Beyond the Collision: *Understanding Road Accident Dynamics in Montgomery County*

1. Introduction and Background

Road accidents pose a significant public safety challenge in the United States, leading to over 44,000 fatalities in 2023 alone, according to the National Highway Traffic Safety Administration (NHTSA) and the National Safety Council (NSC). These incidents cause loss of life, injury, and substantial economic impacts due to property damage, medical expenses, and productivity losses. Montgomery County, Maryland, was chosen because it offers a unique blend of urban, suburban, and rural landscapes representing many regions across the United States. This diverse environment, combined with its heavy traffic flows from proximity to Washington, D.C., makes it an ideal area to study road safety concerns and implement targeted safety interventions.

By utilizing datasets from the Automated Crash Reporting System (ACRS) of the Maryland State Police, this project aims to uncover the key causes of accidents in Montgomery County, explore the complex factors contributing to these incidents, and provide actionable insights to help reduce the frequency and severity of accidents. To achieve this, the following questions need to be addressed:

1. Crash Patterns and Trends:

- What are the crash hotspots and peak times in Montgomery County?
- How do accident trends vary across different locations and times of day?

2. Severity of Accidents:

- What is the annual breakdown of crash severity from 2021 to 2024?
- How has the severity of accidents changed over the years?

3. Relationship with Traffic Violations:

- Is there a correlation between road crashes and traffic violations in Montgomery?
- What trends can we expect in the relationship between traffic violations and accidents in the upcoming years?

4. Key Causes of Accidents:

- What are the primary causes of accidents in Montgomery County, such as driver distraction, substance abuse, and others?
- How can each of these causes be addressed to prevent future accidents?
- What interventions could be implemented to mitigate these risk factors?

The analysis will support data-driven decision-making for policymakers, urban planners, and the public, facilitating the implementation of targeted interventions. These interventions could range from infrastructure improvements (such as better signage or road design) to enhanced law enforcement strategies. Ultimately, this study aims to reduce road accidents' economic and human toll, making Montgomery County's roadways safer for all. We want to clarify that accidents are not accidental*, and they will continue to happen at similar rates every year.* There are a lot of factors we cannot control. In this analysis, we want to focus on the factors we can control.

2. Datasets

The datasets were sourced from the Montgomery County Open Data Portal to enhance public safety and provide transparency on traffic incidents and enforcement activities. Collected by the Montgomery County Police Department and the Maryland State Police, the data is funded by the Montgomery County Government. Covering the period from 2021 onwards, these datasets allow for a comprehensive analysis of traffic incidents and trends.

Key publications associated with the datasets include NHTSA Annual Reports, Montgomery County Annual Traffic Reports, and Maryland State Police Safety Publications, which provide local and state-level context.

The datasets include:

- **Montgomery Accident Dataset** includes
    - **Crash Reporting – Incident Data**: ~45K rows, 37 columns, including variables such as **crash time**, **location**, **weather conditions**, and **road type**.
    - **Driver Data**: ~87K rows, 39 columns, capturing variables like **driver behavior** (e.g., speeding, distracted driving), **impairment status**, and **age**.
    - **Non-Motorist Data**: ~3K rows, 29 columns, focusing on incidents involving **pedestrians** and **cyclists** and the conditions leading to their involvement in crashes.
- **Montgomery Traffic Violations Data**: ~458K rows, 43 columns, providing records of violations (e.g., **speeding tickets**, **DUIs**) to analyze enforcement trends and their relationship with accidents.
- **US Accidents Data**: ~10K rows, 11 columns, providing data on incidents all over the US, capturing the **state, county,** and **year** of the accidents.

These datasets cover Montgomery County, Maryland, and provide sufficient granularity to analyze data at the city, neighborhood, and intersection levels. The data allows us to identify accident hotspots, examine trends in driver behavior, and assess the impact of environmental factors on accident severity.

We used a Python script to clean and preprocess crash reporting data, particularly focused on driver information. It imported the raw dataset, handled issues with mixed data types, and added new columns to ensure consistency with other datasets, such as non-motorist data. Additionally, the script selected only relevant fields from the original data, renaming columns for clarity and ease of analysis. This cleaning process was necessary to prepare the dataset for seamless integration into Tableau for further visualization and analysis.

