Road to Safety: Traffic Accident Analysis

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1. Introduction

Welcome to the "Road to Safety: Traffic Accident Analysis" challenge, an initiative that blends the prowess of artificial intelligence with the pressing need for safer roads. In this journey, we venture into the realm of data analysis, focusing our efforts on the critical issue of traffic accidents in Catalunya.

As a data scientist participating in this challenge, I am thrilled to delve into a rich dataset, teeming with intricate details of traffic incidents. My objective is clear: to sift through this wealth of information, unearth patterns, and construct predictive models that shed light on the underlying causes of road accidents.

This report is designed to serve two fundamental purposes:

1. **Unveiling Insights**: Here, I aim to present a clear and accessible analysis of the data. By weaving through the complexities of the dataset, I intend to bring forward the primary factors contributing to traffic accidents, any unexpected trends that emerge, and the implications these hold for road safety.
2. **Proposing Solutions**: The insights gleaned are not just for academic interest; they are stepping stones towards tangible change. In this report, I will propose practical, actionable recommendations aimed at mitigating the risks of road accidents. These suggestions may range from policy reforms to modifications in road infrastructure, all geared towards a safer future on the roads of Catalunya.

2. Key Findings

3. Data Visualizations

4. In-depth Analysis

4.1 General Trends

(What are the overall trends in traffic accidents, fatalities, and serious injuries in Catalonia from 2010-2021?)

Figure 1, as described, provides a comprehensive view of traffic accident trends in Catalonia from 2010 to 2021, both in absolute and relative terms. The chart is divided into two subplots, with the top depicting absolute numbers and the bottom showing relative changes over time. Let's discuss the key findings from both aspects:

Absolute Terms (Top Subplot)

1. **Overall Decrease in Traffic Accidents:** The data indicates a general decline in the total number of traffic accidents over the 11-year period. This could be attributed to various factors, including improvements in road safety, better enforcement of traffic laws, or advances in vehicle safety features.
2. **Serious Injuries as the Most Common Outcome:** Among the three categories (fatalities, serious injuries, and light injuries), serious injuries are reported as the most frequent outcome of traffic accidents. This highlights the severity of many traffic incidents, even if they are not fatal.
3. **Ranking of Categories:** The order of prevalence is serious injuries, followed by light injuries, and lastly fatalities. This distribution suggests that while many accidents result in injury, a smaller proportion are fatal. The relatively lower number of fatalities, compared to injuries, could be indicative of effective emergency response and medical care.

Relative Terms (Bottom Subplot)

1. **Decreasing Trend Across All Categories:** All three categories - fatalities, serious injuries, and light injuries - show a decreasing trend in relative terms. This suggests that not only are there fewer accidents, but the severity of these accidents is also diminishing.
2. **Comparative Decrease in Categories:** While all categories show a decrease, light injuries and fatalities have decreased more significantly (around 40%) compared to serious injuries (around 30%). This disparity in reduction rates might reflect different rates of improvement in safety measures or medical care, or it could indicate changes in the nature or reporting of these incidents.
3. **Implications of Relative Trends:** The relative trends are particularly insightful because they provide a context for the absolute numbers. For instance, a decrease in light injuries and fatalities at a higher rate than serious injuries might imply that interventions have been more effective in preventing less severe and fatal accidents.

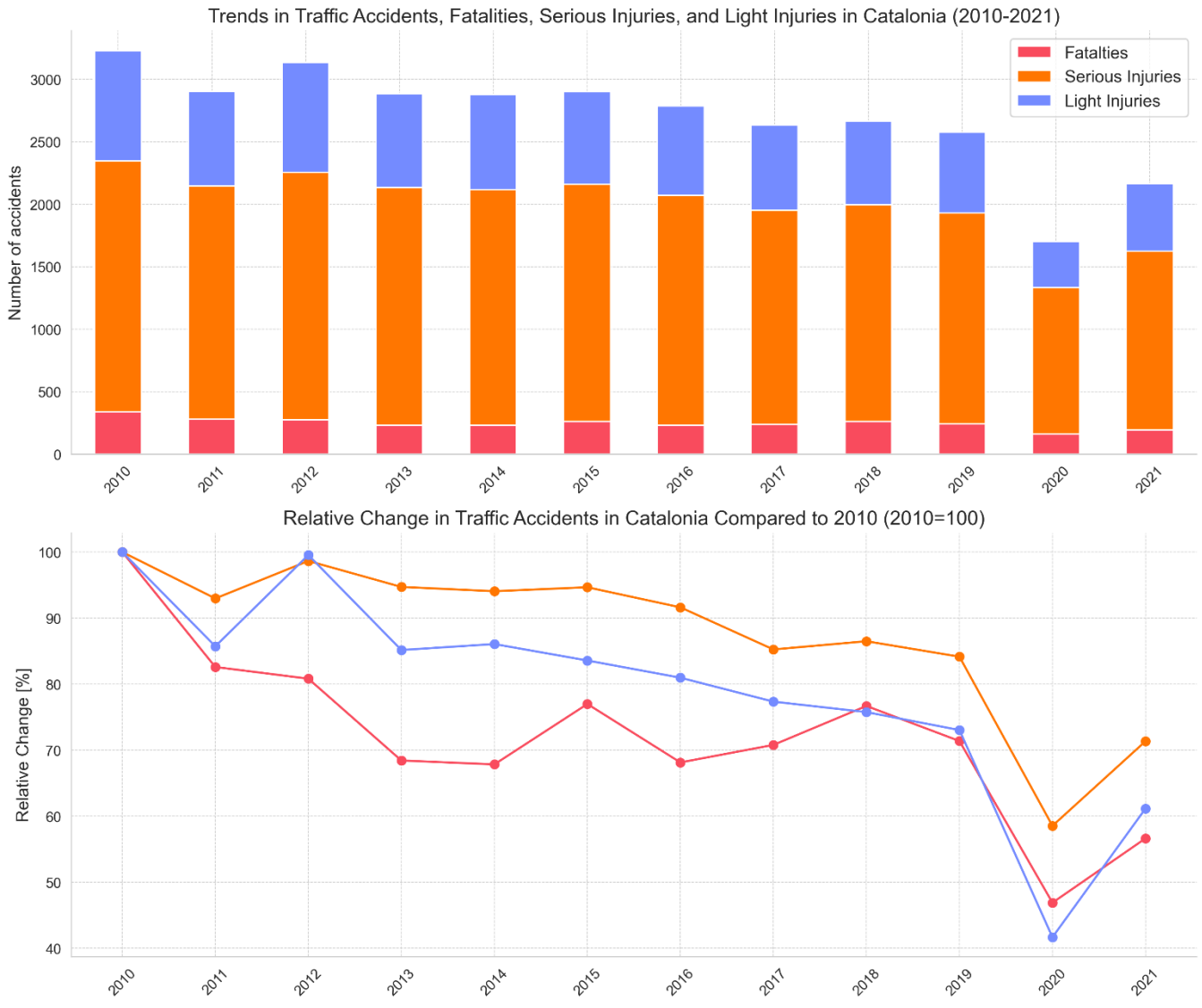


Figure 1 Trends in traffic accidents, fatalities, and serious injuries in Catalonia from 2010-2021.

Overall Interpretation

The data presents an encouraging picture of improving road safety in Catalonia. The overall reduction in traffic accidents and their severity is a positive sign, possibly reflecting successful road safety policies, public awareness campaigns, advancements in vehicle safety, and medical care improvements. However, the fact that serious injuries still constitute the largest proportion of accidents suggests a need for targeted interventions. It would be beneficial to understand why serious injuries have not decreased at the same rate as other categories and to address this issue specifically in future road safety strategies.

4.2 Accident Characteristics

What common characteristics (time of day, type of road, etc.) are observed in the most severe accidents?

Figure 2 provides a comprehensive overview of severe traffic accidents (fatalities and serious injuries) from 2010 to 2021, aggregated to highlight key characteristics. This figure breaks down the accidents based on various conditions such as time of day, type of road, weather conditions, lighting conditions, and road surface conditions. It offers insights into the most common scenarios under which severe accidents have occurred during this period.

