a difference in the significance of these coefficients. Indeed, while columns (1) to (7) in Table 8 indicate that none of the estimated coefficients of the BAC law is statistically significant, Table 8 reports that the coefficient of BAC law is negative and statistically significant at 10 per cent level for the major injury rate as indicated in column (6). Furthermore, while Table 4 tells us that GDL program reduce accident rates except for the fatality rate (column (4)), Table 8 reveals that the estimated coefficient of GDL program is negative but only significant for the accident number rate, the fatality-major injury, the major injury (columns (1),(3) and (6), Table 8). Finally, regarding the significance of the estimated coefficient of the interaction term in the two tables, they are the same. However, the magnitude of the estimated coefficients of BAC, GDL laws and their interaction term in Table 8 are at least four times higher than those reported in Table 4. Also, the signs of the partial effects coefficient of BAC law or GDL program are always positive; that is not necessarily the case in Table 4 where the sign of the coefficient of the partial effects is negative for fatality-injury rate, injury rate and minor injury rate.

Table 7: Validity of instruments: First stage regression results (all drivers)

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	BAC		GDLxBAC		GDL	
	Coef.	Std.Err.	Coef.	Std.Err.	Coef.	Std.Err.
BAC in neighboring provinces	-0.062	(0.043)	-0.093***	(0.035)	-0.065***	(0.017)
GDL in neighboring provinces	-0.067*	(0.036)	-0.021	(0.038)	0.146***	(0.056)
GDL x BAC in neighboring provinces	0.104*	(0.056)	0.114**	(0.051)	-0.004	(0.037)
Ideology of the political party	0.308***	(0.019)	0.024	(0.103)	-0.305***	(0.106)
Relevance test						
- Test on excluded instruments F:						
	85.27			2.61		143.30
	(0.000)			(0.037)		(0.000)
-SW multivariate F test of excluded instruments						5.07
	5.48			9.37		5.07
:	(0.064)			(0.009)		(0.079)
- Weak identification test						
Cragg-Donald Wald F statistic: 19.41						
Kleibergen-Paap rk Wald F statistic: 20.47						
		Stock-Yogo weak	ID test	critical values		
			5%	maximal IV	relative bias	16.85
			10%	maximal IV	relative bias	10.27
			10%	maximal IV	relative bias	10.27
			20%	maximal IV	relative bias	6.71
			30%	maximal IV	relative bias	5.34
			10%	maximal IV	size	24.58
			15%	maximal IV	size	13.96
			20%	maximal IV	size	10.26
			25%	maximal IV	size	8.31
- Weak-instrument-robust inference						
Anderson-Rubin Wald test F(4,193)= 4.87 P-val=0.0009						
Anderson-Rubin Wald test Chi-sq(4)= 19.77 P-val=0.0006						
Exogeneity test						
Underidentification test						
Kleibergen-Paap rk LM statistic: Chi-sq(2)=13.40 P-val= 0.0640						

Notes: This table reports the first stage regression results. Here, I instrument BAC_{tm}, GDL_{tm}, $BAC_{tm} \times GDL_{tm}$ using BAC_{-pt}, GDL_{-pt}, $BAC_{-pt} \times GDL_{-pt}$ and $LEFTH_{tp}$. Standard errors clustered at the municipality level are reported in parentheses under coefficients, and p-values are given in parentheses under F-statistics. Individual coefficients are statistically significant at the *** 1% or ** 5% or * 10% significance level. The Sanderson-Windmeijer (SW) chi-squared and F statistics test the null hypotheses of under-identification and weak instruments for each endogenous variable separately. The null hypothesis of the Kleibergen-Paap LM test is that the structural equation is under-identified. The Kleibergen-Paap Wald statistics for the weak instruments tests the null hypothesis that instruments are jointly weak.

Table 8: Second stage regression results (all drivers)

		(1)	(2)	(3)	(4)	(5)	(6)	(7)
Variables		Accident number	Fatalities & injuries	Fatalities-Major injuries	Fatalities	Injuries	Major injuries	Minor injuries
without	BAC	0.00991	-7.850	-0.000983	0.000965	-7.851	-0.00195	-7.849
interaction		(4.709)	(5.326)	(0.135)	(0.0303)	(5.311)	(0.118)	(5.219)
	GDL	-0.855	-6.473**	-0.0620	-0.00330	-6.469**	-0.0587	-6.411**
		(2.842)	(2.566)	(0.101)	(0.0225)	(2.553)	(0.0933)	(2.496)
with	BAC	-15.85	-14.09	-0.686	-0.0305	-14.06	-0.655*	-13.40
interaction		(12.28)	(13.48)	(0.431)	(0.0725)	(13.42)	(0.381)	(13.19)
	GDL x BAC	31.32**	12.32	1.352**	0.0621	12.25	1.290**	10.96
		(14.49)	(16.92)	(0.619)	(0.111)	(16.85)	(0.555)	(16.52)
	GDL	-14.01**	-11.65	-0.630*	-0.0294	-11.62	-0.601**	-11.02
		(7.034)	(9.294)	(0.322)	(0.0548)	(9.258)	(0.286)	(9.069)
	Observations	51,216	51,216	51,216	51,216	51,216	51,216	51,216
	Municipality FE	YES	YES	YES	YES	YES	YES	YES
	Year x Month FE	YES	YES	YES	YES	YES	YES	YES

Notes: This table reports the results of the second stage estimation of the effect of BAC law or GDL program on accident rates involving all drivers. All columns include BAC, GDL laws and their interaction term. Columns (1) to (7) use dependent variables such as accident number, fatalities and injuries, fatalities and major injuries, fatalities, injuries, major injuries and minor injuries rates. I controlled month, year and municipality fixed effect. Standard errors clustered at the at the municipality level are reported in parentheses under coefficients, and p-values are given in parentheses under F-statistics. Individual coefficients are statistically significant at the *** 1% or ** 5% or * 10% significance level.

The results of the second stage reported in Table 8 indicate that BAC reduces the fatality-injury rate, the fatality-major injury rate, the injury rate, the major injury rate and the minor injury rate when GDL is not in force. Moreover, columns (1) and (4) reveal that BAC law does not prevent the accident number rate and the fatality rate from rising. Finally, columns (1) to (7) show that the GDL program reduces all accident rates when BAC law is not in force. To conclude on this point, except for BAC law effect on the fatality-major injury rate and the major injury rate all previous results are consistent with those obtained in Table 4 (OLS results) even if the effect of each law on these rates is not significant.

Table 8 also indicate that BAC (GDL) and GDL (BAC) reduce all accident rates when GDL (BAC) is in force. Columns (1) to (7) report that the estimated coefficients of the interaction term between BAC, GDL laws are positive for all rates. However, the estimated and negative coefficient of BAC law is only significant for the effect of this law on the major injury rate (column (6), Table 8). Similarly, columns (1), (3) and (6) of Table 8 indicate that the estimated coefficients of GDL program are negative and significant for the accident number rate, the fatality-major injury rate and major injury rate.

Comparing the results of the second stage of Table 8 with those of OLS in Table 4 when the interaction term is taken into account, I observe that the signs of the coefficients of the BAC, and GDL laws are the same in both tables. However, there is a difference in the significance of these coefficients. Indeed, while columns (1) to (7) in Table 4 indicate that none of the estimated coefficients of the BAC law is statistically significant, Table 8 reports that the coefficient of BAC law is negative and statistically significant at 10 per cent level for the major injury rate as indicated in column (6). Furthermore, while Table 4 tells us that GDL program reduce accident rates except for the fatality rate (column (4)), Table 8 reveals that the estimated coefficient of GDL program is negative but only significant for the accident number rate, the fatality-major injury, the major injury (columns (1),(3) and (6), Table 8). Finally, regarding the significance of the estimated coefficient of the interaction term in the two tables, they are the same. However, the magnitude of the estimated coefficients of BAC, GDL laws and their interaction term in Table 8 is at least four times higher than those reported in Table 4. Also, the signs of the partial effects coefficient of BAC law or GDL program are always positive; that is not necessarily the case in Table 4 where the sign of the coefficient of the partial effects is negative for fatality-injury rate, injury rate and minor injury rate.

8 Conclusion

This study used the linear fixed-effect model to analyse the effects of BAC and GDL laws on road accident rates taking into consideration the potential problem of endogeneity between these laws and accident rates. It appeared from the analysis that lowering the BAC level to 50 mg/100ml reduces the fatality and injury rate, the injury rate and the minor injury rate involving experienced drivers. I also found that BAC law reduces fatality rate involving novice drivers (16 to 19 years old). However, when the BAC law is being implemented, and the GDL program is introduced, the effect of the two laws vanishes. BAC law does not prevent accident number rate, fatality and major injury rate and major injury rate involving all novice drivers and experienced drivers from rising even when GDL program is introduced. However, the joint implementation of BAC and GDL laws leads to a decline in the fatality and injury rate, injury rate and minor injury rate among novice drivers (16 to 19, and 20 to 24 years old). As for the GDL program when BAC is not in force, it reduces accident number involving novice drivers and experienced drivers (25 to 90 years); the fatality and major injury rate, the fatality rate and major injury rate involving novice drivers aged 16 to 19 years old. Furthermore, I observed that when GDL program is in place and the BAC law is introduced, the fatality and injury rate, the injury rate and the minor injury rate involving all novice drivers and experienced drivers (25 to 34 years, 45 to 54, 55 to 64 and 65 to 90 years old) decrease. Based on the results, this study showed that the effectiveness of the BAC and GDL road regulation policies depends on their interaction term effect, the severity of the injury at an accident, and the age of drivers. Therefore, the findings of this paper are highly relevant to policy-makers in the establishment and implementation of laws and programs aiming at reducing accident rates and promoting road safety.

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Table 9: Effect of BAC law or GDL program on accident number rate[a], fatalities and injuries rate involving novice and experienced drivers

		(1)	(2)	(3)	(4)
Age group		16-24	25-90	16-24	25-90
Variables		without	interaction	with	interaction
Accident number rate	BAC[b]	3.214***	2.776***	-1.566	-1.189
		(0.924)	(0.857)	(1.219)	(2.028)
	GDL x BAC			2.426*	4.955**
				(1.243)	(1.972)
	GDL[c]	-2.854***	-2.322*	-1.394**	-4.074**
		(1.035)	(1.266)	(0.696)	(1.758)
	F-Statistic and p-Values on Joint Hypothesis				
	Ho: $\alpha+\beta+\delta=0$				
	F-Statistics			2.12	0.03
				(0.15)	(0.87)
	Ho: $\alpha+\delta=0$				
	F-Statistics			28.77	34.79
				(0.00)	(0.00)
	Ho: $\beta+\delta=0$				
	F-Statistics			1.39	2.3
				(0.239)	(0.131)
	Weighted average in 1992	32.91	26.08	32.91	26.08
Fatalities & injuries rate	BAC	-1.252*	-0.487	0.029	-1.853
		(0.716)	(0.808)	(2.216)	(3.031)
	GDL x BAC			-1.616	1.707
				(2.194)	(2.899)
	GDL	-3.939***	-4.083**	-3.349**	-4.686*
		(1.339)	(1.779)	(1.666)	(2.722)
	F-Statistic and p-Values on Joint Hypothesis				
	Ho: $\alpha+\beta+\delta=0$				
	F-Statistics			6.92	2.77
				(0.011)	(0.090)
	Ho: $\alpha+\delta=0$				
	F-Statistics			7.16	0.13
				(0.000)	(0.721)
	Ho: $\beta+\delta=0$				
	F-Statistics			7.88	10.81
				(0.00)	(0.00)
	Weighted average in 1992	28.90	25.66	28.90	25.66
	Observations	51,216	51,216	51,216	51,216
	Municipality FE	YES	YES	YES	YES
	Year x Month FE	YES	YES	YES	YES

Notes: This table reports the results of the effect of BAC law or GDL program on accident number rate, fatalities and injuries rate involving novice and experienced drivers. Columns (1-2) include BAC, GDL laws and columns (3-4) also their interaction term. Columns 1 to 4 use dependent variables such as accident number, fatalities and injuries, fatalities and major injuries, fatalities, injuries, major injuries and minor injuries rates. I controlled month, year and municipality fixed effect. Standard errors clustered at the at the municipality level are reported in parentheses under coefficients, and p-values are given in parentheses under F-statistics. Individual coefficients are statistically significant at the *** 1% or ** 5% or * 10% significance level.

[a] In column 1 to 4, the ratio of the total number of each accident category and total population, is multiplied by 10,000; [b] Restricted Blood Alcohol Concentration law (BAC): BAC law level = 50 milligrams of alcohol in 100 millilitres of blood (50mg/100ml). It takes value one in the municipality m in the month and year t where it is in force; otherwise, BAC law is equal to zero. [c] Graduated Driver Licensing (GDL); it is equal to one if the program already is in force in the municipality m in the month and year t; if not, GDL program takes value zero.