Key Variables and Usage:

- **US States, accident count** gives accident distribution across U.S. states and provides a comprehensive overview of how accidents and crash reports are geographically spread.
- **The severity of the Crash, Crash time, and Location** will help to analyze the major fatalities happening and during what hour of the day the accidents are at peak including the location
- **Traffic violations and crash Reports over time** will help analyze the correlation between traffic violations and crashes, which will help in enforcement efforts (e.g., issuing speeding tickets) to impact accident rates and driver behavior over time.
- **Driver behavior variables and accident reasons** (e.g., speeding, DUI) from the Driver Data will be used to explore how specific actions correlate with accident severity.
- **Pedestrian and cyclist involvement** data will be crucial for identifying vulnerabilities and suggesting safety improvements for non-motorists.
- **Crash time, location, and weather conditions** will help analyze when and where accidents are most likely to occur, as well as the external factors contributing to them.

Limitations: While the datasets are comprehensive, some limitations include the potential underreporting of accident causes, minor accidents, and inconsistencies in data collection between different agencies.

3. Data Story

Fig 1.1: Statewise Distribution of Road Accidents in the U.S.

The Statewise Distribution of Road Accidents in the U.S. **map chart** uses U.S. accident data to display the distribution of accidents across states. Darker shades indicate higher accident frequencies, with California, Texas, and Florida having the most accidents. This map provides a national context, helping to compare Montgomery County's accident rates with other states.

The **average accident count** is a continuous variable represented in raw numbers **fixed at State, Year, and Month**. This map frames the discussion by highlighting national trends, setting the stage for a closer look at Montgomery County's accident data.

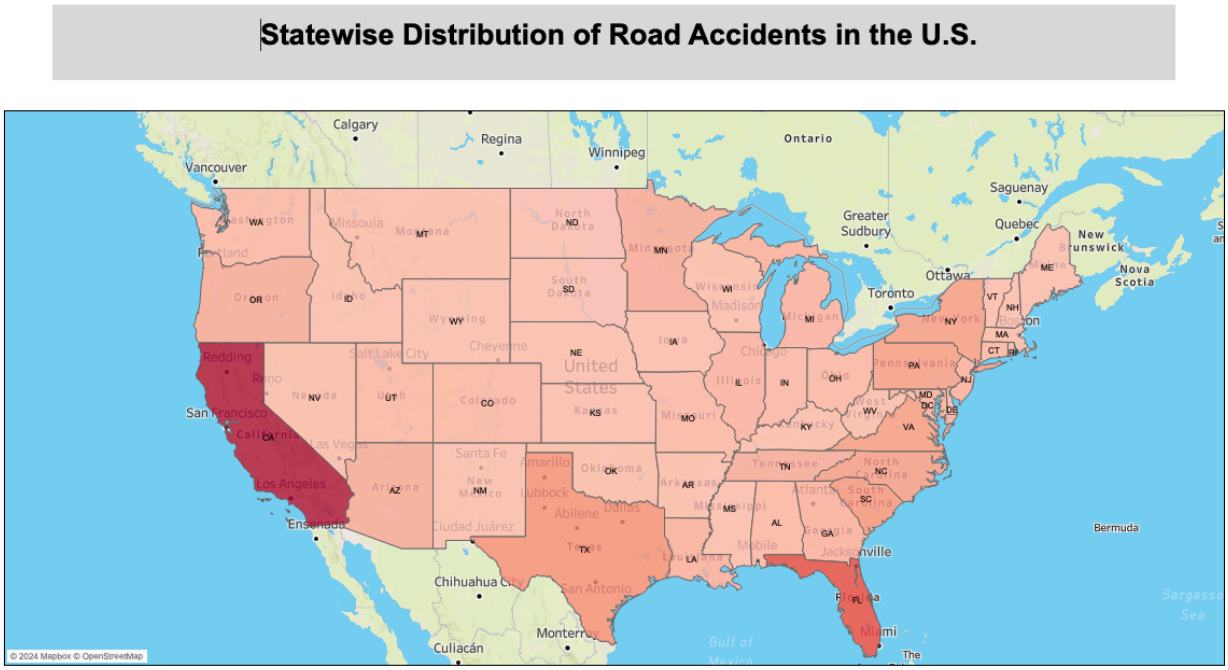


Fig 1.1

Fig 1.2: Road Accident Density in Montgomery County

The Road Accident Density in Montgomery County **map chart** leverages the Montgomery accident dataset to pinpoint accident hotspots using geographic coordinates. High-density areas, highlighted in red, reveal locations with a higher concentration of incidents. The ACRS Report Type represents the severity and count of accidents in each location on the map. The severity of the crash is denoted as the size of the bubble.