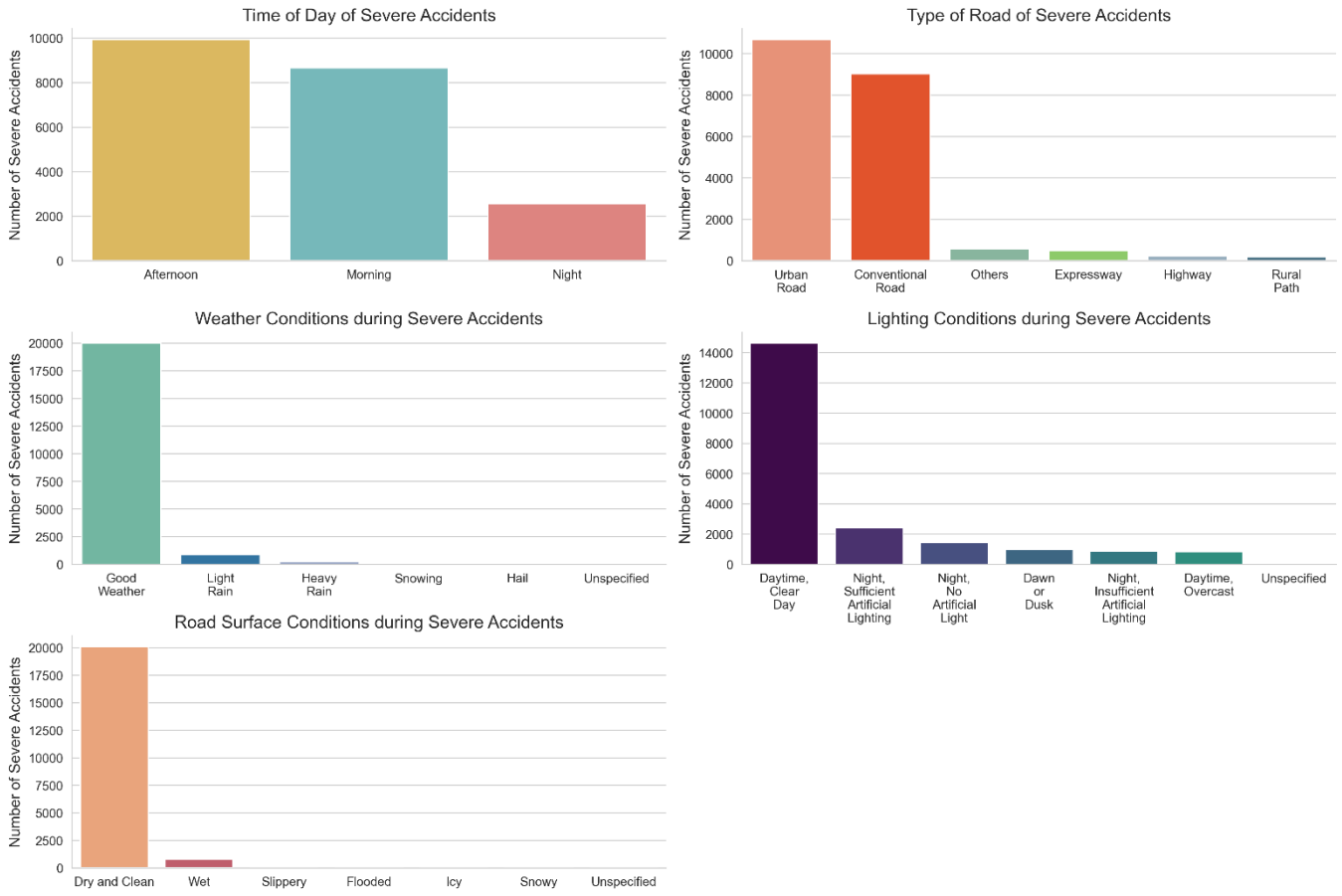


Figure 2 Characterization of severe accidents conditions: time of day, type of road, Weather conditions, Light conditions and road surface.

1. **Time of Day:** Most severe accidents occur in the afternoon and morning. The frequency of accidents drops significantly during the night.
2. **Type of Road:** Urban roads and conventional roads see the highest number of severe accidents. Highways have a notably lower incidence of severe accidents.
3. **Weather Conditions:** Good weather or light rain are the most common conditions during severe accidents. Extreme weather like heavy rain and snow are less common, possibly due to less traffic or more cautious driving in such conditions.
4. **Lighting Conditions:** Most accidents happen in clear daylight or at night with sufficient artificial lighting, indicating that poor lighting is not a major factor in severe accidents.
5. **Road Surface Conditions:** Dry and clean road surfaces are predominant in severe accidents, with wet conditions being less common. This might indicate good road maintenance or effective drainage systems.

Figure 3 delves into the trends of severe accidents over the years, from 2010 to 2021, offering a temporal perspective on the data. By examining the same categories as in Figure 2 — time of day, type of road, weather,

lighting, and road surface conditions — this figure reveals how the patterns of severe accidents have evolved year by year. It provides a deeper understanding of whether certain types of accidents are becoming more or less common and highlights the effectiveness of road safety measures over time.

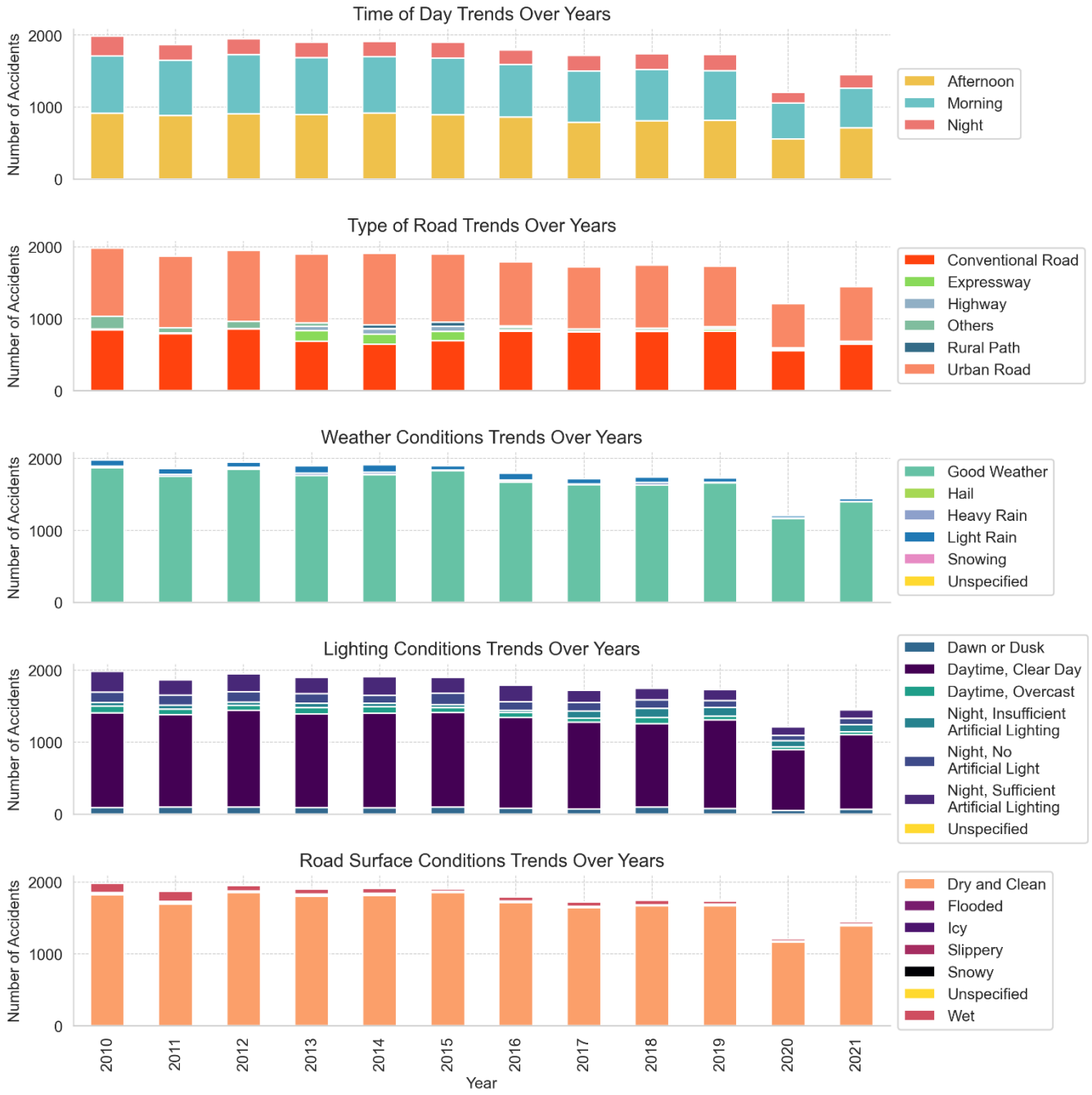


Figure 3 Trends of severe accidents conditions over the years: time of day, type of road, Weather conditions, Light conditions and road surface.

