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Association Between Road Traffic Accidents and Economic Growth with a Special Focus on Alcohol Consumption – A Comparison of Six Alpine Countries

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Abstract: By preventing traffic accidents, the economic burden on health care can be reduced. The aim of our research was to examine the relationship between road traffic accidents with injuries and changes in the number of passenger cars per thousand inhabitants with regard to economic development and alcohol consumption in the Alpine region. A study on the ecological relationships was conducted for the Alpine countries that had data going back at least 20 years. Spearman's rank correlations were used for analysis. Road traffic accidents involving injuries were significantly and negatively correlated with years, Gross domestic product and cars per thousand inhabitants. A significant positive correlation was found between road traffic accidents and alcohol consumption. In conclusion, an increase in the number of cars in itself does not lead to more accidents and avoidable deaths in any country. Therefore, policy makers should consider investigating the introduction of zero tolerance in these countries.

Keywords: Road Traffic Accidents, Road Traffic Accidents with Injuries, Pure Alcohol Consumption, Economic Growth, Alpine Region,

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INTRODUCTION

Transportation is a necessary component of economic development and has driven Gross Domestic Product (GDP) growth (Wang, 2020). Economic prosperity entails a higher number of vehicles, so it can be assumed that the number of traffic accidents would increase. Injuries and fatalities are influenced by the quality and type of vehicles used for transportation, for instance, the repercussions of a traffic accident in which motorcycles are involved are usually more dangerous for the individual than traffic accidents involving automobiles (Scuffham, 2003). In a Brazilian research study the relationship between GDP and three variables linked (traffic accident mortality, deaths per vehicle; and vehicles per inhabitant) to traffic accidents were analysed. They found that the aforementioned variables' distribution indicate that GDP and vehicles per capita maintained a similar increasing rate between 2005 and 2015. On the other hand, mortality rates show a decreasing association with GDP. Corresponding to what was observed in developed countries, the relation between mortality by traffic accidents and GDP changed in the analysed period 2005 and 2015 (Pinheiro et al., 2021). Driving under the influence of alcohol is an important risk factor in traffic accidents, which cause high levels of morbidity and mortality globally (Haghpanahan et al., 2019). A Spanish study found a positive correlation between alcohol consumption and traffic death rates (Arranz & Gil, 2009). This correlation confirms it to be a major problem for public health and safety worldwide (Christophersen et al., 2016). In the context of driving, zero tolerance laws (ZTLs) typically prohibit any amount of alcohol in the bloodstream while driving. This means that drivers cannot have a blood alcohol concentration (BAC) above 0.00%, or in some cases, a very low limit such as 0.02% or 0.05%. Alcohol consumption is a leading cause of accidents, including traffic accidents, workplace accidents, and accidents at home. In fact, according to the National Highway Traffic Safety Administration (NHTSA), alcohol-impaired driving accounted for 28% of all traffic fatalities in the United States in 2019 (National Highway Traffic Safety Administration., 2020; Alcohol-Impaired Driving., 2020)

Alpine countries include 8 countries, namely Austria, Switzerland, France, Germany, Italy, Slovenia, Monaco and Liechtenstein. In Alpine countries, transport is based on the principle of 0.05% blood alcohol concentration (BAC) tolerance. Several studies have examined these countries together because of their economic and cultural similarities (Dupire et al., 2020; ESPON, 2020; Tallinucci et al., 2003).

Research indicates that ZTLs on their own show weak correlation with the road safety performance of countries, although, positive effects were found in some cases (Straßgütl & Evers, 2022) or in the worst case, no impact was identified (Modijefski et al., 2021). We can assume that ZTLs cannot be deemed counterproductive measures. Therefore, taking into consideration the introduction of ZTLs in combination with media publicity and persistent police enforcement, as such, could prove to be an effective deterrence (Hosseinichimeh et al., 2022). The European Commission's Recommendation (2001/115/EC) on the maximum BAC advised member states to adopt random breath testing as part of enforcement to strengthen deterrence. Based on a recent 4-year retrospective study any blood alcohol concentration can be misleading due to the delay between an accident and the sample collection (Cittadini et al., 2023).The aim of the research was to investigate the relationship between economic development, number of road traffic accidents, the increase in the number of passenger cars and the rate of alcohol consumption in the Alpine region for the countries where at least 20 years of data could be obtained.