The primary goal of this map is to help local authorities identify where most accidents occur and how severe they are, making it easier to implement targeted infrastructure improvements or law enforcement measures. However, while identifying accident-prone areas, it doesn't provide insight into the underlying causes, such as road conditions or driver behavior, limiting its scope.

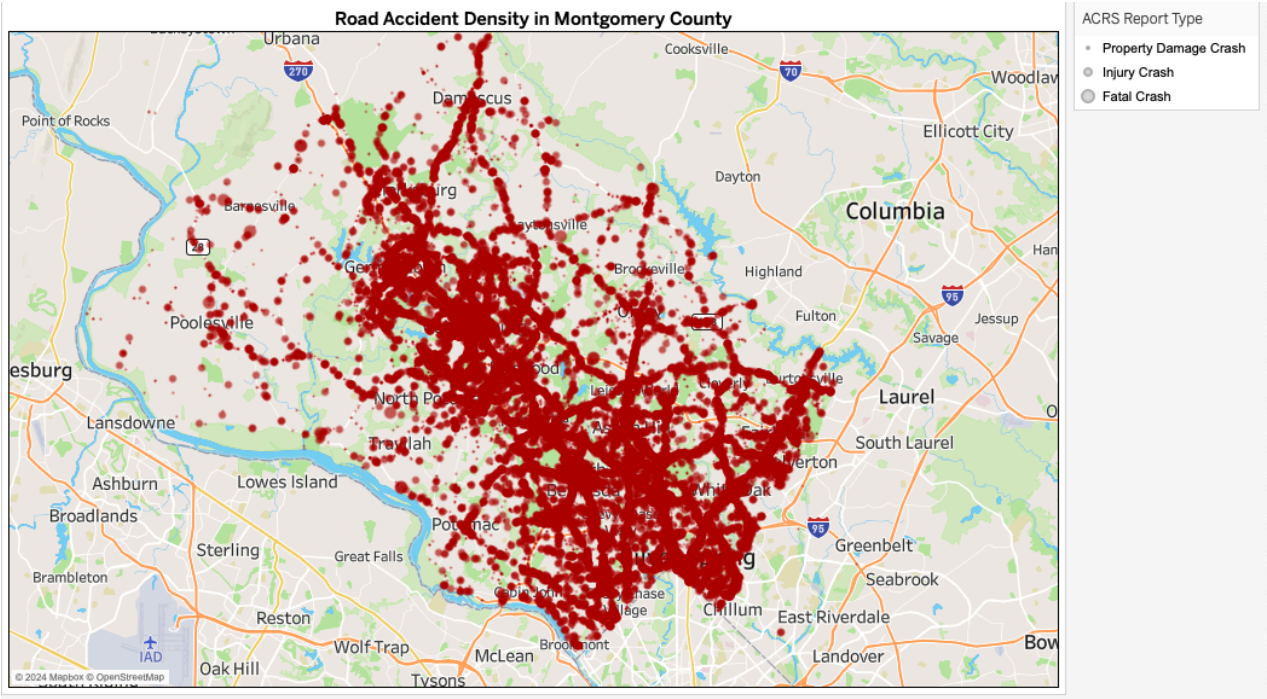


Fig 1.2.

Fig 1.3: Crash Incidents by Hour and Day

The Crash Incidents by Hour and Day **heatmap** visualizes accident frequency based on time and day, with darker shades representing higher numbers of incidents. The **crash hour and day** of the week are categorical variables **extracted from the Crash Date/Time variable**, while the Report Number gives the number of accidents in raw numbers. Peak accident times are during weekday rush hours, especially late in the afternoon.

This chart is instrumental in identifying critical periods for interventions, such as increasing law enforcement presence or launching public safety campaigns during these high-risk times. We were able to conclude that peak times of crashes are between the hours of 7-9 A.M. and 3-6 P.M. These are the times people are going to and leaving work.