Table 10: Effect of BAC law or GDL program on fatalities and major injuries rate, fatalities rate[a] involving novice (16-24 years old and experienced drivers (25-90 years old)

		(1)	(2)	(3)	(4)
Age group		16-24	25-90	16-24	25-90
Variables		without	interaction	with	Interaction
Fatalities-Major injuries rate	BAC[b]	0.216***	0.146***	0.031	-0.010
		(0.045)	(0.037)	(0.103)	(0.112)
	GDL x BAC			0.233***	0.195*
				(0.089)	(0.107)
	GDL[c]	-0.158**	-0.124*	-0.243***	-0.193*
		(0.073)	(0.071)	(0.088)	(0.099)
	F-Statistic and p-Values on Joint Hypothesis				
	Ho: $\alpha+\beta+\delta=0$				
	F-Statistics			0.04	0.01
				(0.84)	(0.94)
	Ho: $\alpha+\delta=0$				
	F-Statistics			32.04	26.75
				(0.00)	(0.00)
	Ho: $\beta+\delta=0$				
	F-Statistics			0.05	0.00
				(0.821)	(0.952)
	Weighted average in 1992	1.87	1.49	1.87	1.49
Fatalities rate	BAC	0.002	0.009**	-0.018	-0.012
		(0.006)	(0.004)	(0.016)	(0.014)
	GDL x BAC			0.026	0.027**
				(0.016)	(0.014)
	GDL	-0.019*	-0.020**	-0.029*	-0.030**
		(0.012)	(0.009)	(0.015)	(0.013)
	F-Statistic and p-Values on Joint Hypothesis				
	Ho: $\alpha+\beta+\delta=0$				
	F-Statistics			1.76	1.17
				(0.19)	(0.28)
	Ho: $\alpha+\delta=0$				
	F-Statistics			1.44	24.43
				(0.231)	(0.00)
	Ho: $\beta+\delta=0$				
	F-Statistics			0.12	0.70
				(0.721)	(0.405)
	Weighted average in 1992	0.34	0.29	0.34	0.29
	Observations	51,216	51,216	51,216	51,216
	Municipality FE	YES	YES	YES	YES
	Year x Month FE	YES	YES	YES	YES

Notes: This table reports the results of the effect of BAC law or GDL program on fatalities and major injuries rate, fatalities rate involving novice (16-24 years old and experienced drivers (25-90 years old). Columns (1-2) include BAC, GDL laws and columns (3-4) also their interaction term. Columns 1 to 4 use dependent variables such as accident number, fatalities and injuries, fatalities and major injuries, fatalities, injuries, major injuries and minor injuries rates. I controlled month, year and municipality fixed effect. Standard errors clustered at the at the municipality level are reported in parentheses under coefficients, and *p*-values are given in parentheses under F-statistics. Individual coefficients are statistically significant at the *** 1% or ** 5% or * 10% significance level.
[a] In column 1 to 4, the ratio of the total number of each accident category and total population, is multiplied by 10,000; [b] Restricted Blood Alcohol Concentration law (BAC): BAC law level = 50 milligrams of alcohol in 100 millilitres of blood (50mg/100ml). It takes value one in the municipality m in the month and year t where it is in force; otherwise, BAC law is equal to zero. [c] Graduated Driver Licensing (GDL); it is equal to one if the program already is in force in the municipality m in the month and year t; if not, GDL program takes value zero.

Table 11: Effect of BAC law or GDL program on injuries rate[a], major injuries rate, minor injuries rate involving novice (16-24 years old and experienced drivers (25-90 years old)

		(1)	(2)	(3)	(4)
Age group		16-24	25-90	16-24	25-90
Variables		without	interaction	with	interaction
Injuries rate	BAC[b]	-1.254*	-0.497	0.0468	-1.841
		(0.713)	(0.805)	(2.207)	(3.018)
	GDL x BAC			-1.641	1.679
				(2.187)	(2.886)
	GDL[c]	-3.919***	-4.063**	-3.319**	-4.656*
		(1.339)	(1.772)	(1.660)	(2.710)
	F-Statistic and p-Values on Joint Hypothesis				
	Ho: $\alpha+\beta+\delta=0$				
	F-Statistics			6.90	2.78
				(0.011)	(0.101)
	Ho: $\alpha+\delta=0$				
	F-Statistics			7.25	0.16
				(0.00)	(0.694)
	Ho: $\beta+\delta=0$				
	F-Statistics			7.85	10.77
				(0.00)	(0.00)
	Weighted average in 1992	28.56	25.37	28.56	25.37
Major injuries rate	BAC	0.213***	0.136***	0.049	0.002
		(0.043)	(0.034)	(0.094)	(0.099)
	GDL x BAC			0.207**	0.167*
				(0.082)	(0.095)
	GDL	-0.138**	-0.103	-0.214***	-0.162*
		(0.066)	(0.063)	(0.080)	(0.09)
	F-Statistic and p-Values on Joint Hypothesis				
	Ho: $\alpha+\beta+\delta=0$				
	F-Statistics			0.21	0.01
				(0.651)	(0.945)
	Ho: $\alpha+\delta=0$				
	F-Statistics			0.02	25.32
				(0.882)	(0.00)
	Ho: $\beta+\delta=0$				
	F-Statistics			32.41	0.02
				(0.00)	(0.90)
	Weighted average in 1992	1.53	1.20	1.53	1.20
Minor injuries rate	BAC	-1.468**	-0.633	-0.00236	-1.843
		(0.688)	(0.783)	(2.169)	(2.937)
	GDL x BAC			-1.849	1.512
				(2.160)	(2.808)
	GDL	-3.781***	-3.959**	-3.106*	-4.494*
		(1.341)	(1.728)	(1.630)	(2.633)
	F-Statistic and p-Values on Joint Hypothesis				
	Ho: $\alpha+\beta+\delta=0$				
	F-Statistics			7.32	2.94
				(0.010)	(0.090)
	Ho: $\alpha+\delta=0$				
	F-Statistics			10.43	0.71
				(0.00)	(0.40)
	Ho: $\beta+\delta=0$				
	F-Statistics			7.63	10.22
				(0.00)	(0.00)
	Weighted average in 1992	24.17	27.03	24.17	27.03
	Observations	51,216	51,216	51,216	51,216
	Municipality FE	YES	YES	YES	YES
	Year x Month FE	YES	YES	YES	YES

Notes: This table reports the results of the effect of BAC law or GDL program on injuries rate, major injuries rate, minor injuries rate involving novice (16-24 years old and experienced drivers (25-90 years old). Columns (1-2) include BAC, GDL laws and columns (3-4) also their interaction term. Columns 1 to 4 use dependent variables such as accident number, fatalities and injuries, fatalities and major injuries, fatalities, injuries, major injuries and minor injuries rates. I controlled month, year and municipality fixed effect. Standard errors clustered at the at the municipality level are reported in parentheses under coefficients, and *p*-values are given in parentheses under F-statistics. Individual coefficients are statistically significant at the *** 1% or ** 5% or * 10% significance level.
[a] In column 1 to 4, the ratio of the total number of each accident category and total population, is multiplied by 10,000; [b] Restricted Blood Alcohol Concentration law (BAC): BAC law level = 50 milligrams of alcohol in 100 millilitres of blood (50mg/100ml). It takes value one in the municipality m in the month and year t where it is in force; otherwise, BAC law is equal to zero. [c] Graduated Driver Licensing (GDL); it is equal to one if the program already is in force in the municipality m in the month and year t; if not, GDL program takes value zero.

Table 12: Effect of GDL or BAC law on accident number rate[a], fatalities and injuries rate involving sub groups of novice and experienced drivers

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Age group		16-19	20-24	25-34	35-44	45-54	55-64	65-90	16-19	20-24	25-34	35-44	45-54	55-64	65-90
Variables			without	interaction								with	interaction		
Accident number rate	BAC[b]	3.212***	5.281***	3.174***	2.848**	3.237***	2.988***	1.897***	-0.966	-0.182	-0.165	-2.369	-2.260	-2.290	0.212
		(0.813)	(0.968)	(1.558)	(0.906)	(1.233)	(1.102)	(0.939)	(0.408)	(1.821)	(1.980)	(2.791)	(2.665)	(2.165)	(0.577)
	GDL x BAC								5.208***	5.473**	4.160**	6.498**	6.900***	6.604***	2.076***
									(1.992)	(2.147)	(1.868)	(2.685)	(2.585)	(2.486)	(0.606)
	GDL[c]	-3.209***	-3.290**	-1.840*	-3.215**	-3.408*	-2.750*	-1.333***	-5.086***	-3.663***	-3.295**	-5.526**	-5.868**	-5.160**	-2.052***
		(1.152)	(1.400)	(1.099)	(1.569)	(1.737)	(1.588)	(0.432)	(1.559)	(1.339)	(1.516)	(2.201)	(2.385)	(2.187)	(0.416)
	F-Statistic and p-Values on Joint Hypothesis														
	Ho: $\alpha+\beta+\delta=0$														
	F-Statistics								0.28	0.41	0.18	0.34	0.26	0.26	0.37
									(0.599)	(0.520)	(0.669)	(0.559)	(0.613)	(0.613)	(0.541)
	Ho: $\alpha+\delta=0$														
	F-Statistics								23.71	19.84	27.87	15.16	35.39	53.23	39.93
									(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
	Ho: $\beta+\delta=0$														
	F-Statistics								0.02	0.72	1.22	0.87	2.32	2.35	0
									(0.890)	(0.398)	(0.270)	(0.352)	(0.129)	(0.127)	(0.963)
	Weighted average in 1992	29.40	35.59	27.83	18.24	11.49	10.49	7.17	29.40	35.59	27.83	18.24	11.49	10.49	7.17
Fatalities-Injuries rate	BAC	-3.222*	-1.762	-1.840	-3.418*	-0.772	0.143	0.420	-4.833	0.0287	-1.411	-6.401	-5.382	-5.206	-0.816
		(1.636)	(1.221)	(1.146)	(2.026)	(1.448)	(1.059)	(0.374)	(4.484)	(2.216)	(3.910)	(6.520)	(5.688)	(4.634)	(0.714)
	GDL x BAC								2.008	-1.616	-0.534	3.715	5.787	6.692	1.523*
									(3.787)	(2.194)	(3.729)	(5.737)	(5.623)	(4.866)	(0.808)
	GDL	-6.352***	-5.970***	-3.498	-6.138*	-7.969**	-7.881**	-3.197***	-7.076**	-3.349**	-3.311	-7.459	-10.03*	-10.32**	-3.724***
		(2.153)	(2.060)	(2.263)	(3.389)	(3.704)	(3.241)	(0.630)	(3.213)	(1.666)	(3.281)	(5.205)	(5.434)	(4.909)	(0.767)
	F-Statistic and p-Values on Joint Hypothesis														
	Ho: $\alpha+\beta+\delta=0$														
	F-Statistics								6.07	6.48	2.04	2.77	2.96	3.49	13.76
									(0.01)	(0.01)	(0.15)	(0.09)	(0.08)	(0.06)	(0.00)
	Ho: $\alpha+\delta=0$														
	F-Statistics								6.48	3.66	6.05	6.29	0.31	5.89	3.88
									(0.01)	(0.05)	(0.01)	(0.01)	(0.57)	(0.01)	(0.05)
	Ho: $\beta+\delta=0$														
	F-Statistics								7.48	5.93	4.06	3.49	4.00	16.59	9.04
									(0.00)	(0.01)	(0.04)	(0.06)	(0.04)	(0.00)	(0.00)
	Weighted average in 1992	25.60	41.67	34.58	17.55	9.22	9.15	6.81	41.67	34.58	17.55	9.22	9.15	6.81	
	Observations	51,216	51,216	51,216	51,216	51,216	51,216	51,216	51,216	51,216	51,216	51,216	51,216	51,216	51,216
	Municipality FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
	Year x Month FE	YES	YES	YES	YES	YES	YES		YES YES	YES	YES	YES	YES	YES	YES

Notes: This table reports the results of the effect of BAC law or GDL program on accident number rate, fatalities and injuries rate involving sub groups of novice and experienced drivers. Columns (1-7) include BAC, GDL laws and columns (8-14) also their interaction term. Columns 1 to 14 use dependent variables such as accident number, fatalities and injuries, fatalities and major injuries, fatalities, injuries, major injuries and minor injuries rates. I controlled month, year and municipality fixed effect. Standard errors clustered at the at the municipality level are reported in parentheses under coefficients, and p-values are given in parentheses under F-statistics. Individual coefficients are statistically significant at the *** 1% or ** 5% or * 10% significance level.

[a] In column 1 to 14, the ratio of the total number of each accident category and total population, is multiplied by 10,000; [b] Restricted Blood Alcohol Concentration law (BAC): BAC law level = 50 milligrams of alcohol in 100 millilitres of blood (50mg/100ml). It takes value one in the municipality m in the month and year t where it is in force; otherwise, BAC law is equal to zero. [c] Graduated Driver Licensing (GDL); it is equal to one if the program already is in force in the municipality m in the month and year t; if not, GDL program takes value zero.