METHODOLOGY

In the present analysis indicators from the World Health Organization's (WHO) "Health for All" (HFA) and the Organisation for Economic Co-operation and Development's (OECD) online database were used. (European Health for All Database, 2023; The Organisation for Economic Co-Operation and Development, 2023) These data could be used to assess the European Region's fundamental demographics, health status, healthcare resources and expenditures. The following indicators were used: pure alcohol consumption, litres per capita, age 15+ (HFA_426); road traffic accidents with injury per 100,000 (HFA_436); passenger cars per 1,000 inhabitants and GDP. GDP statistics were extracted from version 10 of the "Penn World Table" (PWT) (University of Groningen, 2023), an online database comprising data on income. The database included output side real GDP at current PPPs (purchasing power parities) in order to assess relative living standards between nations across time, as well as the populations of countries (in millions). These two indicators were divided to get the GDP per capita.

Using minimum 20 years of data from 2000 to 2019, a study on ecological correlations was executed for

six Alpine countries which are the following: Austria, Switzerland, France, Germany, Italy and Slovenia. There was not enough data available regarding Monaco and Lichtenstein; thus, these countries were excluded from the analysis.
All data were presented by line charts. In order to analyse the relationship between economic growth, pure alcohol consumption, road traffic accidents and the number of passenger cars on mostly asymmetric datasets spearman rank correlations were executed. Correlation coefficients were calculated with p-values. The results were considered significant if the p-values from the given statistical analysis were less than 0.05.

RESEARCH RESULTS

In Austria the pure alcohol consumption per capita was 13.35 litres in the year 2000 with 685.62 road traffic accidents with injury per 100,000 (Figure 1). In the given year 500.53 passenger cars were available per 1,000 inhabitants with a GDP of 38,984.87 USD. On the one hand, pure alcohol consumption decreased over the years to a value of 11.90 litres and the rate of road traffic accidents decreased as well to 510.78 per 100,000 people by the year of 2019. On the other hand, GDP and the number of cars increased by the year of 2019, GDP was 55,613.25 USD and the available number of cars was approximately 560.69 per 100,000 people.
The rate of road traffic accidents significantly (rho=-0.914, p<0.001) decreased over the years and it was significantly negatively correlated with GDP (rho=-0.914, p<0.001), which means that as the GDP increased in the country then the rate of accidents decreased. Furthermore, the number of passenger cars showed a significant negative association (rho=-0.832, p=0.001) with accidents. However, increase in pure alcohol consumption was significantly (rho=0.646, p=0.002) related to the increase of road traffic accidents and it was negatively correlated (rho=-0.673, p=0.001) with GDP. During the years studied, time and the pure alcohol consumption showed a negative correlation (rho=-0.700; p<0.001).
The pure alcohol consumption per capita was 11.26 and 11.12 litres in Switzerland in the year of 2000 and 2001 with 417.34 road traffic accidents with injury per 100,000 in 2001 (Figure 2). While 493.441 passenger cars were available per 100,000 inhabitants. The GDP was 48.391.4 USD in 2000 which increased to 71831.6 in 2019.
Apart from a minor temporary increase related to the pure alcohol consumption, it decreased over the years to a value of 9.41 in the year of 2019 and the rate of road traffic accidents decreased to 253.95 per 100,000 people. Meanwhile the cars per 1,000 inhabitants increased to 539.22.
During the time frame of the study, pure alcohol consumption was significantly positively (rho=0.961, p<0.001) associated with road traffic accidents, however, during the years a negative trend was observed (rho=-0.984, p<0.001) regarding road traffic accidents. Furthermore, traffic accidents were negatively correlated (rho=-0.965; p<0.001) with GDP. In addition, GDP and alcohol consumption was negatively associated (rho=-0.939, p<0.001) and a negative association was observed regarding road traffic accidents and number of passenger cars (rho=-0.939, p<0.001) in Switzerland. During the years a strong negative correlation was found between time and the alcohol consumption per capita (rho=-0.968; p<0.001).
The pure alcohol consumption per capita was 12.91 litres in 2000 which decreased to 10.56 litres by the year of 2019 (Figure 3). Between 2000 and 2019 the rate of road traffic accidents with injury decreased from 613.3 to 477.47 per 100,000 inhabitants. In 2000 GDP was 37,226.3 USD which increased over the years to 51,592.6 USD. The indicator of passenger cars per 1,000 citizens was 521.095 in 2000, which increased to 566.784 by the year of 2019.
During the years observed pure alcohol consumption per capita showed a significant negative trend (rho=-0.981; p<0.001), the same negative association was found regarding road traffic accidents and time (rho=-0.765; p<0.001), which means that as the years passed a significant negative correlation was found. The increase of GDP had a significant negative correlation with road traffic accidents (rho=-0.744; p<0.001) and with alcohol consumption (rho=-0.962; p<0.001). Road traffic accidents per 100,000 inhabitants showed a significant correlation (rho=0.708; p=0.001) with alcohol consumption, furthermore, it was not associated with passenger cars per 1,000 inhabitants (rho=0.027; p=0.910).
The pure alcohol consumption in Slovenia was 12.80 litres per capita with a GDP of 24,453.4 USD in 2000, while the pure alcohol consumption decreased to 11.05 litres with GDP of 39,716.3 USD by 2019 (Figure 4). In 2000 there were 426.361 passenger cars per 1,000 inhabitants with 613.03 road traffic accidents with injury, and the rate of passenger cars increased to 552.593 and the road traffic accidents decreased to 362.32 in 2019.
In Slovenia a non-significant negative association was found between the years and pure alcohol consumption (rho=-0.381; p=0.098), but a significant correlation was found towards road