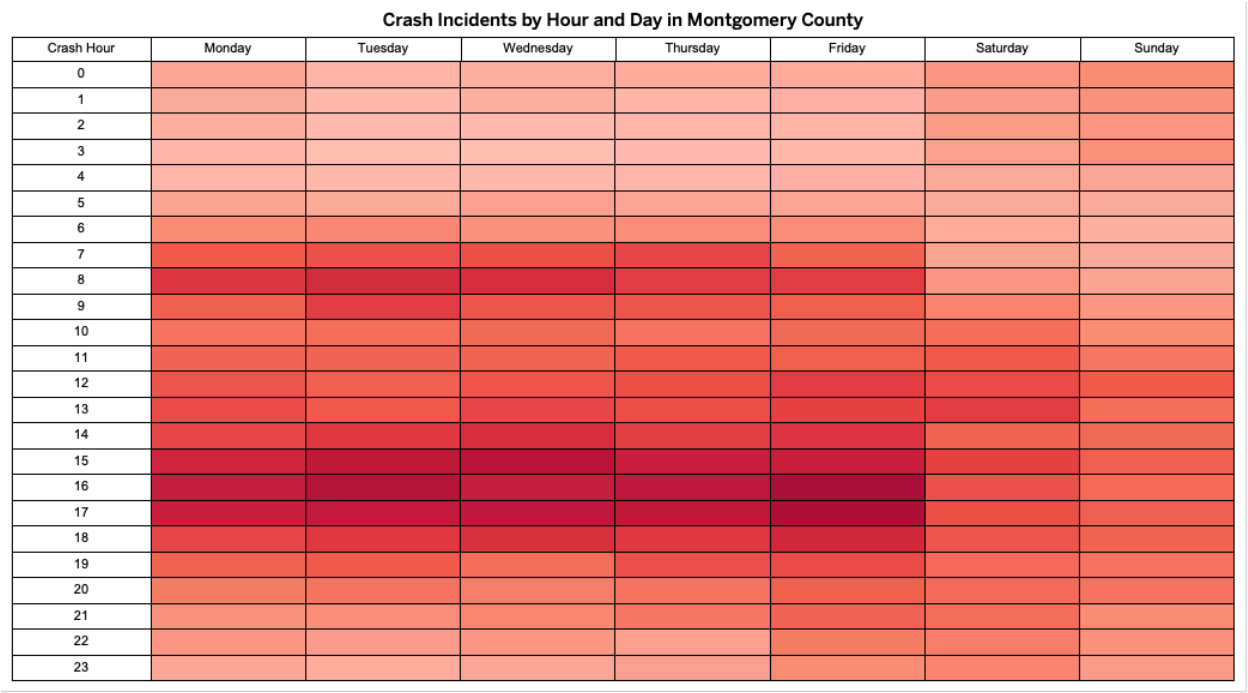


Fig 1.3.

Fig 1.4: Annual Breakdown of Crash Incidents by Severity

The Annual Breakdown of Crash Incidents by Severity **bar chart** presents a year-over-year comparison of accident severity (Property Damage, Injury, Fatal) from 2021 to 2024, using the Montgomery Accident Dataset. Accident count is measured in raw numbers using Report Number, **categorized by severity type** using the ACRS report type. The bar chart shows that property damage incidents are the most frequent, while injury crashes are also significant.

This chart helps policymakers track accident severity trends and assess whether interventions are effectively reducing severe accidents. We can see that fatal crashes are not very common in the grand scheme of things, which is good.