1. **Weather-Related Trends:** There is a noticeable decrease in severe accidents occurring during light rain and on wet roads over the years. This could suggest the effectiveness of weather-related safety policies or infrastructure improvements, like better road drainage or more effective public awareness campaigns during rainy conditions.

2. **Stability in Other Conditions:** The rest of the data aligns with the aggregated view in Figure 2, but the year-by-year analysis doesn't show significant shifts in other categories. This consistency might indicate that the overall driving conditions and behaviors have remained relatively stable over this period.

4.3 Geographical Insights

Which municipalities or counties in Catalonia have the highest incidence of traffic accidents? How does this correlate with population density or road network characteristics?

Barcelona, as the most populous municipality, unsurprisingly leads in the absolute number of accidents (Figure 4). However, when accounting for population size, Barcelona exhibits a lower rate of accidents per capita, contrasting with less populous municipalities. This finding is critical in understanding the impact of population density on traffic accident rates. Figure 5 provides a per capita perspective, showing that smaller municipalities, despite fewer total accidents, have higher accident rates per capita. This could indicate varying driving behaviors, road conditions, or safety measures in less populated areas compared to a metropolis like Barcelona.

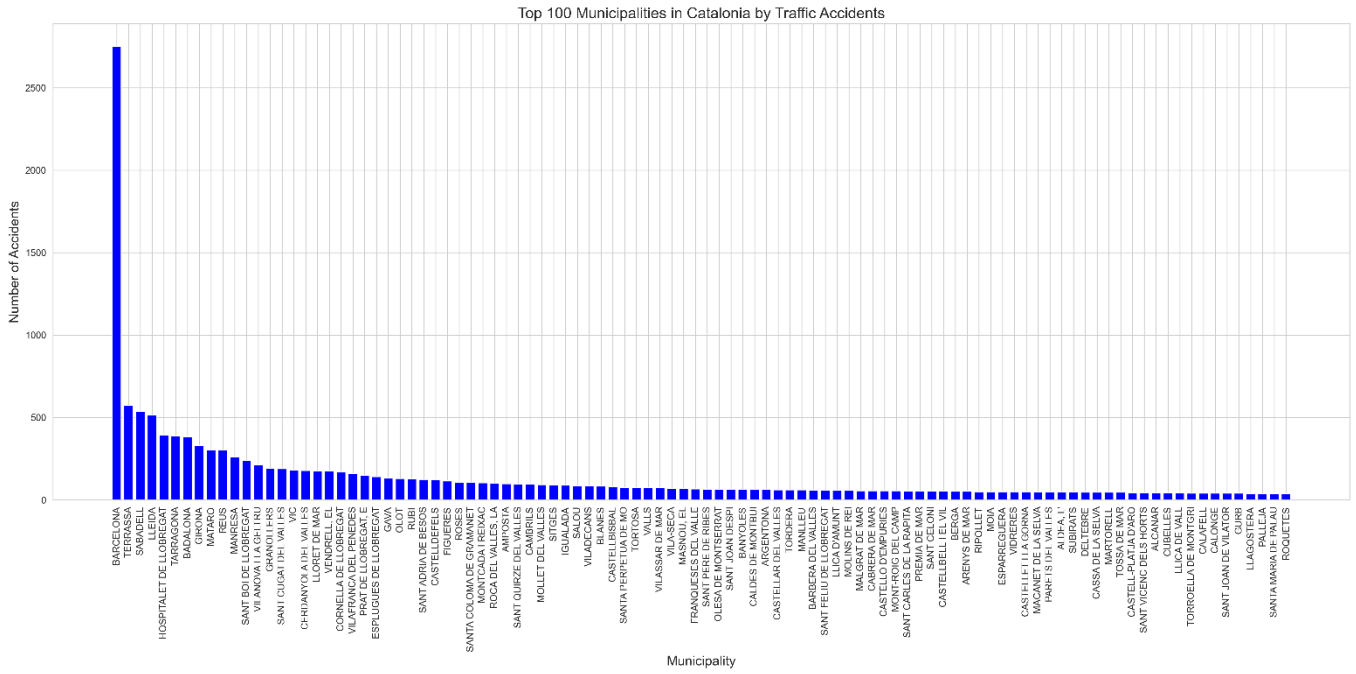


Figure 4 top 100 municipalities per number of accidents in the period 2010-2021 in Catalonia.

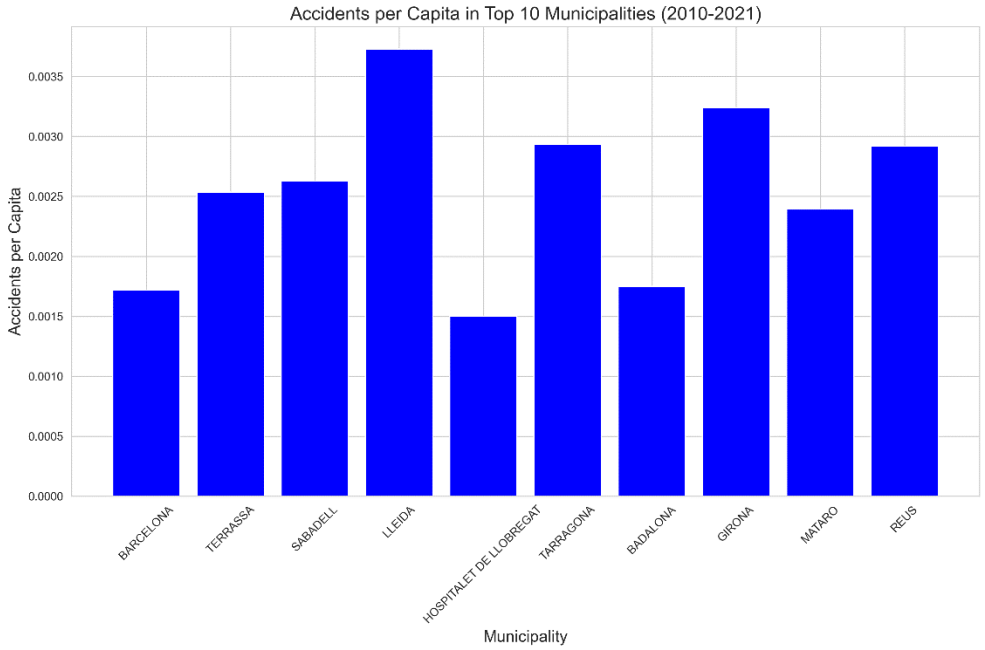


Figure 5 top 10 municipalities per number of accidents per capita in the period 2010-2021 in Catalonia.

A decreasing trend in accidents from 2010 to 2021 across the top 10 municipalities (Figure 6) suggests effective safety measures and possibly changes in traffic patterns or road usage over time. Figure 7 reveals a significant correlation between population size and accidents per capita. Municipalities with smaller populations tend to have higher accident rates per capita. This correlation may point to factors like lower traffic volumes, different types of roads, or varying levels of road safety infrastructure and enforcement in these areas.