Other Results for the Robustness

BAC law and GDL program effects on accident rates involving novice and experienced drivers (shared responsibility of drivers)

The results presented in Tables 15 and 16 indicate the impact of BAC and GDL laws on age-related driver's injury, fatalities and injury rates with shared responsibility between all the drivers involved. In fact, age-related injury and fatalities rates are calculated by assigning a proportion of the number of deaths or injuries per driver. For example, in the case of an accident causing 4 fatalities and involving 3 drivers aged 16, 25 and 34 years old, the proportion of 4 deaths/3 drivers will be applied per driver. By doing so, the responsibilities related to the 4 deaths are shared between the 3 drivers. In this way, there is no longer a double count in the analysis of the number of injuries and deaths due to multiple vehicle accidents. Considering the example above, it will therefore be necessary to apply the proportions of 4/3, 8/3, 12/3 respectively for the age groups of drivers 16 to 24 years old, 25 to 90 years old and 16 to 90 years old. These calculations are performed at the beginning of the third step as described in Appendix B. Thus, the rates used in the analysis of the results presented in Tables 15 and 16 are calculated in the same way as those reported in Tables 4 to 14 with the changes described earlier at the beginning of the third step which relate to the weighting of these rates with the number of drivers involved in each accident.

Columns (1) to (7) of Table 15 indicate that when injury responsibilities are shared among the drivers involved in an accident, the BAC (GDL) law has no significant impact on accident rates engaging novice drivers aged 16 to 24 years old with the exception of the fatalities-major injuries rate and major injury rate for which the estimated GDL coefficients are negative and significant at the 10 percent level when GDL (BAC) is not present.

By adding the interaction term, column (6) of Table 15 indicates that BAC (GDL) law has no impact on all accident rates when GDL (BAC) is not present. Thus, none of the estimated coefficients of BAC and GDL laws are significant. Only the estimated coefficients of the interaction term on major injuries are negative and statistically significant at 10 percent level (column (6), Table 15). Moreover, the negative sign of the coefficients of the partial effect means that the GDL program reduces the fatalities-major injury rate and the major injury rate involving novice drivers aged 16 to 24 years old when the responsibilities causing these injuries are equally distributed between all drivers.

Columns (1) to (7) in Table 16 indicate that when the responsibilities for fatalities or injuries are shared among the drivers involved in an accident, the fatalities-injuries rate, the injuries rate and the minor injuries rate involving experienced drivers increase after the implementation of BAC law. Columns (2), (5) and (6) indicate that the estimated coefficients of the BAC law are positive and significant at the 10 percent level. The coefficient of BAC law is only positive and statistically significant at 10 percent level for the accident number rate when the interaction term between BAC, GDL laws (column (1), Table 16) is included in

Table 13: Effect of GDL or BAC law on fatalities and major injuries rate[a], fatalities rate involving sub groups of novice and experienced drivers

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Age group		16-19	20-24	25-34	35-44	45-54	55-64	65-90	16-19	20-24	25-34	35-44	45-54	55-64	65-90
Variables			without	interaction								with	interaction		
Fatalities-Major injuries rate	BAC[b]	0.111	0.313***	0.161***	0.168**	0.233***	0.156**	0.175***	-0.263	0.031	0.014	-0.120	-0.114	-0.161	0.009
		(0.069)	(0.074)	(0.058)	(0.071)	(0.051)	(0.065)	(0.030)	(0.182)	(0.103)	(0.148)	(0.209)	(0.177)	(0.170)	(0.051)
	GDL x BAC_DWI								0.466***	0.233***	0.182	0.359*	0.436**	0.397**	0.204***
									(0.153)	(0.089)	(0.138)	(0.185)	(0.175)	(0.162)	(0.054)
	GDL[c]	-0.284**	-0.160	-0.0618	-0.112	-0.209	-0.254*	-0.103***	-0.452***	-0.243***	-0.125	-0.240	-0.364**	-0.398**	-0.173***
		(0.118)	(0.105)	(0.0859)	(0.129)	(0.129)	(0.140)	(0.0384)	(0.147)	(0.088)	(0.119)	(0.177)	(0.173)	(0.181)	(0.043)
	F-Statistic and p-Values on Joint Hypothesis														
	Ho: $\alpha+\beta+\delta=0$														
	F-Statistics								1.55	8.24	0.84	0.42	0.02	0.08	0.22
									(0.22)	(0.00)	(0.36)	(0.52)	(0.89)	(0.78)	(0.64)
	Ho: $\alpha+\delta=0$														
	F-Statistics								11.54	23.66	10.71	18.26	42.55.	13.51	36.18
									(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
	Ho: $\beta+\delta=0$														
	F-Statistics								0.04	0.49	0.80	3.93	1.90	0.00	0.69
									(0.83)	(0.48)	(0.37)	(0.04)	(0.16)	(0.97)	(0.40)
	Weighted average in 1992	1.60	2.13	1.84	1.27	0.60	0.62	0.44	1.60	2.13	1.84	1.27	0.60	0.62	0.44
Fatalities rate	BAC	-0.021	0.012	0.001	-0.003	0.012	-0.004	0.02***	-0.067**	-0.018	-0.017	-0.029	-0.025	-0.054**	-0.015
		(0.013)	(0.009)	(0.007)	(0.008)	(0.008)	(0.008)	(0.007)	(0.031)	(0.016)	(0.018)	(0.029)	(0.028)	(0.025)	(0.011)
	GDL x BAC_DWI								0.058**	0.026	0.023	0.0329	0.047*	0.063**	0.044***
									(0.027)	(0.016)	(0.017)	(0.028)	(0.028)	(0.025)	(0.012)
	GDL	-0.034*	-0.014	-0.011	-0.013	-0.029*	-0.032	-0.01	-0.055**	-0.029*	-0.019	-0.025	-0.047*	-0.055**	-0.033***
		(0.018)	(0.015)	(0.011)	(0.017)	(0.018)	(0.019)	(0.011)	(0.023)	(0.015)	(0.016)	(0.025)	(0.025)	(0.026)	(0.011)
	F-Statistic and p-Values on Joint Hypothesis														
	Ho: $\alpha+\beta+\delta=0$														
	F-Statistics								5.14	0.20	2.09	0.21	0.92	1.43	0.82
									(0.02)	(0.66)	(0.15)	(0.65)	(0.34)	(0.23)	(0.37)
	Ho: $\alpha+\delta=0$														
	F-Statistics								0.56	1.73	0.68	0.32	9.22	1.08	11.22
									(0.45)	(0.18)	(0.00)	(0.57)	(0.00)	(0.30)	(0.00)
	Ho: $\beta+\delta=0$														
	F-Statistics								0.04	0.55	0.37	0.86	0.01	0.46	0.60
									(0.83)	(0.45)	(0.54)	(0.35)	(0.94)	(0.49)	(0.43)
	Weighted average in 1992	0.29	0.37	0.31	0.19	0.12	0.08	0.11	0.29	0.37	0.31	0.19	0.12	0.08	0.11
	Observations	51,216	51,216	51,216	51,216	51,216	51,216	51,216	51,216	51,216	51,216	51,216	51,216	51,216	51,216
	Municipality FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
	Year x Month FE	YES	YES	YES	YES	YES	YES		YES YES	YES	YES	YES	YES	YES	YES

Notes: This table reports the results of the effect of BAC law or GDL program on fatalities and major injuries rate, fatalities rate involving sub groups of novice and experienced drivers.Columns (1-7) include BAC, GDL laws and columns (8-14) also their interaction term. Columns 1 to 14 use dependent variables such as accident number, fatalities and injuries, fatalities and major injuries, fatalities, injuries, major injuries and minor injuries rates. I controlled month, year and municipality fixed effect. Standard errors clustered at the at the municipality level are reported in parentheses under coefficients, and p-values are given in parentheses under F-statistics. Individual coefficients are statistically significant at the *** 1% or ** 5% or * 10% significance level.

[a] In column 1 to 14, the ratio of the total number of each accident category and total population, is multiplied by 10,000; [b] Restricted Blood Alcohol Concentration law (BAC): BAC law level = 50 milligrams of alcohol in 100 millilitres of blood (50mg/100ml). It takes value one in the municipality m in the month and year t where it is in force; otherwise, BAC law is equal to zero. [c] Graduated Driver Licensing (GDL); it is equal to one if the program already is in force in the municipality m in the month and year t; if not, GDL program takes value zero.

Table 14: Effect of GDL or BAC law on injuries rate[a], major injuries rate, minor injuries rate involving sub groups of novice and experienced drivers

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Age group		16-19	20-24	25-34	35-44	45-54	55-64	65-90	16-19	20-24	25-34	35-44	45-54	55-64	65-90
Variables			without	interaction								with	interaction		
Injuries rate	BAC[b]	-3.201*	-1.774	-1.841	-3.415*	-0.784	0.146	0.399	-4.765	0.0468	-1.393	-6.371	-5.356	-5.152	-0.801
		(1.627)	(1.216)	(1.142)	(2.020)	(1.442)	(1.054)	(0.371)	(4.460)	(2.207)	(3.895)	(6.492)	(5.664)	(4.612)	(0.713)
	GDL x BAC_DWI								1.949	-1.641	-0.558	3.682	5.739	6.629	1.479*
									(3.768)	(2.187)	(3.715)	(5.711)	(5.599)	(4.843)	(0.809)
	GDL[c]	-6.318***	-5.956***	-3.487	-6.124*	-7.940**	-7.848**	-3.179***	-7.021**	-3.319**	-3.292	-7.434	-9.985*	-10.27**	-3.692***
		(2.144)	(2.058)	(2.256)	(3.375)	(3.691)	(3.224)	(0.629)	(3.198)	(1.660)	(3.269)	(5.181)	(5.411)	(4.885)	(0.764)
	F-Statistic and p-Values on Joint Hypothesis														
	Ho: $\alpha+\beta+\delta=0$														
	F-Statistics								4.51	2.58	5.24	5.10	10.02	0.07	0.04
									0.04	0.11	0.02	0.03	0.00	0.79	0.84
	Ho: $\alpha+\delta=0$														
	F-Statistics								6.50	3.72	6.12	6.33	0.28	5.87	3.60
									0.01	0.05	0.01	0.01	0.59	0.01	0.05
	Ho: $\beta+\delta=0$														
	F-Statistics								7.50	5.89	4.07	3.51	3.98	16.86	9.04
									0.00	0.01	0.04	0.06	0.04	0.00	0.00
	Weighted average in 1992	25.31	41.30	34.27	17.36	9.10	9.07	6.70	25.31	41.30	34.27	17.36	9.10	9.07	6.70
Major injuries rate	BAC	0.132**	0.301***	0.159***	0.171***	0.221***	0.159***	0.154***	-0.195	0.049	0.032	-0.091	-0.088	-0.107	0.025
		(0.061)	(0.071)	(0.053)	(0.065)	(0.046)	(0.060)	(0.026)	(0.158)	(0.094)	(0.132)	(0.183)	(0.154)	(0.151)	(0.045)
	GDL x BAC_DWI								0.408***	0.207**	0.159	0.326**	0.388**	0.334**	0.160***
									(0.134)	(0.0819)	(0.124)	(0.159)	(0.151)	(0.143)	(0.048)
	GDL	-0.251**	-0.146	-0.0508	-0.0991	-0.179	-0.221*	-0.0854**	-0.398***	-0.214***	-0.106	-0.215	-0.317**	-0.343**	-0.141***
		(0.104)	(0.099)	(0.076)	(0.115)	(0.113)	(0.122)	(0.036)	(0.130)	(0.080)	(0.105)	(0.153)	(0.150)	(0.157)	(0.039)
	F-Statistic and p-Values on Joint Hypothesis														
	Ho: $\alpha+\beta+\delta=0$														
	F-Statistics								0.96	9.06	0.56	0.59	0.02	0.17	0.14
									0.36	0.00	0.46	0.44	0.89	0.68	0.71
	Ho: $\alpha+\delta=0$														
	F-Statistics								15.43	24.91	11.79	19.70	42.55	14.90	34.60
									0.00	0.00	0.00	0.00	0.00	0.	0.00
	Ho: $\beta+\delta=0$														
	F-Statistics								0.03	0.75	0.74	3.48	1.90	0.03	0.29
									0.86	0.38	0.39	0.06	0.16	0.86	0. 59
	Weighted average in 1992	1.31	1.76	1.53	1.08	0.48	0.53	0.33	1.31	1.76	1.53	1.08	0.48	0.53	0.33
Minor injuries rate	BAC	-3.334**	-2.076*	-2.000*	-3.605*	-1.005	-0.0132	0.245	-4.570	-0.002	-1.425	-6.292	-5.268	-5.045	-0.826
		(1.581)	(1.179)	(1.107)	(1.968)	(1.407)	(1.032)	(0.361)	(4.332)	(2.169)	(3.799)	(6.328)	(5.533)	(4.491)	(0.708)
	GDL x BAC_DWI								1.541	-1.849	-0.717	3.347	5.351	6.295	1.320
									(3.663)	(2.160)	(3.633)	(5.570)	(5.476)	(4.715)	(0.806)
	GDL	-6.068***	-5.810***	-3.436	-6.025*	-7.761**	-7.627**	-3.094***	-6.624**	-3.106*	-3.186	-7.215	-9.668*	-9.924**	-3.551***
		(2.078)	(2.078)	(2.226)	(3.296)	(3.606)	(3.133)	(0.625)	(3.097)	(1.630)	(3.192)	(5.047)	(5.277)	(4.753)	(0.748)
	F-Statistic and p-Values on Joint Hypothesis														
	Ho: $\alpha+\beta+\delta=0$														
	F-Statistics								4.29	2.66	5.11	4.96	10.42	0.08	0.03
									0.04	0.10	0.02	0.03	0.00	0.78	0.85
	Ho: $\alpha+\delta=0$														
	F-Statistics								7.98	5.45	7.75	8.02	0.01	4.43	1.98
									0.00	0.02	0.00	0.00	0.90	0.03	0.16
	Ho: $\beta+\delta=0$														
	F-Statistics								7.65	5.80	4.03	3.63	3.99	15.82	8.73
									0.00	0.01	0.04	0.05	0.04	0.00	0. 00
	Weighted average in 1992	24	39.54	32.74	16.28	8.62	8.53	6.36	24	39.54	32.74	16.28	8.62	8.53	6.36
	Observations	51,216	51,216	51,216	51,216	51,216	51,216	51,216	51,216	51,216	51,216	51,216	51,216	51,216	51,216
	Municipality FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
	Year x Month FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Notes: This table reports the results of the effect of BAC law or GDL program on injuries rate, major injuries rate, minor injuries rate involving sub groups of novice and experienced drivers. Columns (1-7) include BAC, GDL laws and columns (8-14) also their interaction term. Columns 1 to 14 use dependent variables such as accident number, fatalities and injuries, fatalities and major injuries, fatalities, injuries, major injuries and minor injuries rates. I controlled month, year and municipality fixed effect. Standard errors clustered at the at the municipality level are reported in parentheses under coefficients, and *p*-values are given in parentheses under F-statistics. Individual coefficients are statistically significant at the *** 1% or ** 5% or * 10% significance level.