traffic accidents (rho=-0.881; p<0.001). Road traffic accidents was positively, but non-significantly associated with alcohol consumption (rho=0.307; p=0.188), and it was negatively correlated with GDP (rho=-0.735; p<0.001). The passenger cars per 1,000 inhabitants showed a negative association with road traffic accidents (rho=-0.853; p=0.001). An increase in the GDP had a negative but non-significant association with pure alcohol consumption (rho=-0.304; p<0.200).

The pure alcohol consumption per capita in Italy was 9.78 litres in 2000 and it decreased to 7.65 litres by the year of 2019 (Figure 5). The rate of road traffic accidents with injury per 100,000 was 632.45 in 2000 and it decreased 399.5 between 2000 and 2019. In 2000 GDP was 36,713.8 USD which increased over the years to 41,427,0 USD. Meanwhile passenger cars per 1,000 citizens was 572.2 in 2000, which increased to 662.1 by the year of 2019.

During the years studied the pure alcohol consumption per capita showed a significant negative trend (rho=-0.731; p<0.001), the same negative association was found regarding road traffic accidents and time (rho=-0.990; p<0.001), therefore as the time passed a significant negative correlation was found between the variables. An increase regarding GDP had a significant negative correlation with road traffic accidents (rho=-0.741; p<0.001) and with alcohol consumption (rho=-0.588; p=0.006).

The rate of passenger cars per 1,000 inhabitants showed a significant correlation (rho=-0.868; p<0.001) with road traffic accidents. Furthermore, a positive correlation (rho=0.725; p<0.001) was found between pure alcohol consumption and road traffic injuries.

In France the pure alcohol consumption per capita was 13.92 litres in the year 2000 with 274.60 road traffic accidents with injury per 100,000 (Figure 6). In that year 455.90 passenger cars were available per 1,000 inhabitants with a GDP of 35,082.44 USD. Pure alcohol consumption decreased over the years to 11.44 litres, in addition the rate of road traffic accidents decreased as well to 108.98 per 100,000 people by the year of 2019. Furthermore, GDP and the number of cars increased by the year of 2019, GDP was 44,823 USD and the available number of cars was equal to 558,35 per 100,000 people.

Road traffic accidents significantly (rho=-0.979, p<0.001) decreased over the years and it was significantly negatively correlated with GDP (rho=-0.935, p<0.001), which means that an increase in GDP could contribute to a decrease regarding the rate of accidents. Furthermore, the number of passenger cars was significantly (rho=-0.979, p=0.001) negatively associated with accidents. Furthermore, increase in pure alcohol consumption was significantly (rho=0.975; p<0.001) related to the increase of road traffic accidents and it was negatively correlated (rho=-0.934; p<0.001) with GDP. During the years studied, time and the pure alcohol consumption showed a negative correlation (rho=-0.979; p<0.001).