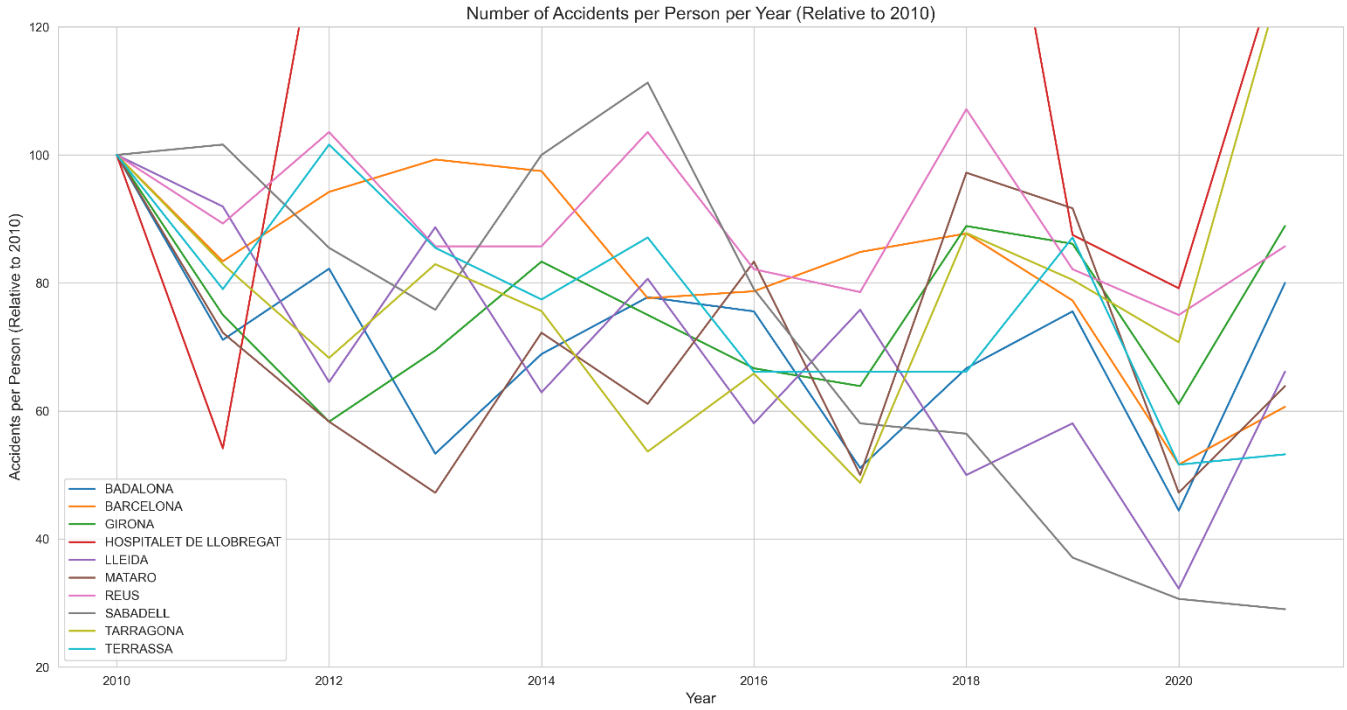


Figure 6 Traffic Accidents per capita per year in top 10 Catalan Municipalities by number of accidents (2010-2021).

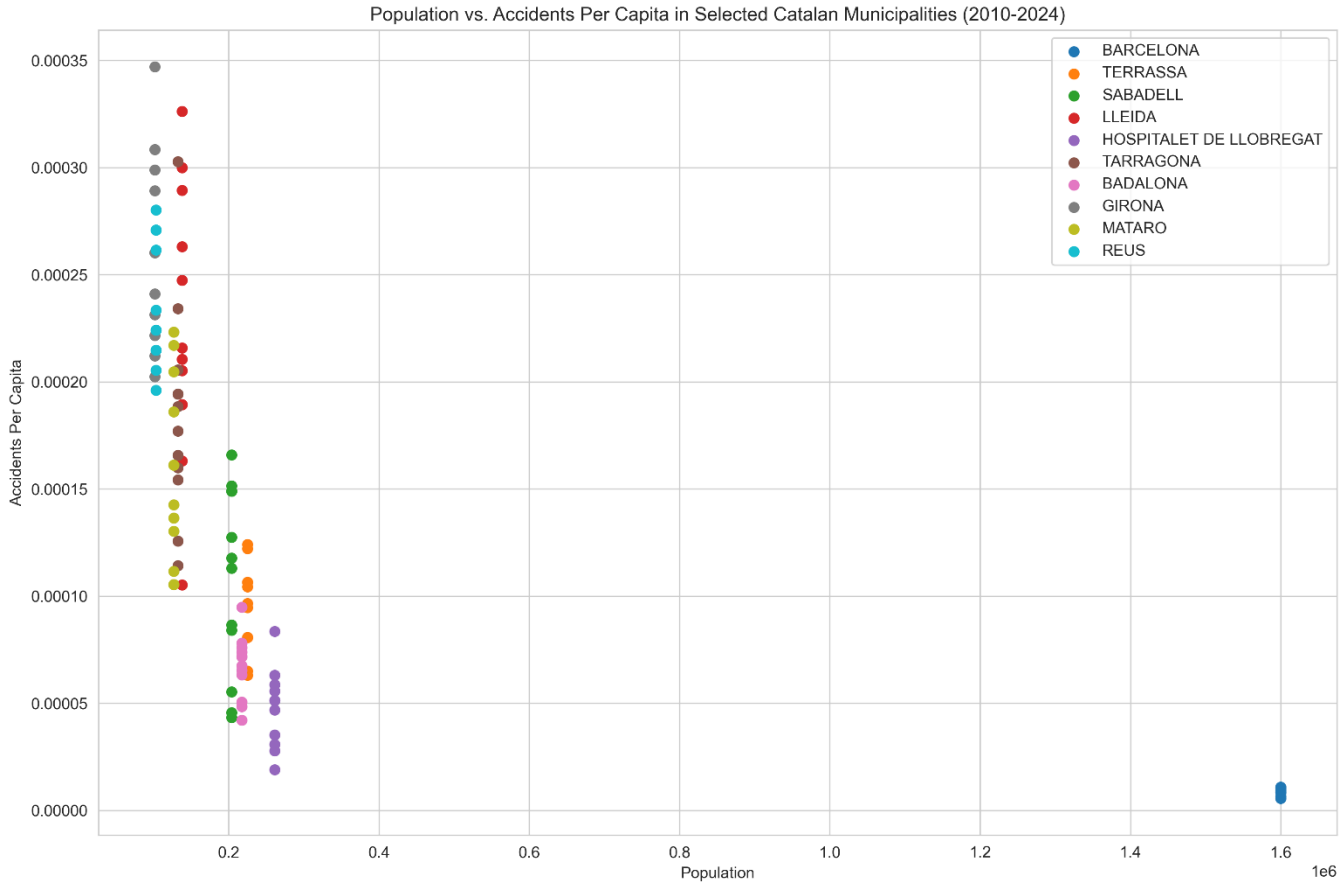


Figure 7 Correlation between population and accidents per capita in top 10 Catalan Municipalities by number of accidents (2010-2021).

4.4 Yearly Trends

How have traffic accident patterns (frequency, severity) changed yearly from 2010 to 2021?

From 2010 to 2021, traffic accident patterns in Catalonia have evolved significantly, as evidenced by Figures 1, 3, and 6:
Yearly Trends (Figure 1): There's been a general decrease in the frequency of traffic accidents over this period. This trend could be attributed to improved road safety measures, changes in traffic regulations, or advancements in vehicle safety features.
Severity of Accidents (Figure 3): The severity of accidents, measured in terms of injuries or fatalities, has also shown a decreasing trend. This suggests that, alongside the reduction in accident frequency, the accidents that do occur are less severe, possibly due to better emergency response systems and safer vehicle designs.
Top 10 Municipalities (Figure 6): In the top 10 municipalities by the number of accidents, there's a consistent decrease in accident rates from 2010 to 2021. This decline indicates the effectiveness of localized road safety initiatives and potentially shifts in urban traffic patterns.
These patterns highlight the effectiveness of road safety policies and technology improvements in reducing both the frequency and severity of traffic accidents in Catalonia over the past decade.