[a] In column 1 to 14, the ratio of the total number of each accident category and total population, is multiplied by 10,000; [b] Restricted Blood Alcohol Concentration law (BAC): BAC law level = 50 milligrams of alcohol in 100 millilitres of blood (50mg/100ml). It takes value one in the municipality m in the month and year t where it is in force; otherwise, BAC law is equal to zero. [c] Graduated Driver Licensing (GDL); it is equal to one if the program already is in force in the municipality m in the month and year t; if not, GDL program takes value zero.

the analysis. Similarly, the coefficient of the interaction term is negative and significant at the 5 percent threshold for the accident number rate which means that the interaction term increases the expected effect of the two laws on this accident rate involving experienced drivers.

Columns (1) to (7) in Table 16 indicate that by sharing injury responsibilities between drivers involved in an accident, the accident number rate decreases when only the GDL program is in force. Indeed, the sign of the estimated coefficient of the GDL program for the accident number rate is positive and significant at the 5 percent as indicated in column (1) of Table 16. Also, negative sign of the partial effect of the GDL program consists of reducing the accident number rate involving experienced drivers aged 25 to 90 when drivers share equally their responsibilities of the causes of accident.

Table 15: Effect of BAC law or GDL program on all accident rates[a] involving novice drivers (shared responsibility of drivers 16 to 24 years old)

		(1)	(2)	(3)	(4)	(5)	(6)	(7)
Variables		Accident number	Fatalities-Injuries	Fatalities-Major injuries	Fatalities	Injuries	Major injuries	Minor injuries
without	BAC[b]	1.631	0.521	-0.00604	-0.000759	0.522	-0.00528	0.527
interaction		(1.112)	(0.401)	(0.0221)	(0.00601)	(0.401)	(0.0207)	(0.389)
	GDL[c]	0.211	-0.524	-0.0337*	-0.00341	0.215	-0.0303*	0.245
		(0.662)	(0.199)	(0.0196)	(0.00688)	(0.201)	(0.0167)	(0.198)
with	BAC	1.825	0.528	0.00517	-0.00434	0.533	0.00952	0.523
interaction		(1.280)	(0.387)	(0.0256)	(0.00683)	(0.387)	(0.0240)	(0.372)
	GDL x BAC	-0.630	-0.0231	-0.0363	0.0116	-0.0347	-0.0479*	0.0133
		(0.774)	(0.280)	(0.0305)	(0.00900)	(0.279)	(0.0275)	(0.265)
	GDL	-0.143	0.225	-0.0117	-0.0104	0.235	-0.00132	0.237
		(0.265)	(0.243)	(0.0296)	(0.00932)	(0.244)	(0.0257)	(0.233)
	F-Statistic and p-Values on Joint Hypothesis							
	Ho: $\alpha + \beta + \delta = 0$							
	F-Statistics	2.06	2.22	2.27	0.12	2.22	2.85	2.57
		(0.152	(0.138	(0.133)	(0.725)	(0.137)	(0.093)	(0.110)
	Ho: $\alpha + \delta = 0$							
	F-Statistics	1.97	1.06	1.29	0.76	1.02	2.39	1.25
		(0.161)	(0.304)	(0.257)	(0.384)	(0.312)	(0.124)	(0.264)
	Ho: $\beta + \delta = 0$							
	F-Statistics	0.66	0.71	5.32	0.03	0.69	7.32	1.09
		(0.417)	(0.401)	(0.022)	(0.871)	(0.407)	(0.007)	(0.298)
	Observations	51,216	51,216	51,216	51,216	51,216	51,216	51,216
	Municipality FE	YES	YES	YES	YES	YES	YES	YES
	Year x Month FE	YES	YES	YES	YES	YES	YES	YES

Notes: This table reports the results of the effect of BAC law or GDL program on all accident rates involving novice drivers (shared responsibility of drivers 16 to 24 years old). All columns include BAC, GDL laws and their interaction term. Columns (1) to (7) use dependent variables such as accident number, fatalities and injuries, fatalities and major injuries, fatalities, injuries, major injuries and minor injuries rates. I controlled month, year and province fixed effect. Standard errors clustered at the at the municipality level are reported in parentheses under coefficients, and p-values are given in parentheses under F-statistics. Individual coefficients are statistically significant at the *** 1% or ** 5% or * 10% significance level.

[a] In columns (1) to (7), the ratio of the total number of each accident category and total population, is multiplied by 10,000; [b] Restricted Blood Alcohol Concentration law (BAC): BAC law level = 50 milligrams of alcohol in 100 millilitres of blood (50mg/100ml). It takes value one in the province p in month and year t where it is in force; otherwise, BAC law is equal to zero. [c] Graduated Driver Licensing (GDL); it is equal to one if the program already is in force in the province p in month and year t; if not, GDL program takes value zero.

Table 16: Effect of BAC law or GDL program on accident rates[a] involving experienced drivers (shared responsibility of drivers 25 to 90 years old)

		(1)	(2)	(3)	(4)	(5)	(6)	(7)
Variables		Accident number	Fatalities-injuries	Fatalities-Major injuries	Fatalities	Injuries	Major injuries	Minor injuries
without interaction	BAC[b]	1.249	1.366*	0.0853	-0.00109	1.367*	0.0864	1.281*
		(0.954)	(0.781)	(0.0887)	(0.0189)	(0.766)	(0.0739)	(0.705)
	GDL[c]	-2.418**	0.422	0.0158	-0.102	0.524	0.118	0.406
		(1.174)	(0.695)	(0.0588)	(0.0795)	(0.639)	(0.114)	(0.711)
with interaction	BAC	2.214*	1.767	0.158	0.0106	1.757	0.147	1.610
		(1.225)	(1.243)	(0.134)	(0.0316)	(1.214)	(0.106)	(1.116)
	GDL x BAC	-3.068**	-1.276	-0.230	-0.0373	-1.238	-0.193	-1.046
		(1.421)	(1.743)	(0.178)	(0.0447)	(1.705)	(0.140)	(1.581)
	GDL	-0.627	1.166*	0.150	-0.0801	1.246*	0.230	1.016*
		(0.597)	(0.696)	(0.126)	(0.0561)	(0.730)	(0.177)	(0.608)
	F-Statistic and p-Values on Joint Hypothesis							
	Ho: $\alpha + \beta + \delta = 0$							
	F-Statistics	1.85	6.95	0.74	2.48	7.91	1.54	5.96
		(0.174)	(0.009)	(0.391)	(0.117)	(0.005)	(0.215)	(0.015)
	Ho: $\alpha + \delta = 0$							
	F-Statistics	0.85	0.38	0.84	2.2	0.43	0.41	0.56
		(0.358)	(0.537)	(0.360)	(0.139)	(0.511)	(0.522)	(0.454)
	Ho: $\beta + \delta = 0$							
	F-Statistics	4.77	0.01	1.17	1.44	0.00	0.26	0.00
		(0.030)	(0.935)	(0.281)	(0.231)	(0.994)	(0.610)	(0.982)
	Observations	51,216	51,216	51,216	51,216	51,216	51,216	51,216
	Municipality FE	YES	YES	YES	YES	YES	YES	YES
	Year x Month FE	YES	YES	YES	YES	YES	YES	YES

Notes: This table reports the results of the effect of BAC law or GDL program on accident rates involving experienced drivers (shared responsibility of drivers 25 to 90 years old. All columns include BAC, GDL laws and their interaction term. Columns (1) to (7) use dependent variables such as accident number, fatalities and injuries, fatalities and major injuries, fatalities, injuries, major injuries and minor injuries rates. I controlled month, year and province fixed effect. Standard errors clustered at the at the municipality level are reported in parentheses under coefficients, and p-values are given in parentheses under F-statistics. Individual coefficients are statistically significant at the *** 1% or ** 5% or * 10% significance level.

[a] In columns (1) to (7), the ratio of the total number of each accident category and total population, is multiplied by 10,000; [b] Restricted Blood Alcohol Concentration law (BAC): BAC law level = 50 milligrams of alcohol in 100 millilitres of blood (50mg/100ml). It takes value one in the province p in month and year t where it is in force; otherwise, BAC law is equal to zero. [c] Graduated Driver Licensing (GDL); it is equal to one if the program already is in force in the province p in month and year t; if not, GDL program takes value zero.

GDL program persistent effects on accident rates involving novice drivers: from date of implementation of GDL program to 2013

The process leading to the calculation of accident rates in this section is almost the same as that described in Appendix B with some changes in step three. Indeed, in step three, I always assumed that novice drivers are always those aged between 16 and 24 years old. Then, I took into account the fact that the average duration of the GDL process is three years. Thus, the youngest and oldest at the beginning of the process will be 19 and 27 years old at the end of the process, respectively.

To calculate accident rates, I first created 9 variables: age19, age20, age21, age22, age23, age24, age25, age26 and age27, which represent the ages of novice drivers aged 16 to 24 years old at the date of implementation of the GDL program in each of the four provinces. Thus, age19, age20, age21, age22, age23, age24, age25, age26, and age27 are set to 0 when the driver is under the GDL program from the year of its implementation in the province. Then, by assuming, that each province has implemented the GDL program in year t, from year t + 3, the variables created (age19, age20, age21, age22, age23, age24, age25, age26, and age27) take the value 1. For example the value of age19 is replaced by the value 1 when in year t + 3 the driver is 19 years old; in year t + 4 the driver is 20 years old, in year t + 5 the driver is 21 years old, in year t + 6 the driver is 22 years old; in year t + 7 the driver is 23 years old, in year t + 8 the driver is 24 years old; in year t + 9 the driver is 25 years old; in year t + 10 the driver is 26 years old .... in the year 2013 the driver is 16 years old + (2013-t). Similarly, the value of Age20 is replaced by the value 1 when in year t + 3 the driver is 20 years old; in year t + 4 the driver is 21 years old, in year t + 5 the driver is 22 years old, in year t + 6 the driver is 23 years old; in year t + 7 the driver is 24 years old, in year t + 8 the driver is 25 years old; in year t + 9 the driver is 26 years old; in year t + 10 the driver is 27 years old .... in the year 2013 the driver is 17 years old + (2013-t)... Similarly, the value of age27 is replaced by the value 1 when in year t + 3 the driver is 27 years old; in year t + 4 the driver is 28 years old, in year t + 5 the driver is 29 years old, in year t + 6 the driver is 30 years old; in year t + 7 the driver is 31 years old, in year t + 8 the driver is 32 years old; in year t + 9 the driver is 33 years old; in year t + 10 the driver is 34 years old .... in the year 2013 the driver is 24 years old + (2013-t).