CONCLUSIONS

The analysis of economic growth, as measured by GDP, and road traffic accidents in the six examined Alpine countries reveals several significant associations. In general, an increase in GDP was found to be inversely related to the rate of road traffic accidents in these countries. This negative correlation suggests that as the economic prosperity of a country grows, there is a corresponding decrease in the rate of road traffic accidents. This finding aligns with previous research that highlights the positive impact of economic development on road safety (Kopits & Cropper, 2005; Yannis et al., 2014). The analysis also indicates a significant negative correlation between road traffic accidents with injuries and the number of passenger cars per 1,000 inhabitants. This finding might indicate that traffic related accidents are linked to vehicle ownership, although the confounder-unadjusted correlation is not in the direction that would have been expected, as the presence of more cars on the roads did not have a positive effect on the number of accidents (Kopits & Cropper, 2005; Yannis et al., 2014). This correlation may be due to the fact that the indicator presents injury-related data and it does not take into account the minor accidents that are not recorded or reported. The role of alcohol consumption as a potential contributing factor for road traffic accidents is another crucial aspect of this study. Across the Alpine countries involved in our study, a consistent positive correlation was observed between pure alcohol consumption and road traffic accidents. This correlation highlights the fact the significance of addressing alcohol-related issues in road safety efforts. It aligns with previous research that has highlighted the global public health concern associated with alcohol-related accidents (Chikritzhs & Livingston, 2021). The discussion of alcohol-related road safety should also include the concept of ZTLs, which prohibit any detectable level of alcohol in the bloodstream while driving. Research indicates mixed findings on the direct impact of ZTLs on road safety. While some studies suggest positive effects (Straßgütl & Evers, 2022), others indicate no significant impact (Howard, Harris & McIntyre, 2020; Hoekstra & Wegman,

2011). However, it is important to recognize that ZTLs, in combination with media campaigns and rigorous police enforcement, may collectively serve as effective deterrents to reduce alcohol-related accidents (Young et al., 2018). The study's findings carry important policy implications for the Alpine countries and other regions with similar economic and cultural characteristics. Policy makers should consider the potential benefits of continued economic growth in improving road safety. Additionally, the importance of effective measures to combat alcohol-impaired driving, such as ZTLs and awareness campaigns, should not be underestimated (Negussie et al., 2018). Finally, this study opens avenues for future research, since further investigation could delve into the effectiveness of specific road safety measures, the impact of cultural and social factors on road traffic accidents, and the evaluation of alternative policies to combat alcohol-related accidents.

Ecological study design, found on county level associations and correlations could not be traced back to individuals. The primary strength of the study is that 20 years of data could be examined for several factors. One limitation is the potential bias associated with blood alcohol concentration, which could not apply due to the lack of this indicator from monitoring systems available online. Finally, the present study lacks the data regarding Monaco and Liechtenstein.

In summary, this study contributes insights into the complex interplay between economic growth, alcohol consumption, and road traffic accidents in the Alpine countries. It highlights the need for comprehensive road safety strategies that consider economic development, alcohol policies, and effective enforcement measures to mitigate the risks associated with road traffic accidents.

Availability of the data and materials

The data presented in this study are available to the public (World Health Organization, European Health Information Gateway: https://gateway.euro.who.int/en/hfa-explorer/ and Groningen Growth and Development Centre: https://www.rug.nl/ggdc/productivity/pwt/?lang=en).

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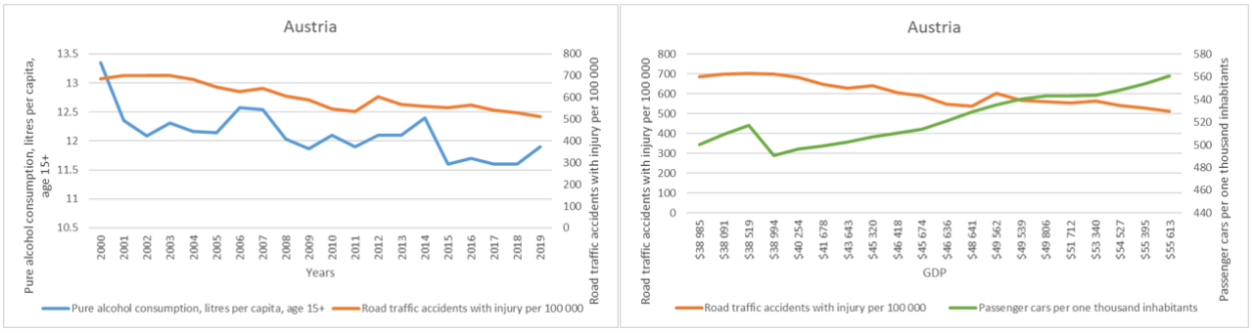