4.5 Day and Time Patterns

On what days of the week and times of day do most accidents occur? Are there notable differences between weekdays and weekends?

Already discussed in figure 2 and 3

4.6 Environmental Impact

How do different weather conditions affect the likelihood of accidents? Is there a correlation between visibility, road conditions, and accident severity?

Already discussed in Figure 2 and 3

4.7 Road and Traffic Features

What impact do road features (such as speed limits and road types) and traffic density have on the occurrence of accidents?

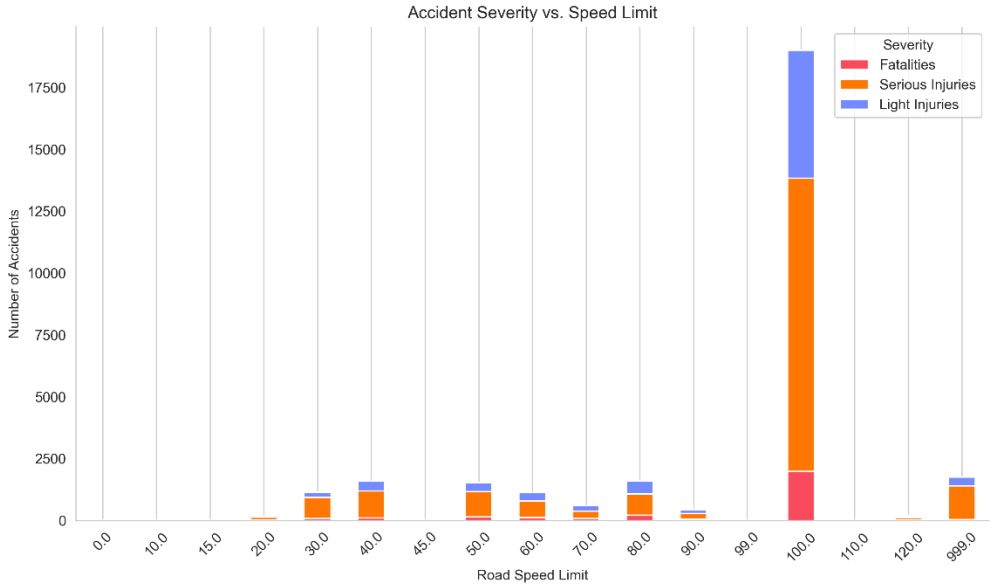


Figure 8

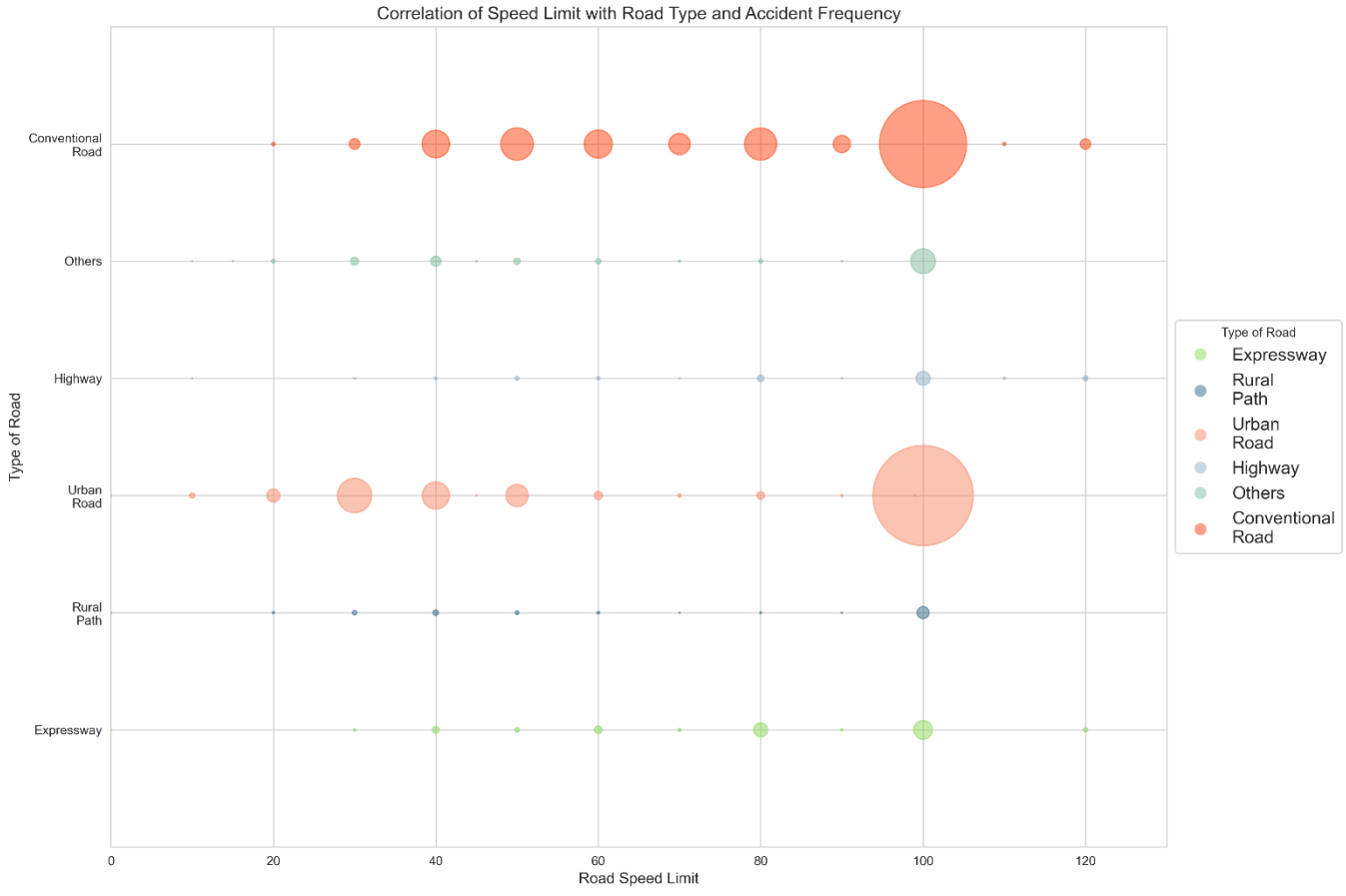


Figure 9

4.8 Vehicle Types and Accident Severity

Does the involvement of specific types of vehicles (like heavy trucks and motorcycles) correlate with more severe accidents?