Finally, for each municipality, I created the group of drivers aged 16 to 24 who have followed and completed the program since the date of the implementation of the GDL program in the province until 2013. This group is composed of drivers whose age is designated by previously created variables (age19, age20, age21, age22, age23, age24, age25, age26 and age27). After this step, follow those (5 and 6) described in Appendix B. Table 17 indicates that the GDL program has a persistent effect on all novice drivers aged 16 to 24 years who passed it. This effect is reflected in the decrease in the accident rates involving them when the BAC law is also in force as shown in column 1 of that Table 17. Indeed, it can be noted that without the interaction term, the estimated coefficients of GDL on the accident number rate, the fatalities-major injuries rate, the fatalities rate, and the major injuries are negative but non-statistically significant. As for the estimated coefficients on the fatalities-injuries rate, the injury rate and the minor injury rate, they are positive but statistically insignificant. By introducing the interaction term, I note that the estimated coefficients of GDL on all accident rates are negative but only statistically significant for the accident number rate.

Table 17: Effect of BAC law or GDL program on accident rates[a] involving novice drivers: from date of implementation of GDL program to 2013

		(1)	(2)	(3)	(4)	(5)	(6)	(7)
Variables		Accident number	Fatalities-Injuries	Fatalities-Major injuries	Fatalities	Injuries	Major injuries	Minor injuries
without interaction	BAC[b]	0.536	1.700	-0.0912*	0.0251*	1.675	-0.116**	1.795
		(0.718)	(1.294)	(0.0522)	(0.0147)	(1.297)	(0.0468)	(1.293)
	GDL[c]	-1.527	0.203	-0.0649	-0.0117	0.215	-0.0533	0.270
		(1.335)	(0.848)	(0.0869)	(0.0148)	(0.838)	(0.0759)	(0.783)
with interaction	BAC	0.0593	1.006	-0.135*	0.0307*	0.976	-0.166**	1.145
		(0.995)	(1.602)	(0.0761)	(0.0161)	(1.604)	(0.0700)	(1.575)
	GDL x BAC	1.578	2.299	0.145	-0.0186	2.317	0.163	2.155
		(2.347)	(1.909)	(0.173)	(0.0294)	(2.328)	(0.151)	(2.191)
	GDL	-2.478**	-1.182	-0.152	-0.000474	-1.182	-0.152	-1.029
		(1.134)	(1.382)	(0.115)	(0.0199)	(1.370)	(0.103)	(1.292)
	Observations	51,216	51,216	51,216	51,216	51,216	51,216	51,216
	Municipality FE	YES	YES	YES	YES	YES	YES	YES
	Year x Month FE	YES	YES	YES	YES	YES	YES	YES

Notes: This table reports the results of the effect of BAC law or GDL program on accident rates involving novice drivers: from date of implementation of GDL program to 2013. All columns include BAC, GDL laws and their interaction term. Columns (1) to (7) use dependent variables such as accident number, fatalities and injuries, fatalities and major injuries, fatalities, injuries, major injuries and minor injuries rates. I controlled month, year and province fixed effect. Standard errors clustered at the at the municipality level are reported in parentheses under coefficients, and p-values are given in parentheses under F-statistics. Individual coefficients are statistically significant at the *** 1% or ** 5% or * 10% significance level.

[a] In columns (1) to (7), the ratio of the total number of each accident category and total population, is multiplied by 10,000; [b] Restricted Blood Alcohol Concentration law (BAC): BAC law level = 50 milligrams of alcohol in 100 millilitres of blood (50mg/100ml). It takes value one in the province p in month and year t where it is in force; otherwise, BAC law is equal to zero. [c] Graduated Driver Licensing (GDL); it is equal to one if the program already is in force in the province p in month and year t; if not, GDL program takes value zero.

Table 18: Two Stage Least Squares Estimates: IV without weighting (all drivers)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
SECOND STAGE							
Variables	Accident number	Fatalities-Injuries	Fatalities-Major	Fatalities	Injuries	Major	Minor
BAC	-79.240	-56.97	-1.13	-0.016	-56.96	-1.114	-55.84
	(132.7)	(96.48)	(2.233)	(0.569)	(96.620)	(2.401)	(94.61)
GDLxBAC	58.42	27.07	0.584	0.120	26.95	0.464	26.48
	(107.7)	(65.53)	(1.642)	(0.333)	(65.56)	(1.683)	(64.08)
GDL	-74.63	-52.91	-1.123	-0.011	-52.90	-1.112	-51.79
	(124.8)	(90.81)	(2.095)	(0.546)	(90.95)	(2.270)	(89.06)
Observations	51,216	51,216	51,216	51,216	51,216	51,216	51,216
Municipality FE	YES	YES	YES	YES	YES	YES	YES
Year x Month FE	YES	YES	YES	YES	YES	YES	YES
First stage							
Variables		BAC		GDLxBAC		GDL	
		Coef.	Std.Err.	Coef.	Std.Err.	Coef.	Std.Err.
BAC in neighboring provinces		0.0003	(0.010)	0.039***	(0.010)	0.028**	(0.011)
GDL in neighboring provinces		-0.009	(0.010)	-0.002	(0.008)	0.009	(0.007)
GDL x BAC in neighboring provinces		0.014	(0.022)	-0.036***	(0.014)	-0.038***	(0.014)
Ideology of the political party		0.308***	(0.019)	0.024	(0.103)	-0.312***	(0.106)
Test on excluded instruments: F(4,193)		80.99		5.37		17.63	
Underidentification test							
Kleibergen-Paap rk LM statistic: Chi-sq(2)=0.60 P-val=0.7408							
Weak identification test							
-Kleibergen-Paap rk Wald F statistic: 0.15							
-Cragg-Donald Wald F statistic: 0.26							
Weak-instrument-robust inference							
-Anderson-Rubin Wald test F(4,193)= 0.74 P-val=0.5677							
-Anderson-Rubin Wald test Chi-sq(4)= 2.99 P-val=0.5594							
Stock-Yogo weak ID test critical values							
5% maximal IV relative bias							16.85
10% maximal IV relative bias							10.27
20% maximal IV relative bias							6.71
30% maximal IV relative bias							5.34
10% maximal IV size							24.58
15% maximal IV size							13.96
20% maximal IV size							10.26
25% maximal IV size							8.31

Cluster standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Appendix A

Table A.1:Key characteristics of provincial acts regulating impaired driving

	(Date of implementation)	License suspension period
Alberta	DWI <50 mg% since 1999 DWI = 0.0 mg% since 2003 for new drivers	- 24 hours Since 2012: (i) Immediate 3 days & 3 days vehicle seizure (1st charge) (ii) Immediate 15 days & 7 days vehicle seizure (2nd charge) (iii) Immediate 30 days & (iii) 7 days vehicle seizure (3rd charge)
Ontario	DWI <50 mg% 1981 BAC = 0.0 mg% since 1994 for new drivers	- 12 hours - Since 2009: 24 hours (i) Immediate 3 days (1st charge) (ii) 7 days and obligation to attend an alcohol education program (2nd charge) (iii) 30 days, obligation to complete a remedial alcohol treatment program and obligation to have an ignition interlock condition placed on your driver's six months (3rd charge)
Quebec	N/A	N/A
Saskatchewan	DWI <40 mg% 1996 BAC = 0.0 mg% since 2001 for probationary or new drivers	(i) In 2001, 24 hours and an optional ignition interlock program for first-time drinking and driving offenders (ii) Since 2005, licence suspension for experienced drivers to 15 days (iii) In 2007, the optional ignition interlock program was expanded to allow repeat offenders to voluntarily participate in the program.

Sources:Transport Canada (2011), Transport Canada (2013) and Blais et al. (2015)

Table A.2: Key features of the learner stage

Component	AB	SK	ON	QC
Effective date	2003	2005	1994	1997
Change date			2005[a]	2010[b]
Entry age	14	16	16	16
Entry tests: Vision knowledge	Yes Yes	Yes Yes	Yes Yes	Yes Yes
Parental consent: Age applied	Yes under 18	Yes Yes under 18	No N/A	Yes under 18
Minimum duration: Without driver education With driver education	12 month N/A	9 month 9 month	12 month 8 month	12 month 8 month
Maximum duration	None	None	5 years	None
Supervisor: Age license Type time licensed BAC level	18 or over Fully licensed N/S	Class 5 1 year <.04	Fully licensed 4 years <.05	Fully licensed 2 years <=.08
Minimum driving	None	None	None	None
Driver education: voluntary	Yes	No	Yes	Yes
BAC level	Zero	Zero	Zero	Zero
Passenger restrictions:	Yes	Yes	Yes	N/A
Night restrictions	12am - 5am	None	12am - 5am	None
Minimum exit age	16	16	6 & 8 month	16 & 8 month

Source: Extract of Traffic Injury Research Foundation (Mayhew et al. (2005))

[a]Restriction on passengers prohibiting drivers aged 19 and under from carrying more than one passenger aged 19 or under during the first six months of the intermediate stage; [b] The driving course becomes mandatory for obtaining a passenger vehicle license.

Table A.3: Some key features of the intermediate stage

Component	AB	SK	ON	QC
Minimum entry age	16	16	16 & 8 month	16 & 8 month
Entry requirements: Road test	Yes	Yes	Yes	Yes
Parental consent: Age applied	No	No	No	Yes
Age applied	N/A	N/A	N/A	under 18
Minimum duration:	24 month	18 month	12 month	24 month
Maximum duration	None	None	5 years	24 month
BAC limit	Zero	Zero	Zero	Zero
Night restrictions	None	None	None	None
Passenger Restrictions: Number	N/A	Yes	Yes	N/A
Limit to seatbelts	Yes	Yes	Yes	N/A
N Sign/Plate	None	None	None	None
Road restriction	None	None	None	None
Penalties for GDL violations	Yes	Yes	Yes	Yes
Lower demerit Point threshold	8 instead of 15	Yes	9 instead 15 of 15	4 instead of 15 of 15

Source: Extract of Traffic injury Research Foundation (Mayhew et al. (2005))

Table A.4: Data variable definitions and sources

	Provinces			
	Alberta	Ontario	Quebec	Saskatchewan
	1992-2013	1992-2013	1992-2013	1992-2013
Basic information				
Unique number of the accident	Yes	Yes	Yes	Yes
Accident date	Yes	Yes	Yes	Yes
Total driver vehicles	Yes	Yes	Yes	Yes
Total involved persons	Yes	Yes	Yes	Yes
Total fatalities	Yes	Yes	Yes	Yes
Total major injuries	Yes	Yes[a]	Yes	Yes[a]
Total minor injuries	Yes[a]	Yes[a]	Yes	Yes[a]
Road jurisdiction (authority)	Yes	Yes	Yes	Yes
Collision severity	Yes	Yes	Yes	Yes
Municipality code[b]	N/A	Yes	Yes	N/A
Accident site[c]	Yes	Yes	N/A	Yes
Municipality name	Yes	Yes	Yes	Yes
Road jurisdiction[d]	Yes	Yes	Yes	Yes
Road surface condition	Yes	Yes	Yes	Yes
Driver and vehicle information				
Driver age	Yes	Yes	Yes	Yes
Driver sex	Yes	Yes	Yes	Yes
Driver province or state	Yes	Yes	Yes	Yes
Make of vehicle	Yes	Yes	Yes	N/A
Model year	Yes	Yes	Yes	N/A
Vehicle province or state	Yes	Yes	Yes	N/A
Involved person information				
Involved person age	Yes	Yes	N/A	Yes
Involved person sex	Yes	Yes	N/A	Yes
Injury severity	Yes	Yes	N/A	Yes
Source:Provincial ministry of	Alberta Transportation	Ontario Transportation	Quebec Transportation	Saskatchewan Transportation

Notes: This table reports information (variables, sources, definitions) on collision data from the provinces of Alberta, Ontario, Quebec, and Saskatchewan. It provides data availability for the variables that I use in the analysis. "Yes" indicates data availability, while "N/A" indicates data unavailability. [a] I generate fatal, major injury, minor injury from injury severity variable on each person involved in accident; [b] Municipality Code designates geographical code of the municipality of the accident site; [c] Accident site includes non-intersection, intersection with provincial highway, intersection with street, on highway, on street; [d] Road jurisdiction designates municipal, provincial highway, township, county or district, regional municipality, private property, federal, other.