Figure 1.
(A) Pure alcohol consumption and road traffic accidents in Austria from 2000 to 2019.
(B) The connection between GDP per capita with road traffic accidents and passenger cars in Austria.

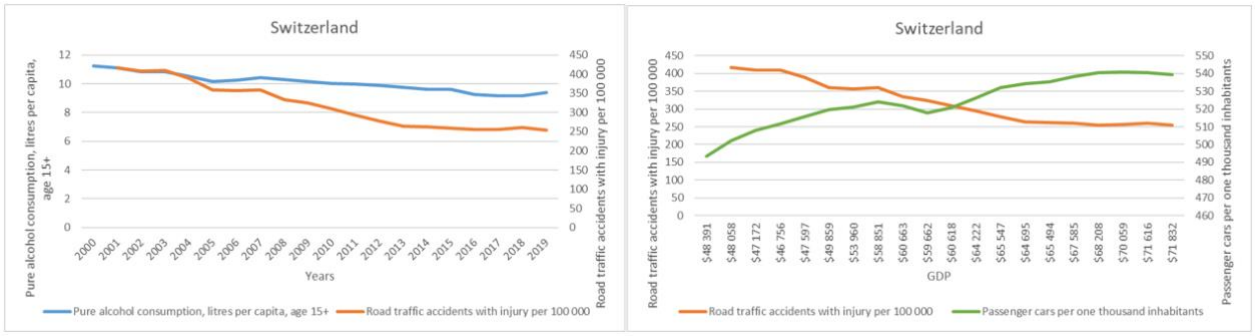

Figure 2.
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(B) The connection between GDP per capita with road traffic accidents and passenger cars in Switzerland.

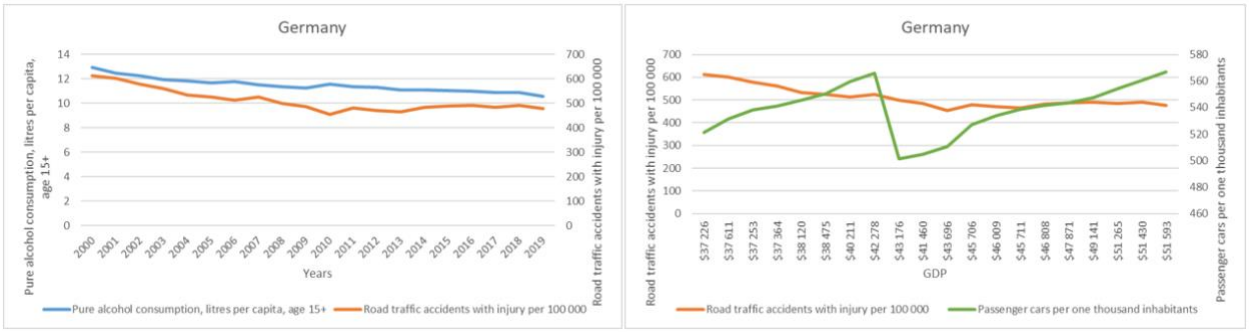

Figure 3.
(A) Pure alcohol consumption and road traffic accidents in Germany from 2000 to 2019.
(B) The connection between GDP per capita with road traffic accidents and passenger cars in Germany.