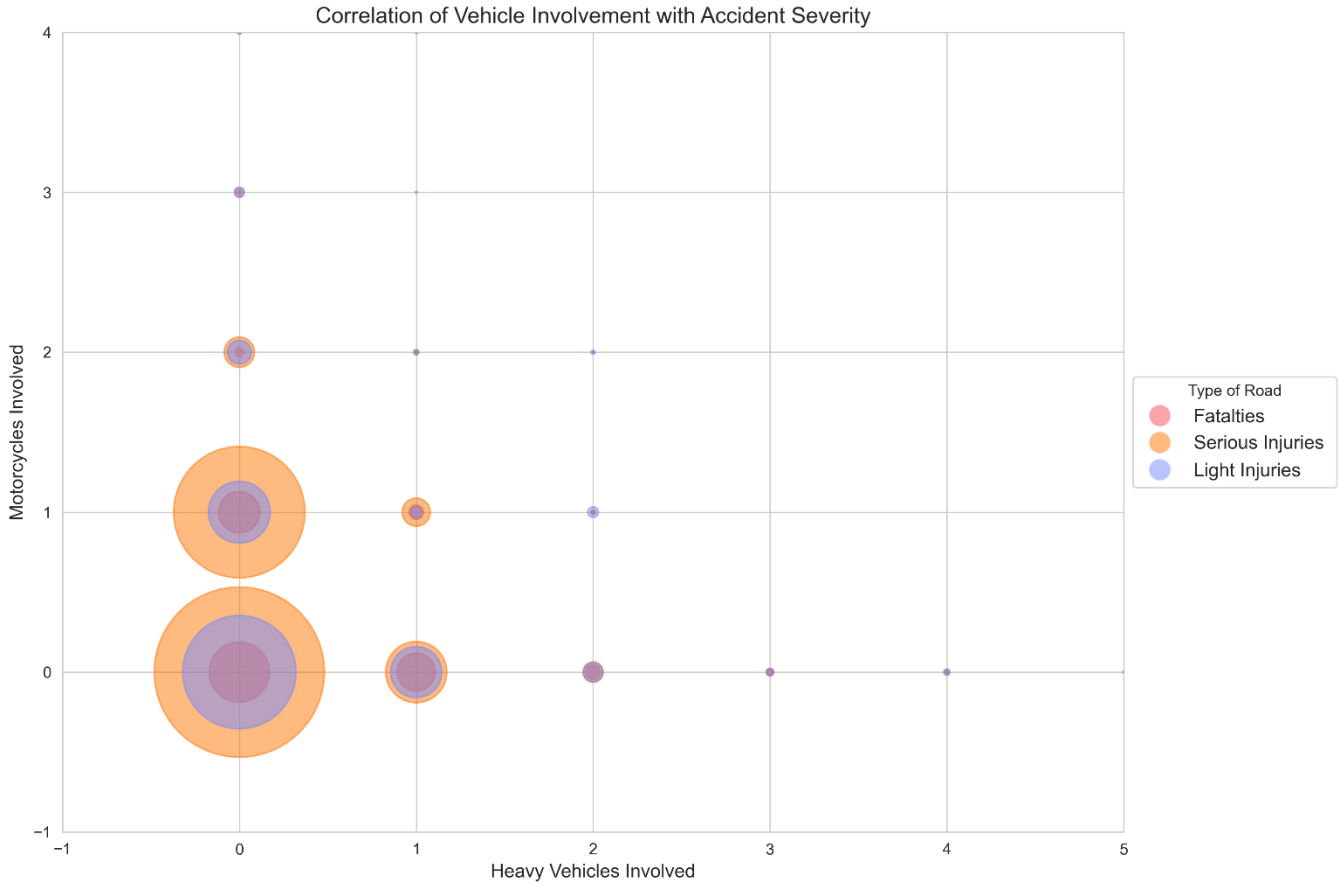


Figure 10

4.9 Temporal Clustering

Are there specific periods (months, years) where accident patterns cluster significantly? What might be the causes for these clusters?