Table A.5: Municipality of the four provinces of this study

	Alberta	Ontario	Quebec	Saskatchewan	Total
All accident (Number of accident)	1,554,434	3,171,958	2,197,638	1,207,995	8,132,025
Accident with population more than 10,000 inhabitants and limited age 16 to 90	1,293,820	2,735,162	1,845,599	999,640	6,872,175
Accident with population more than 10,000 inhabitants and limited age 16 to 90	1,265,697	2,733,757	1,841,870	997,621	6,793,358
Total reduction relative to (%) total number of accident	18.57	13.81	16.18	17.41	16.46
All municipalities in 1992	394	850	1,378	861	3,483
* Municipalities with population more than 10,000 inhabitants from 1992	13	105	69	7	194
Total observations (municipality/month) by province over 22 years (1992-2013)	13*12*22 =3,432	105*12*22=27,720	69*12*22=18,216	7*12*22=1,848	51,216

Notes: This table reports informations on the data used before and after the two restrictions. First, using the population estimates between two censuses of the year 1992, I reduced my study to municipalities with more than 10,000 inhabitants because I noticed that in localities with a small population size, accident frequency is very low. Thus, accident rates cannot be observed over several periods, thus increasing the variance of accident rates between cities. The second restriction is to exclude drivers who are under 16 years of age.

Table A.6: neighboring provinces of the four provinces of this study

	neighboring provinces		
Province	Province 1	Province 2	Province 3
Alberta	British Columbia	Saskatchewan	
Ontario	Manitoba	Quebec	
Quebec	Ontario	New Brunswick	Newfoundland and Labrador
Saskatchewan	Alberta	Manitoba	

Table A.7: Date of GDL and BAC implementations in neighboring provinces

Neighboring provinces	GDL implementation	BAC implementation
British Columbia	August, 1998	1979
Manitoba	January, 2003	April 1998
New Brunswick	January, 1996	1985
Newfoundland and Labrador	January, 1999	1995

Table A.8: Government party in power when BAC and GDL laws are implemented or changed in the four provinces

Provinces	Political party	Ideology according to Harrisson and Geen (2010)
Alberta	From 1992 to 2013: Progressive Conservative Association	Progressive Conservative Association: Right
Ontario	From 1992 to 1995: New Democratic Party	New Democratic Party : left
	From 1996 to 2002: Progressive Conservative Party	Progressive Conservative Party: Right
	From 2003 to 2013: Liberal Party	Liberal Party: Left
Quebec	From 1992 to 1994 and 2003 to 2011: Liberal party of Quebec	Liberal party of Quebec : Left
	From 1995 to 2002 and 2012 to 2013 Quebecois party	Quebecois party: Left
Saskatchewan	From 1992 to 2007: Saskatchewan New Democratic Party	Saskatchewan New Democratic Party: Left
	From 2008 to 2013 : Saskatchewan Party	Saskatchewan Party: Right

Appendix B

Consider Tables B.1 and B.2 representing information (case of pure fiction) on four accidents that occurred in different municipalities of the province (PR) and the people involved in it respectively.

Table B.1: Drivers and collision information (from drivers and collision file)

Unique number of accident	Date of accident accident	Total vehicle count	Total fatalities	Road jurisdiction jurisdiction	Collision severity[a]	County code	Municipality code	Municipality name	Province accident	Driver sex	Vehicle province	Driver age
10000103	17/08/2002	3	0	1	2	852	173192	AAAAA	PR	M	PR	33
10000103	17/08/2002	3	0	1	2	852	173192	AAAAA	PR	M	PR	35
10000103	17/08/2002	3	0	1	2	852	173192	AAAAA	PR	M	PR	29
10000104	18/08/2002	1	0	4	2	805	187044	BBBBB	PR	F	PR	67
10000105	20/08/2002	1	1	2	1	805	187044	BBBBB	PR	M	PR	47
10000106	21/08/2002	4	2	1	1	952	173192	CCCCC	PR	M	PR	33
10000106	21/08/2002	4	2	1	1	952	173192	CCCCC	PR	M	PR	38
10000106	21/08/2002	4	2	1	1	952	173192	CCCCC	PR	F	PR	53
10000106	21/08/2002	4	2	1	1	952	173192	CCCCC	PR	M	PR	18

Notes: This Table reports accidents with at least one injured or dead in different municipalities of the province (PR) and people involved in it. [a] Collision Severity = 1 if Fatal injury; Collision Severity = 2 if Non-fatal injury; Collision severity = 3 if Property damage Only; Collision severity = 4 If Non reportable.

Table B.2: Person involved in fatal and injury collision (from involved person collision file)

Unique number of accident	Accident date	Driver/vehicle number	Vehicle number	Involved person age	Involved person sex	Injury severity[a]
10000103	17/08/2002	1	1	33	M	0
10000103	17/08/2002	2	2	35	M	0
10000103	17/08/2002	2	2	30	F	1
10000103	17/08/2002	3	3	29	M	0
10000103	17/08/2002	3	3	33	F	0
10000104	18/08/2002	1	1	67	F	2
10000104	18/08/2002	1	1	35	M	1
10000105	20/08/2002	1	1	59	M	3
10000105	20/08/2002	1	1	47	M	0
10000106	21/08/2002	4	4	33	M	3
10000106	21/08/2002	4	4	38	M	3
10000106	21/08/2002	4	4	53	F	2
10000106	21/08/2002	4	4	18	M	2

Notes: This Table reports information on people involved in accidents with at least one injured or dead in different municipalities of the province (PR). [a] injury severity = 0 if none; injury severity = 1 if minimal or minor; injury severity = 2 if major; injury severity= 3 if fatal.

First step: Creation of the fatality, major injury and minor injury variables for each accident in province (PR) and calculation of the total number of fatalities, of number of major

injuries and of minor injuries per accident.

The "fatality", "major injury" and "minor injury" variables created by accident will be used to calculate the total number of fatalities (deaths) and injuries per accident in province (PR). These variables are created from the information collected on the persons involved reported in Table B.2. Thus, using Table B.2, I created the variables (see Table B.2.1): "fatality" which takes the value "1 (one)" if the person involved (driver, passenger, pedestrian) is dead and "0 (zero)" if not; "major injury" which takes the value "1 (one)" if the person involved (driver, passenger, pedestrian) is seriously injured and "0 (zero)" otherwise; "minor injury" whose values are "1 (one)" if the person involved (driver, passenger, pedestrian) has had a minor injury and "0 (zero)" otherwise.

Table B.2.1: Person involved and fatal, major and minor injury

Unique number of accident	Accident date	Year	Month	Day	Driver number	Involved person age	Involved person sex	Injury severity	Fatal	Major injury	Minor injury
10000103	17/08/2002	2002	08	17	1	33	M	0	0	0	0
10000103	17/08/2002	2002	08	17	2	35	M	0	0	0	0
10000103	17/08/2002	2002	08	17	2	30	F	1	0	0	1
10000103	17/08/2002	2002	08	17	3	29	M	0	0	0	0
10000103	17/08/2002	2002	08	17	3	33	F	0	0	0	0
10000104	18/08/2002	2002	08	18	1	67	F	2	0	1	0
10000104	18/08/2002	2002	08	18	1	35	M	1	0	0	1
10000105	20/08/2002	2002	08	20	1	59	M	3	1	0	0
10000105	20/08/2002	2002	08	20	1	47	M	0	0	0	0
10000106	21/08/2002	2002	08	21	1	33	M	3	1	0	0
10000106	21/08/2002	2002	08	21	2	38	M	3	1	0	0
10000106	21/08/2002	2002	08	21	3	53	F	2	0	1	0
10000106	21/08/2002	2002	08	21	3	18	M	2	0	1	0

Notes: This Table reports the created variables such as the fatality, major injury and minor injury for each accident in province (PR) by using the injury severity of Table B.2. Thus, fatality = 1 if injury severity = 3; otherwise, fatality = 0. Major injury =1 if injury severity = 2; otherwise, major in jury = 0. Minor injury =1 if injury severity = 1; otherwise, minor injury = 0.

From Table B.2.1 above, for each of four accidents identified by the unique identification number, I calculate the total number of fatalities, the total number of major injuries and the number of minor injuries. Table B.2.2 reports the results obtained.

Table B2.2: Total fatalities, major and minor injuries by accident

1	2	3	4	5	6	7	8	9	10	11	12
	Unique number of accident	Year	Month	Fatality	Major injury	Minor injury	Total number of fatalities	Total number of major injuries	Total number of minor injuries	Involved person age	Involved person sex
1	10000103	2002	08	0	0	0	0	0	0	33	M
2	10000103	2002	08	0	0	0	0	0	0	30	F
3	10000103	2002	08	0	0	1	0	0	1	35	M
4	10000103	2002	08	0	0	0	0	0	0	29	M
5	10000103	2002	08	0	0	0	0	0	0	33	F
6	**10000103**	2002	08				**0**	**0**	**1**		
7	10000104	2002	08	0	1	0	0	1	0	67	F
8	10000104	2002	08	0	0	1	0	0	1	35	M
9	**10000104**	2002	08				**0**	**1**	**1**		
10	10000105	2002	08	1	0	0	1	0	0	59	M
11	10000105	2002	08	0	0	0	0	0	0	47	M
12	**10000105**	2002	08				**1**	**0**	**0**		
13	10000106	2002	08	1	0	0	1	0	0	33	M
14	10000106	2002	08	1	0	1	0	0	0	38	M
15	10000106	2002	08	0	1	0	0	1	0	53	F
16	10000106	2002	08	0	1	0	0	1	0	18	M
17	**10000106**	2002	08				**2**	**2**	**0**		

Notes: This Table reports the total number of fatalities, the total number of major injuries and the total number of minor injuries for each accident identified by the unique identification number.

Calculation example: The total number of fatalities (see line 6 represented by the cell bearing the unique identification number of accident 10000103 and column 8) is equal to the sum of the values of lines 1 to 5 of column 5, ie "0". Similarly, the total numbers of major injuries and minor injuries corresponding to the same accident are respectively "0" (sum of the values in rows 1 to 5 of column 6) and "1" (sum of the values in rows 1 to 5 of column 7).

Table B.2.3 presents a summary of the calculation results of the total number of fatalities, the total number of major injuries and the total number of minor injuries for each of the four accidents identified by the unique numbers 10000103, 10000104, 10000105 and 10000106

Table B2.3: Summary of the calculation results of the total fatalities, major and minor injuries by accident

Unique number of accident	Year	Month	Total number of fatalities	Total number of major injuries	Total number of minor injuries
10000103	2002	08	0	0	1
10000104	2002	08	0	1	1
10000105	2002	08	1	0	0
10000106	2002	08	2	2	0

Step 2: A merger of the results from step 1 (Table B.2.3) with the information in Table B.1

In the second step, I merged the newly created database with the driver database by unique registration number for each accident, by month and by municipality. For this reason, for each accident and by driver (s) involved, I have the total number of fatalities, the total number of major injuries and the total number of minor injuries (the sum of which makes it possible to obtain the number total of injuries). The results of this merger are presented in Table B3.

Table B.3: Information on accidents, drivers involved and the total number of fatalities, major and minor injuries by accident

Unique number of accident	Year	Month	Day	Road juridiction	Municipality name	Accident province	Driver sex	Driver age	Total number of fatalities	Total number of major injuries	Total number of minor injuries
10000103	2002	08	17	1	AAAAA	PR	M	33	0	0	1
10000103	2002	08	17	1	AAAAA	PR	M	35	0	0	1
10000103	2002	08	17	1	AAAAA	PR	M	29	0	0	1
10000104	2002	08	18	4	BBBBB	PR	F	67	0	1	1
10000105	2002	08	20	2	BBBBB	PR	M	47	1	0	0
10000106	2002	08	21	2	CCCCC	PR	M	33	2	2	0
10000106	2002	08	21	2	CCCCC	PR	M	38	2	2	0
10000106	2002	08	21	2	CCCCC	PR	F	53	2	2	0
10000106	2002	08	21	2	CCCCC	PR	M	18	2	2	0

Important note: The total number of fatalities, major injuries and minor injuries per accident is the same for all drivers involved in the accident.

Step 3: Creation of three groups and 5 subgroups of drivers

From Table B.3 above, I created on the one hand 3 different age groups of drivers: groups of all drivers (16-90 years old), group of novice drivers (16-24 years old) and group of experienced drivers (25-90 years old); and on the other hand, subgroups of novice and experienced drivers. Novice and experienced driver groups are subdivided into two and five sub-groups, respectively. Thus, the group of novices consists of the two sub-groups "16-19 years" and "20-24 years" while that of experienced drivers is composed of subgroups: "25-34 years", "35-44 years", "45-54 years" "55-64 years" and "65-90 years".