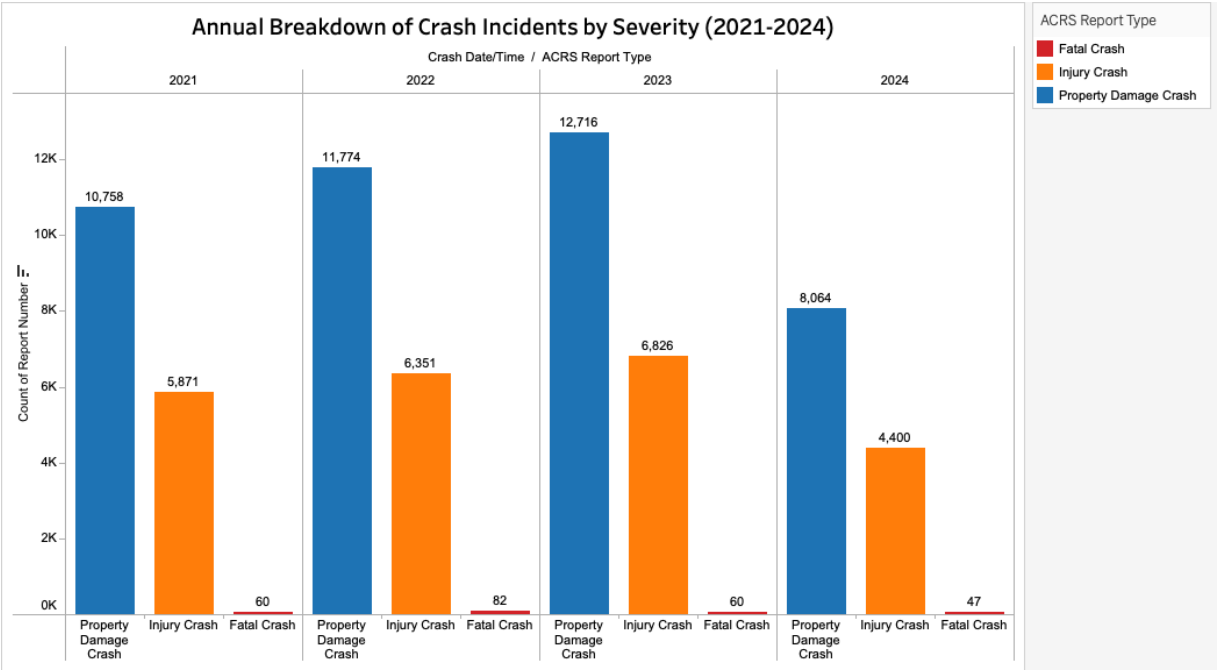


Fig 1.4.

Dashboard created with 3 charts and interactive features to choose from the severity of crashes :

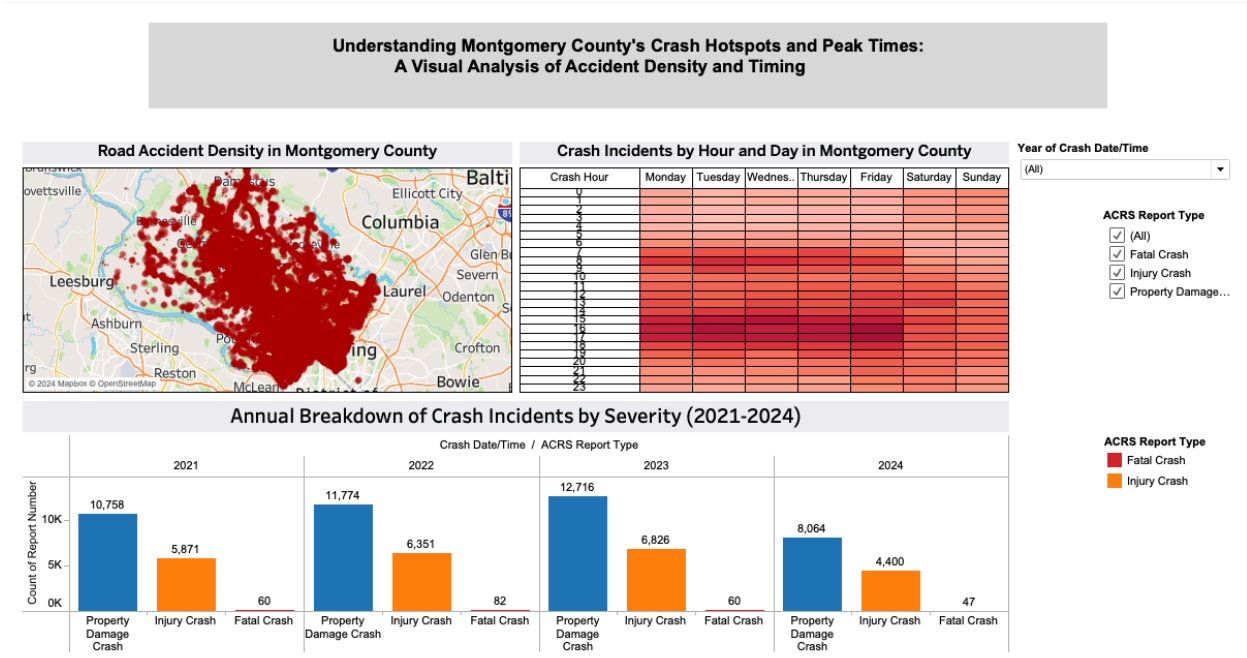


Fig.1.5.