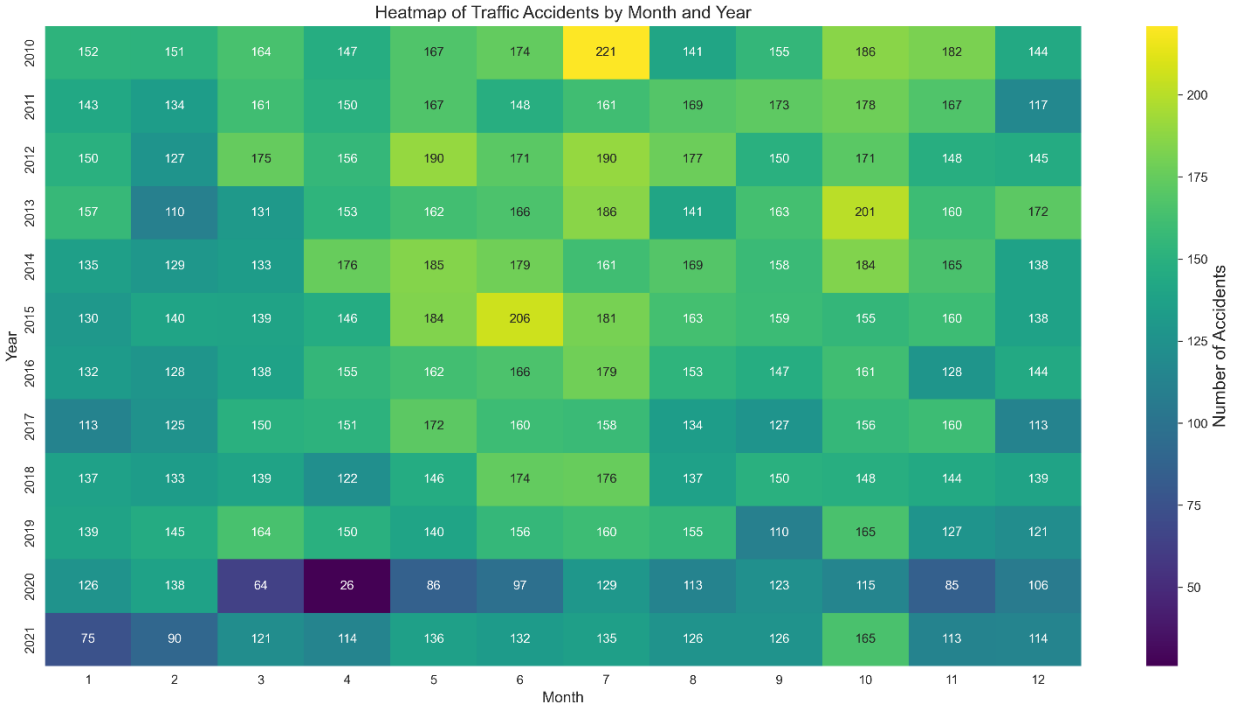
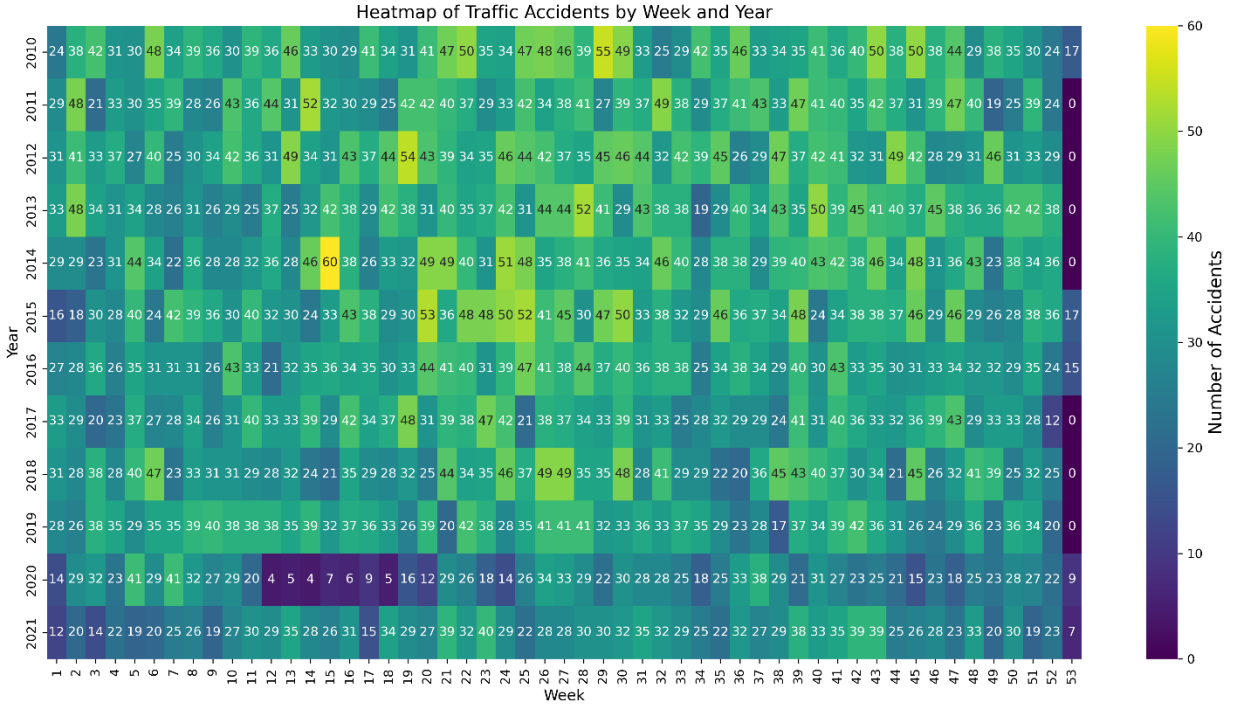
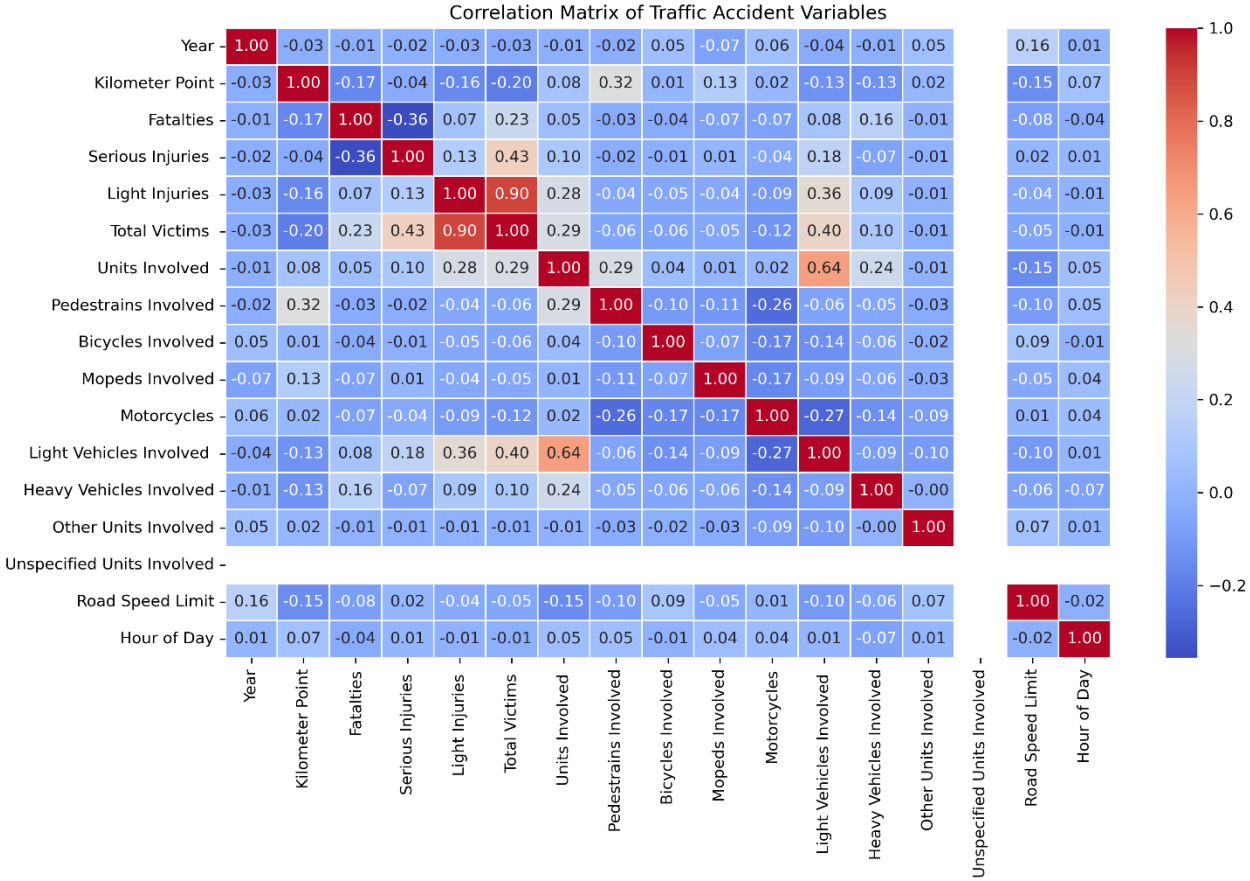
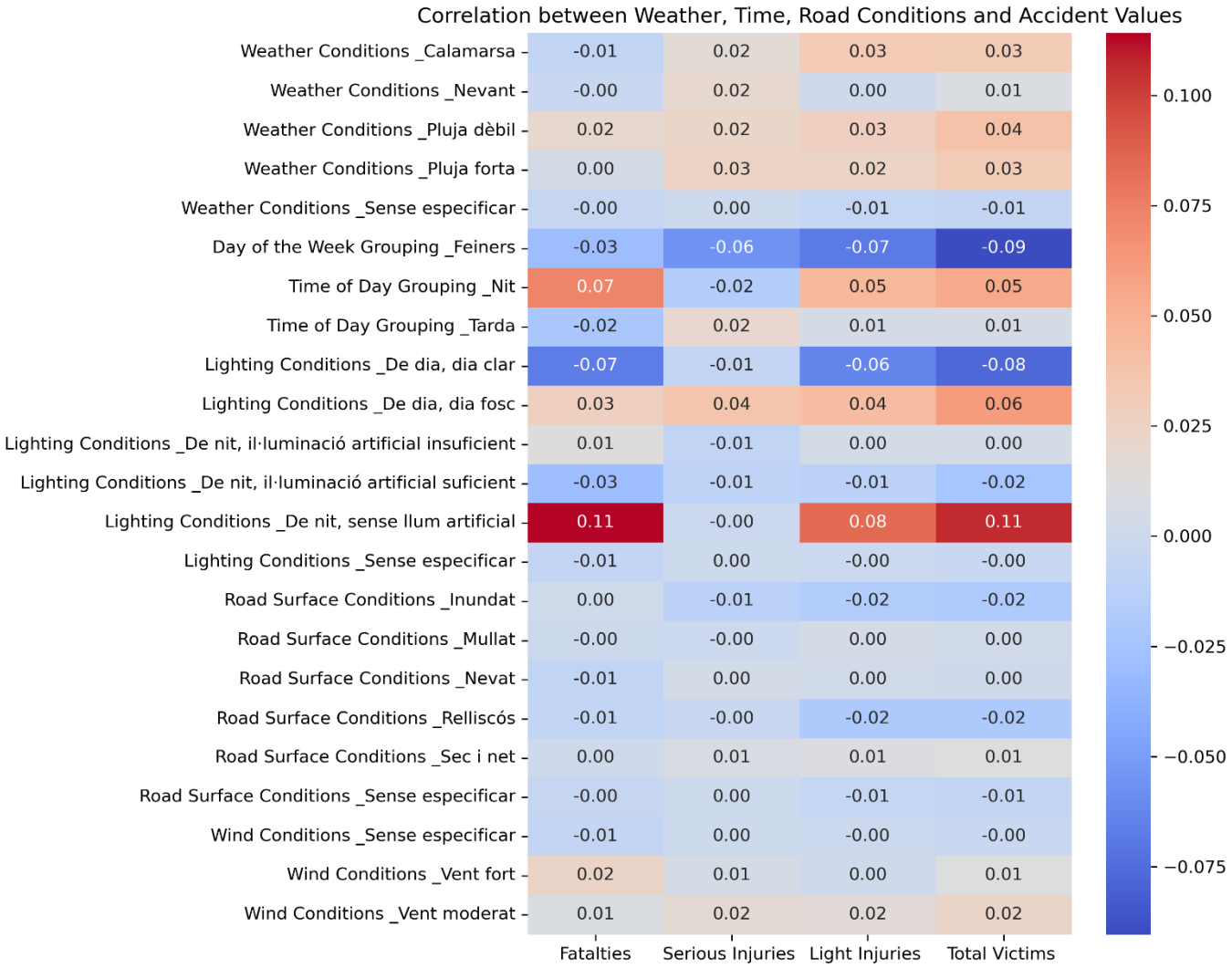