Table B3.1: Total number of fatalities, major and minor injuries by accident involving drivers aged 16 to 90 years old

Unique number of accident	Year	Month	Day	Municipality name	Accident province	Total number of fatalities	Total number of major injuries	Total number of minor injuries
10000103	2002	08	17	AAAAA	PR	0	0	1
10000103	2002	08	17	AAAAA	PR	0	0	1
10000103	2002	08	17	AAAAA	PR	0	0	1
10000104	2002	08	18	BBBBB	PR	0	1	1
10000105	2002	08	20	BBBBB	PR	1	0	0
10000106	2002	08	21	CCCCC	PR	2	2	0
10000106	2002	08	21	CCCCC	PR	2	2	0
10000106	2002	08	21	CCCCC	PR	2	2	0
10000106	2002	08	21	CCCCC	PR	2	2	0

Notes: This Table reports total number of fatalities, total number of major and total number of minor injuries involving all drivers aged 16 to 90 years old by accident.

Table B.3.2: Total number of fatalities, major and minor injuries by accident involving drivers aged 16 to 24 years old

Unique number of accident	Year	Month	Day	Municipality name	Accident province	Total number of fatalities	Total number of major injuries	Total number of minor injuries
10000106	2002	08	21	CCCCC	PR	2	2	0

Notes: This Table reports total number of fatalities, total number of major and total number of minor injuries involving all novice drivers aged 16 to 24 years old by accident.

Table B.3.3: Total number of fatalities, major and minor injuries by accident involving all experienced drivers aged 25 to 90 years old

Unique number of accident	Year	Month	Day	Municipality name	Accident province	Total number of fatalities	Total number of major injuries	Total number of minor injuries
10000103	2002	08	17	AAAAA	PR	0	0	1
10000103	2002	08	17	AAAAA	PR	0	0	1
10000103	2002	08	17	AAAAA	PR	0	0	1
10000104	2002	08	18	BBBBB	PR	0	1	1
10000105	2002	08	20	BBBBB	PR	1	0	0
10000106	2002	08	21	CCCCC	PR	2	2	0
10000106	2002	08	21	CCCCC	PR	2	2	0
10000106	2002	08	21	CCCCC	PR	2	2	0

Notes: This Table reports total number of fatalities, total number of major and total number of minor injuries involving experienced drivers aged 25 to 90 years old by accident.

Table B.3.4: Total number of fatalities, major and minor injuries by accident involving drivers aged 16 to 19 years old

Unique number of accident	Year	Month	Day	Municipality name	Accident province	Total number of fatalities	Total number of major injuries	Total number of minor injuries
10000106	2002	08	21	CCCCC	PR	2	2	0

Notes: This Table reports total number of fatalities, total number of major and total number of minor injuries involving only novice drivers aged 16 to 19 years old by accident.

Table B.3.5: Total number of fatalities, major and minor injuries by accident involving drivers aged 25 to 34 years old

Unique number of accident	Year	Month	Day	Municipality name	Accident province	Total number of fatalities	Total number of major injuries	Total number of minor injuries
10000103	2002	08	17	AAAAA	PR	0	0	1
10000106	2002	08	21	CCCCC	PR	2	2	0

Notes: This Table reports total number of fatalities, total number of major and total number of minor injuries involving only experienced drivers aged 25 to 34 years old by accident.

Table B.3.6: Total number of fatalities, major and minor injuries by accident involving drivers aged 35 to 44 years old

Unique number of accident	Year	Month	Day	Municipality name	Accident province	Total number of fatalities	Total number of major injuries	Total number of minor injuries
10000103	2002	08	17	AAAAA	PR	0	0	1
10000106	2002	08	21	CCCCC	PR	2	2	0

Notes: This Table reports total number of fatalities, total number of major and total number of minor injuries involving only experienced drivers aged 35 to 44 years old by accident.

Table B.3.7: Total number of fatalities, major and minor injuries by accident involving drivers aged 45 to 54 years old

Unique number of accident	Year	Month	Day	Municipality name	Accident province	Total number of fatalities	Total number of major injuries	Total number of minor injuries
10000105	2002	08	17	BBBBB	PR	1	0	0
10000106	2002	08	21	CCCCC	PR	2	2	0

Notes: This Table reports total number of fatalities, total number of major and total number of minor injuries involving only experienced drivers aged 45 to 54 years old by accident.

Table B.3.8: Total number of fatalities, major and minor injuries by accident involving drivers aged 65 to 90 years old

Unique number of accident	Year	Month	Day	Municipality name	Accident province	Total number of fatalities	Total number of major injuries	Total number of minor injuries
10000104	2002	08	17	BBBBB	PR	0	1	1

Notes: This Table reports total number of fatalities, total number of major and total number of minor injuries involving experienced drivers aged 65 to 90 years old by accident.

Step 4: Weighting of total of fatalities, total of major injuries and total of minor injuries by the number of drivers involved in the accident to avoid double counting when at least two drivers in the same age group are concerned; Creation of the accident number variable.
The advantage of this step is to avoid counting for the same accident (unique number), more than once the total number of fatalities, total number of major injuries, total number of minor injuries involving at least two drivers of the same age group.

To do this, within each of the previously created groups and subgroups of drivers, I calculated, from the unique number of each accident, the following ratio (example): (1) sum of total number of fatalities (by unique number of each accident per municipality, per month and per year) divided by the number of drivers corresponding to this unique number; (2) sum of total number of major injuries (by unique number of each accident per municipality, per month and per year) divided by the number of drivers corresponding to this unique number; (3 sum of the number of minor injuries (by unique number of each accident per municipality, per month and per year) divided by the number of drivers corresponding to this unique number. **Important Note**: The results of the different ratio must exactly correspond to the total number of fatalities, the total number of major injuries and the total number of minor injuries per accident obtained in step 1. However, each accident represented by the unique identification number is counted only once within each group or subgroup. This allows me to create the accident number variable that takes the value 1.

Table B.4.1: Total of fatalities, major injuries and minor injuries weighted by drivers number (aged 16 to 90 years old)

Unique number of accident	Year	Month	Day	Municipality name	Accident province	Total number of fatalities	Total number of major injuries	Total number of minor injuries	Total number of accident
10000103	2002	08	17	AAAAA	PR	0	0	1	1
10000104	2002	08	18	BBBBB	PR	0	1	1	1
10000105	2002	08	20	BBBBB	PR	1	0	0	1
10000106	2002	08	21	CCCCC	PR	2	2	0	1

Notes: This Table reports total number of fatalities, total number of major and total number of minor injuries involving all drivers aged 16 to 90 years old by accident without double counting within the group.

Table B.4.2: Total of fatalities, major injuries and minor injuries weighted by drivers number (aged 16 to 24 years old)

Unique number of accident	Year	Month	Day	Municipality name	Accident province	Total number of fatalities	Total number of major injuries	Total number of minor injuries	Total number of accident
10000106	2002	08	21	CCCCC	PR	2	2	0	1

Notes: This Table reports total number of fatalities, total number of major and total number of minor injuries involving all novice drivers aged 16 to 24 years old by accident without double counting within the group.

Table B.4.3: Total of fatalities, major injuries and minor injuries weighted by drivers number (aged 25 to 90 years old)

Unique number of accident	Year	Month	Day	Municipality name	Accident province	Total number of fatalities	Total number of major injuries	Total number of minor injuries	Total number of accident
10000103	2002	08	17	AAAAA	PR	0	0	1	1
10000104	2002	08	18	BBBBB	PR	0	1	1	1
10000105	2002	08	20	BBBBB	PR	1	0	0	1
10000106	2002	08	21	CCCCC	PR	2	2	0	1

Notes: This Table reports total number of fatalities, total number of major and total number of minor injuries involving all experienced drivers aged 25 to 90 years old by accident without double counting within the group.

Table B.4.4: Total of fatalities, major injuries and minor injuries weighted by drivers number (aged 16 to 19 years old)

Unique number of accident	Year	Month	Day	Municipality name	Accident province	Total number of fatalities	Total number of major injuries	Total number of minor injuries	Total number of accident
10000106	2002	08	21	CCCCC	PR	2	2	0	1

Notes: This Table reports total number of fatalities, total number of major and total number of minor injuries involving only novice drivers aged 16 to 19 years old by accident without double counting within the group.

Table B.4.5: Total of fatalities, major injuries and minor injuries weighted by drivers number (aged 25 to 34 years old)

Unique number of accident	Year	Month	Day	Municipality name	Accident province	Total number of fatalities	Total number of major injuries	Total number of minor injuries	Total number of accident
10000103	2002	08	17	AAAAA	PR	0	0	1	1
10000106	2002	08	21	CCCCC	PR	2	2	0	1

Notes: This Table reports total number of fatalities, total number of major and total number of minor injuries involving only experienced drivers aged 25 to 34 years old by accident without double counting within the group.

Table B.4.6: Total of fatalities, major injuries and minor injuries weighted by drivers number (aged 35 to 44 years old)

Unique number of accident	Year	Month	Day	Municipality name	Accident province	Total number of fatalities	Total number of major injuries	Total number of minor injuries	Total number of accident
10000103	2002	08	17	AAAAA	PR	0	0	1	1
10000106	2002	08	21	CCCCC	PR	2	2	0	1

Notes: This Table reports total number of fatalities, total number of major and total number of minor injuries involving only experienced drivers aged 35 to 44 years old by accident without double counting within the group.

Table B.4.7: Total of fatalities, major injuries and minor injuries weighted by drivers number (aged 45 to 54 years old)

Unique number of accident	Year	Month	Day	Municipality name	Accident province	Total number of fatalities	Total number of major injuries	Total number of minor injuries	Total number of accident
10000105	2002	08	17	BBBBB	PR	1	0	0	1
10000106	2002	08	21	CCCCC	PR	2	2	0	1

Notes: This Table reports total number of fatalities, total number of major and total number of minor injuries involving only experienced drivers aged 45 to 54 years old by accident without double counting within the group.

Table B.4.8: Total of fatalities, major injuries and minor injuries weighted by drivers number (aged 65 to 90 years old)

Unique number of accident	Year	Month	Day	Municipality name	Accident province	Total number of fatalities	Total number of major injuries	Total number of minor injuries	Total number of accident
10000104	2002	08	17	BBBBB	PR	0	1	1	1

Notes: This Table reports total number of fatalities, total number of major and total number of minor injuries involving only experienced drivers aged 65 to 90 years old by accident without double counting within the group.

Step 5: Calculation of the sum of the total number of fatalities, the total number of major

injuries, the total number of minor injuries and the total number of accidents by month, year and municipality.

The fifth step was to sum the total number of fatalities, the total number of major injuries, the total number of minor injuries and the total number of accidents per municipality, per month and per year. The results of this study are summarized in Tables B.5.1 to B.5.8.

At this step, within each group, I have taken the sum of the total number of accidents, the total number of fatalities, the total number of major injuries and the total number of minor injuries per municipality, per month and per year respectively. Thus, I have calculated for each driver age group:

$$TNA_{cmy} = \sum_{i=1}^{na} NA_{icmy}$$

where TNA_{cmy} is the total number of accident per municipality (city) c per month and per year; NA_{icmy} is the number of accident i (equal to 1 for each accident) per municipality (city) c per month and per year. na represents the total number of accident per municipality per month and per year.

$$TNFI_{cmy} = \sum_{i=1}^{na} NFIA_{icmy}$$

where $TNFI_{cmy}$ is the total number of fatalities and injuries per municipality (city) c per month and per year; $NFIA_{icmy}$ is the total number of fatalities and injuries of accident i per municipality (city) c per month and per year.

$$TNFMaI_{cmy} = \sum_{i=1}^{na} NFMaIA_{icmy}$$

where $TNFMaI_{cmy}$ is the total number of fatalities and major injuries per municipality (city) c per month and per year; $NFMaIA_{icmy}$ is the total number of fatalities and major injuries of accident i per municipality (city) c per month and per year.

$$TNF_{cmy} = \sum_{i=1}^{na} NFA_{icmy}$$

where TNF_{cmy} is the total number of fatalities per municipality (city) c per month and per year; NFA_{icmy} is the total number of fatalities of accident i per municipality (city) c per month and per year.

$$TNI_{cmy} = \sum_{i=1}^{na} NIA_{icmy}$$

TNI_{cmy} is the total number of injuries per municipality (city) c per month and per year; NIA_{icmy} is the total number of injuries of accident i per municipality (city) c per month and per year.

$$TNMaI_{cmy} = \sum_{i=1}^{na} NMaIA_{icmy}$$

$TNMaI_{cmy}$ is the total number of major injuries per municipality (city) c per month and per year; $NMaIA_{icmy}$ is the total number of major injuries of accident i per municipality (city) c per month and per year.

$$TNMiI_{cmy} = \sum_{i=1}^{na} NMiIA_{icmy}$$

$TNMiI_{cmy}$ is the total number of major injuries per municipality (city) c per month and per year; $NMiIA_{icmy}$ is the total number of major injuries of accident i per municipality (city) c per month and per year.

Table B.5.1: Total number of fatalities, major and minor injuries per month per municipality (drivers aged 16 to 90 years old)

Year	Month	Municipality name	Province name	Total number of fatalities	Total number of major injuries	Total number of minor injuries	Total number of accident
2002	08	AAAAA	PR	0	0	1	1
2002	08	BBBBB	PR	1	1	1	2
2002	08	CCCCC	PR	2	2	0	1

Notes: This Table reports total number of fatalities, total number of major and total number of minor injuries involving all drivers aged 16 to 90 years old by accident, month and municipality.