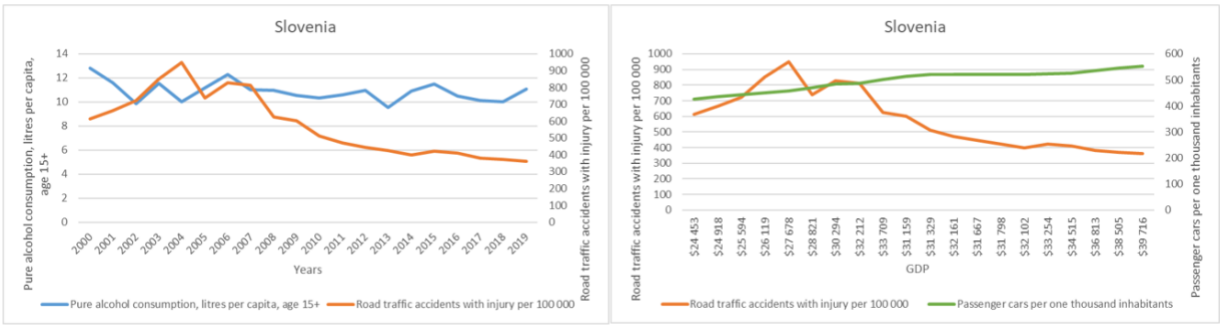

Figure 4.
(A) Pure alcohol consumption and road traffic accidents in Slovenia from 2000 to 2019.
(B) The connection between GDP per capita with road traffic accidents and passenger cars in Slovenia.

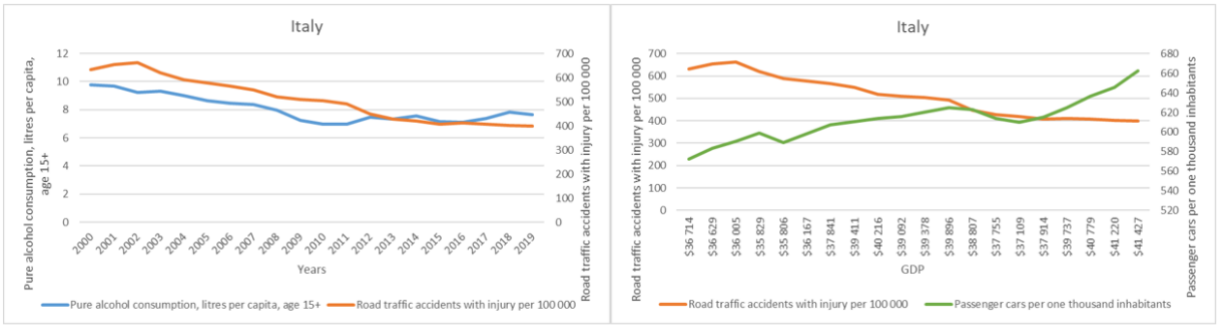

Figure 5.
(A) Pure alcohol consumption and road traffic accidents in Italy from 2000 to 2019.
(B) The connection between GDP per capita with road traffic accidents and passenger cars in Italy.

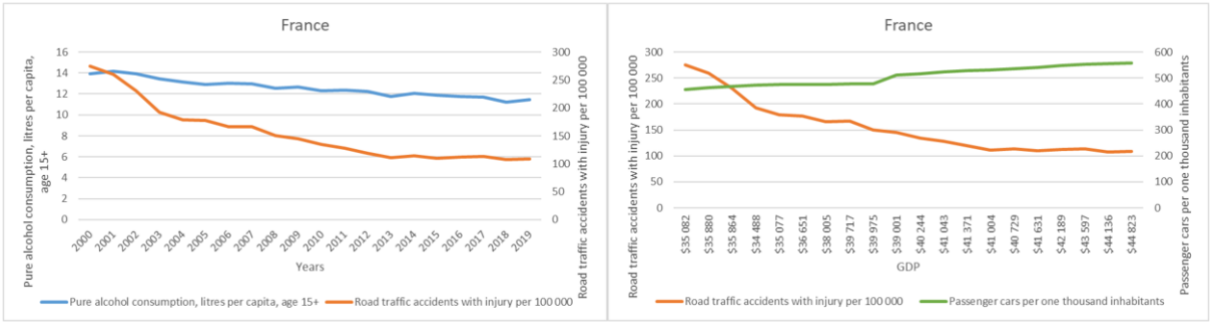

Figure 6.
(A) Pure alcohol consumption and road traffic accidents in France from 2000 to 2019.
(B) The connection between GDP per capita with road traffic accidents and passenger cars in France.