Heatmap of Traffic Accidents by Month and Year
Year
Month
Number of Accidents
2010 152 151 164 147 167 174 221 141 155 186 182 144
2011 143 134 161 150 167 148 161 169 173 178 167 117
2012 150 127 175 156 190 171 190 177 150 171 148 145
2013 157 110 131 153 162 166 186 141 163 201 160 172
2014 135 129 133 176 185 179 161 169 158 184 165 138
2015 130 140 139 146 184 206 181 163 159 155 160 138
2016 132 128 138 155 162 166 179 153 147 161 128 144
2017 113 125 150 151 172 160 158 134 127 156 160 113
2018 137 133 139 122 146 174 176 137 150 148 144 139
2019 139 145 164 150 140 156 160 155 110 165 127 121
2020 126 138 64 26 86 97 129 113 123 115 85 106
2021 75 90 121 114 136 132 135 126 126 165 113 114
1 2 3 4 5 6 7 8 9 10 11 12
200 175 150 125 100 75 50

Figure 11


Heatmap of Traffic Accidents by Week and Year
Year
Week
Number of Accidents
2010 24 38 42 31 30 48 34 39 36 30 39 36 46 33 30 29 41 34 31 41 47 50 35 34 47 48 46 39 55 49 33 25 29 42 35 46 33 34 35 41 36 40 50 38 50 38 44 29 38 35 30 24 17
2011 29 48 21 33 30 35 39 28 26 43 36 44 31 52 32 30 29 25 42 42 40 37 29 33 42 34 38 41 27 39 37 49 38 29 37 41 43 33 47 41 40 35 42 37 31 39 47 40 19 25 39 24 0
2012 31 41 33 37 27 40 25 30 34 42 36 31 49 34 31 43 37 44 54 43 39 34 35 46 44 42 37 35 45 46 44 32 42 39 45 26 29 47 37 42 41 32 31 49 42 28 29 31 46 31 33 29 0
2013 33 48 34 31 34 28 26 31 26 29 25 37 25 32 42 38 29 42 38 31 40 35 37 42 31 44 44 52 41 29 43 38 38 19 29 40 34 43 35 50 39 45 41 40 37 45 38 36 36 42 42 38 0
2014 29 29 23 31 44 34 22 36 28 28 32 36 28 46 60 38 26 33 32 49 49 40 31 51 48 35 38 41 36 35 34 46 40 28 38 38 29 39 40 43 42 38 46 34 48 31 36 43 23 38 34 36 0
2015 16 18 30 28 40 24 42 39 36 30 40 32 30 24 33 43 38 29 30 53 36 48 48 50 52 41 45 30 47 50 33 38 32 29 46 36 37 34 48 24 34 38 38 37 46 29 46 29 26 28 38 36 17
2016 27 28 36 26 35 31 31 31 26 43 33 21 32 35 36 34 35 30 33 44 41 40 31 39 47 41 38 44 37 40 36 38 38 25 34 38 34 29 40 30 43 33 35 30 31 33 34 32 32 29 35 24 15
2017 33 29 20 23 37 27 28 34 26 31 40 33 33 39 29 42 34 37 48 31 39 38 47 42 21 38 37 34 33 39 31 33 25 28 32 29 29 24 41 31 40 36 33 32 36 39 43 29 33 33 28 12 0
2018 31 28 38 28 40 47 23 33 31 31 29 28 32 24 21 35 29 28 32 25 44 34 35 46 37 49 49 35 35 48 28 41 29 29 22 20 36 45 43 40 37 30 34 21 45 26 32 41 39 25 32 25 0
2019 28 26 38 35 29 35 35 39 40 38 38 38 35 39 32 37 36 33 26 39 20 42 38 28 35 41 41 41 32 33 36 33 37 35 29 23 28 17 37 34 39 42 36 31 26 24 29 36 23 36 34 20 0
2020 14 29 32 23 41 29 41 32 27 29 20 4 5 4 7 6 9 5 16 12 29 26 18 14 26 34 33 29 22 30 28 28 25 18 25 33 38 29 21 31 27 23 25 21 15 23 18 25 23 28 27 22 9
2021 12 20 14 22 19 20 25 26 19 27 30 29 35 28 26 31 15 34 29 27 39 32 40 29 22 28 28 30 30 32 35 32 29 25 22 32 27 29 38 33 35 39 39 25 26 28 23 33 20 30 19 23 7
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53
60 50 40 30 20 10 0


Correlation Matrix of Traffic Accident Variables
Year 1.00 -0.03 -0.01 -0.02 -0.03 -0.03 -0.01 -0.02 0.05 -0.07 0.06 -0.04 -0.01 0.05 0.16 0.01
Kilometer Point -0.03 1.00 -0.17 -0.04 -0.16 -0.20 0.08 0.32 0.01 0.13 0.02 -0.13 -0.13 0.02 -0.15 0.07
Fatalties -0.01 -0.17 1.00 -0.36 0.07 0.23 0.05 -0.03 -0.04 -0.07 -0.07 0.08 0.16 -0.01 -0.08 -0.04
Serious Injuries -0.02 -0.04 -0.36 1.00 0.13 0.43 0.10 -0.02 -0.01 0.01 -0.04 0.18 -0.07 -0.01 0.02 0.01
Light Injuries -0.03 -0.16 0.07 0.13 1.00 0.90 0.28 -0.04 -0.05 -0.04 -0.09 0.36 0.09 -0.01 -0.04 -0.01
Total Victims -0.03 -0.20 0.23 0.43 0.90 1.00 0.29 -0.06 -0.06 -0.05 -0.12 0.40 0.10 -0.01 -0.05 -0.01
Units Involved -0.01 0.08 0.05 0.10 0.28 0.29 1.00 0.29 0.04 0.01 0.02 0.64 0.24 -0.01 -0.15 0.05
Pedestrains Involved -0.02 0.32 -0.03 -0.02 -0.04 -0.06 0.29 1.00 -0.10 -0.11 -0.26 -0.06 -0.05 -0.03 -0.10 0.05
Bicycles Involved 0.05 0.01 -0.04 -0.01 -0.05 -0.06 0.04 -0.10 1.00 -0.07 -0.17 -0.14 -0.06 -0.02 0.09 -0.01
Mopeds Involved -0.07 0.13 -0.07 0.01 -0.04 -0.05 0.01 -0.11 -0.07 1.00 -0.17 -0.09 -0.06 -0.03 -0.05 0.04
Motorcycles 0.06 0.02 -0.07 -0.04 -0.09 -0.12 0.02 -0.26 -0.17 -0.17 1.00 -0.27 -0.14 -0.09 0.01 0.04
Light Vehicles Involved -0.04 -0.13 0.08 0.18 0.36 0.40 0.64 -0.06 -0.14 -0.09 -0.27 1.00 -0.09 -0.10 -0.10 0.01
Heavy Vehicles Involved -0.01 -0.13 0.16 -0.07 0.09 0.10 0.24 -0.05 -0.06 -0.06 -0.14 -0.09 1.00 -0.00 -0.06 -0.07
Other Units Involved 0.05 0.02 -0.01 -0.01 -0.01 -0.01 -0.01 -0.03 -0.02 -0.03 -0.09 -0.10 -0.00 1.00 0.07 0.01
Unspecified Units Involved
Road Speed Limit 0.16 -0.15 -0.08 0.02 -0.04 -0.05 -0.15 -0.10 0.09 -0.05 0.01 -0.10 -0.06 0.07 1.00 -0.02
Hour of Day 0.01 0.07 -0.04 0.01 -0.01 -0.01 0.05 0.05 -0.01 0.04 0.04 0.01 -0.07 0.01 -0.02 1.00
Year
Kilometer Point
Fatalties
Serious Injuries
Light Injuries
Total Victims
Units Involved
Pedestrains Involved
Bicycles Involved
Mopeds Involved
Motorcycles
Light Vehicles Involved
Heavy Vehicles Involved
Other Units Involved
Unspecified Units Involved
Road Speed Limit
Hour of Day
1.0
0.8
0.6
0.4
0.2
0.0
−0.2



4.10 Time-Series Forecasting

Based on past trends, create a model to forecast the number of accidents, fatalities, or serious injuries for the upcoming year.

Clearly describe the forecasting model you have developed. This should include the type of model, its structure, and any specific features or techniques it utilizes. Discuss the factors that influenced your decision, such as the model's accuracy, efficiency, suitability to the data characteristics, or its ability to handle the complexities of the dataset.

5. Conclusion