Table B.5.2: Total number of fatalities, major and minor injuries per month per municipality (drivers aged 16 to 24 years old)

Year	Month	Municipality name	Province name	Total number of fatalities	Total number of major injuries	Total number of minor injuries	Total number of accident
2002	08	CCCCC	PR	2	2	0	1

Notes: This Table reports total number of fatalities, total number of major and total number of minor injuries involving all novice drivers aged 16 to 24 years old by accident, month and municipality.

Table B.5.3: Total number of fatalities, major and minor injuries per month per municipality (drivers aged 25 to 90 years old)

Year	Month	Municipality name	Province name	Total number of fatalities	Total number of major injuries	Total number of minor injuries	Total number of accident
2002	08	AAAAA	PR	0	0	1	1
2002	08	BBBBB	PR	1	1	1	2
2002	08	CCCCC	PR	2	2	0	1

Notes: This Table reports total number of fatalities, total number of major and total number of minor injuries involving all experienced drivers aged 16 to 90 years old by accident, month and municipality.

Table B.5.4: Total number of fatalities, major and minor injuries per month per municipality (drivers aged 16 to 19 years old)

Year	Month	Municipality name	Province name	Total number of fatalities	Total number of major injuries	Total number of minor injuries	Total number of accident
2002	08	CCCCC	PR	2	2	0	1

Notes: This Table reports total number of fatalities, total number of major and total number of minor injuries involving only novice drivers aged 16 to 19 years old by accident, month and municipality.

Table B.5.5: Total number of fatalities, major and minor injuries per month per municipality (drivers aged 25 to 34 years old)

Year	Month	Municipality name	Province name	Total number of fatalities	Total number of major injuries	Total number of minor injuries	Total number of accident
2002	08	AAAAA	PR	0	0	1	1
2002	08	CCCCC	PR	2	2	0	1

Notes: This Table reports total number of fatalities, total number of major and total number of minor injuries involving only experienced drivers aged 25 to 34 years old by accident, month and municipality.

Table B.5.6: Total number of fatalities, major and minor injuries per month per municipality (drivers aged 35 to 44 years old)

Year	Month	Municipality name	Province name	Total number of fatalities	Total number of major injuries	Total number of minor injuries	Total number of accident
2002	08	AAAAA	PR	0	0	1	1
2002	08	CCCCC	PR	2	2	0	1

Notes: This Table reports total number of fatalities, total number of major and total number of minor injuries involving only experienced drivers aged 35 to 44 years old by accident, month and municipality.

Table B.5.7: Total number of fatalities, major and minor injuries per month per municipality (drivers aged 45 to 54 years old)

Year	Month	Municipality name	Province name	Total number of fatalities	Total number of major injuries	Total number of minor injuries	Total number of accident
2002	08	BBBBB	PR	1	0	0	1
2002	08	CCCCC	PR	2	2	0	1

Notes: This Table reports total number of fatalities, total number of major and total number of minor injuries involving only experienced drivers aged 45 to 54 years old by accident, month and municipality.

Table B.5.8: Total number of fatalities, major and minor injuries per month per municipality (drivers aged 65 to 90 years old)

Year	Month	Municipality name	Province name	Total number of fatalities	Total number of major injuries	Total number of minor injuries	Total number of accident
2002	08	BBBBB	PR	0	1	1	1

Notes: This Table reports total number of fatalities, total number of major and total number of minor injuries involving only experienced drivers aged 65 to 90 years old by accident, month and municipality.

Step 6: Calculation of different accident rates In the last step, I obtained the different accident rates using the following formulas: [22]

[22] The accident rates refers to the accident number rate, the accident rate with fatalities and injuries, the accident rate with fatalities and major injuries, the accident rate with fatalities, the accident rate with injuries (major and minor), the accident rate with major injuries and the accident rate with minor injuries.

$$ANR_{tm} = \frac{10,000}{Pop} \times TAN_{tm}$$

AR_{tm} refers to the accident number rate per month and year t, and per 10,000 inhabitants of each population group of the municipality m; Pop is the population of each age group (subgroup) of the driver in each municipality.

$$FIR_{tm} = \frac{10,000}{Pop} \times TNFIR_{tm}$$

FIR_{tm} refers to the accident rate with fatalities and injuries per month and year t, and per 10,000 inhabitants of each population group of the municipality m;

$$FMaIR_{tm} = \frac{10,000}{Pop} \times TNFMaI_{tm}$$

$FMaIR_{tm}$ refers to the accident rate with fatalities and major injuries per month and year t, and per 10,000 inhabitants of each population group of the municipality m;

$$FR_{tm} = \frac{10,000}{Pop} \times TNF_{tm}$$

FR_{tm} refers to the accident rate with fatalities per month and year t, and per 10,000 inhabitants of each population group of the municipality m;

$$IR_{tm} = \frac{10,000}{Pop} \times TNI_{tm}$$

IR_{tm} refers to the accident rate with injuries per month and year t, and per 10,000 inhabitants of each population group of the municipality m;

$$MaIR_{tm} = \frac{10,000}{Pop} \times TNMaI_{tm}$$

$MaIR_{tm}$ refers to the accident rate with major injuries per month and year t, and per 10,000 inhabitants of each population group of the municipality m;

$$MiIR_{tm} = \frac{10,000}{Pop} \times TNMiI_{tm}$$

$MiIR_{tm}$ refers to the accident rate with minor injuries per month and year t, and per 10,000 inhabitants of each population group of the municipality m.

Example: Consider the Table B.6.1 derived from that Table B.5.1

Table B.6.1: Total number of fatalities, major and minor injuries by accident involving drivers aged 16 to 90

Year of accident	Month	Municipality name	Total number of fatalities (TNF)	Total number of major injuries (TNMaI)	Total number of minor injuries (TNMiI)	Total number of accident (TNA)	Total number of fatalities and injuries (TNFI)	Population of the municipality (Pop_{16-90})
2002	08	AAAAA	0	0	1	1	0+0+1=1	15000
2002	08	BBBBB	1	1	1	2	1+1+1=3	20000
2002	08	CCCCC	2	2	0	1	2+2+0=4	25000

So for my example above, the accident rates for the 16-90 age group (see Table B6.1) are: For the municipality AAAAA, I have:

$$ANR_{tm} = \frac{10,000}{15,000} \times 1 = 0.666666$$

$$FIR_{tm} = \frac{10,000}{15,000} \times 1 = 0.666666$$

$$FR_{tm} = \frac{10,000}{15,000} \times 0 = 0$$

For the municipality BBBBB

$$ANR_{tm} = \frac{10,000}{20,000} \times 2 = 1$$

$$FIR_{tm} = \frac{10,000}{20,000} \times 3 = 1.5$$

$$FR_{tm} = \frac{10,000}{20,000} \times 1 = 0.5$$

For the municipality CCCCC

$$ANR_{tm} = \frac{10,000}{25,000} \times 1 = 0.4$$

$$FIR_{tm} = \frac{10,000}{25,000} \times 4 = 1.6$$

$$FR_{tm} = \frac{10,000}{25,000} \times 2 = 0.8$$

Table B.6.2: Total number of fatalities, major and minor injuries by accident involving drivers aged 16 to 24

Year of accident	Month	Municipality name	Total number of fatalities (TNF)	Total number of major injuries (TNMaI)	Total number of minor injuries (TNMiI)	Total number of accident (TNA)	Total number of fatalities and injuries (TNFI)	Population of the municipality (Pop_{16-24})
2002	08	CCCCC	2	2	0	1	4	7600

From Table B.6.2, I have for the only municipality CCCCC

$$ANR_{tm} = \frac{10,000}{7,600} \times 1 = 1.31$$

$$FIR_{tm} = \frac{10,000}{7,600} \times 4 = 5.26$$

$$FR_{tm} = \frac{10,000}{7,600} \times 2 = 2.63$$

Table B.6.3: Total number of fatalities, major and minor injuries by accident involving drivers aged 25 to 90

Year of accident	Month	Municipality name	Total number of fatalities (TNF)	Total number of major injuries (TNMaI)	Total number of minor injuries (TNMiI)	Total number of accident (TNA)	Total number of fatalities and injuries (TNFI)	Population of the municipality (Pop_{25-90})
2002	08	AAAAA	0	0	1	1	1	10000
2002	08	BBBBB	1	1	1	2	3	16150
2002	08	CCCCC	2	2	0	1	4	17400

From Table B.6.2, I have for the municipality CCCCC

$$ANR_{tm} = \frac{10,000}{17,400} \times 1 = 0.57$$

$$FIR_{tm} = \frac{10,000}{17,400} \times 4 = 2.29$$

$$FR_{tm} = \frac{10,000}{17,400} \times 2 = 1.15$$

Appendix C

Appendix C.1

"*As I said, Mr. Speaker, I do not intend to discuss in great detail what must be an obvious fact to all members of the Legislature, that is, the very tragic statistics we are aware of on a day-to-day basis in relation to the carnage on our highways.... Without doubt many of these tragedies are, as we all know, related to alcohol abuse on the highway. There is no question but that this problem has commanded and should command the attention of every responsible citizen. I would think any future civilization, looking back on ours and seeing the number of lives that were either lost or destroyed, the mutilation that occurs every day on the highway, will reflect with some degree of wonderment on why we demonstrated the relative degree of tolerance we do demonstrate to such a critical problem.*"

Appendix C.2

"*Drinking and driving, of course, has a devastating effect on the families and friends of those who are injured or killed in alcohol-related crashes. It also increases the cost to society in terms of insurance, health care, and other government services. As a result of this, an all-party committee on drinking safety of eight MLAs (Member of the Legislative Assembly) toured the province consulting with people on proposed legislation. Their recommendations were as follows. They recommended a reduction in the roadside suspension blood-alcohol content level for all drivers from .06 per cent to .04 per cent. They also recommended that driving without impairment, DWI program, be mandatory for new drivers losing their licence the first time with a BAC (blood alcohol concentration) of .04 per cent. In the case of experienced drivers, a DWI course would be required after a second suspension.*"

Appendix C.3

"*We are not here to debate the merits of graduated licensing or to discuss whether or not such a system is needed. The collision statistics on our roads and highways serve as a grim reminder of the pressing need for strong and effective action. I would like to quickly review some of the reasons for introducing the new licensing system. In 1991, the Ministry of Transportation issued more than 350,000 licences to new Ontario drivers. Some 45% of those new drivers, more than 150,000 people, were between the ages of 16 and 19. As members know, traffic collisions are the leading killer of Ontario residents between the ages of 16 and 24. Indeed, crashes take the lives of twice as many young people as suicide and five times as many as cancer. Drivers between 16 and 24 represent about 16% of the province's six million licensed drivers, yet they account for 25% of all drivers killed. At the same time, statistics show that all new drivers, regardless of their age, are far more likely to be involved in serious or fatal collisions than drivers with more experience. Studies have concluded that it takes between two and five years of driving experience to develop all the skills and the judgement needed to avoid collisions. The government's graduated licensing model responds* *directly to these problems and concerns. As you know, the proposed new system is designed to grant driving privileges gradually during a new driver's first two years on the road. But rest assured that we do not propose these restrictions lightly. In 1991, more than 1,000 people were killed in car crashes and more than 90,000 people were injured. In the past 10 years, automobile collisions have resulted in more than 13,000 fatalities in Ontario. The government believes that graduated licensing will help save many of these lives. In New Zealand, fatalities among drivers under 25 were reduced by some 13% when a graduated licensing system for that age group was introduced in 1987. We are convinced that the system will save millions of dollars in insurance costs, health care expenditures and costs related to lost time at work and school, not to mention the costs associated with the human tragedy of motor vehicle crashes. Indeed, the total cost of road collisions in Ontario has been estimated at some $9 billion a year. This, then, is the situation that we are here to address: We have overwhelming statistical evidence that new drivers pose a serious safety threat to themselves and to others. We have further evidence that new drivers' lack of experience involves a heavy cost in lives and money, and we have proposed a new licensing system designed to address these problems.*"

Appendix C.4: **Example of the mechanism by which the population influences the establishment and the vote of a law**

Considering two provinces under this study (Ontario and Quebec), It is more likely for a random voter in the province of Ontario to know more voters in the province of Quebec than voters in Manitoba for the simple reason that Quebec is more populated than Manitoba. In this context, having learned about the content and impact of the BAC law and GDL program put in place in Ontario for example, voters in Quebec could exert pressure on their legislators so that these laws or programs are also implemented in their province. The implementation of the BAC law or the GDL program will depend greatly on the voters and therefore the size of the population. The implementation of a similar law in several provinces, will therefore be influenced in different ways by voters because of the size of the population.