Fig 1.6: Trends in Road Crashes and Traffic Violations

Using **data blending** of the Montgomery Accident dataset and Traffic Violation dataset, the trends in the Road Crashes and Traffic Violations **line chart** illustrate the relationship between road crashes and traffic violations over time (month-year), using continuous variables for both crashes and violations, measured in raw counts.

This chart also includes a **forecast for future trends**, showing a potential rise in both metrics. A clear correlation between traffic violations (e.g., speeding, DUIs) and accidents is visible, suggesting that most traffic violations are due to law enforcement responding to accidents. We can see a decrease in traffic violations/accidents during COVID-19. After COVID-19, there is a steady upward trend in both these lines, forecasted to increase quite a bit in the next two years.

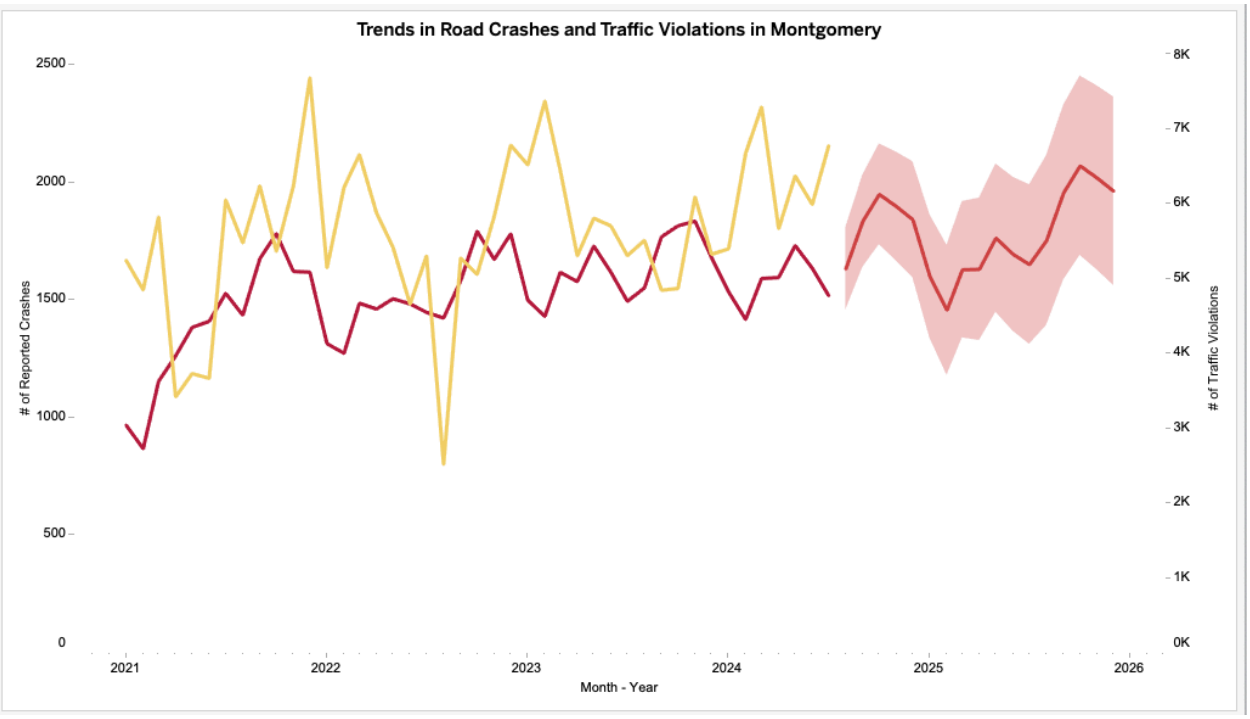


Fig.1.6.

Fig 1.7: Analysis of Different Accident Causes

The Analysis of Different Accident Causes **pie chart** breaks down the causes of accidents in Montgomery County using the Montgomery Accidents datasets, **grouping** the driver at fault, bad weather, and pedestrians at fault.

This chart shows the flaws within the ACRS, as the two largest chunks are the other and driver other fault categories. We must ignore these, as the accident causes are not recorded for most of the data. There is a problem, either with law enforcement not recording enough details at an incident, or with the ACRS algorithm's ability to understand police report data. With the available recorded data, driver distraction, road conditions, and weather-related issues are the leading factors. Accident causes are categorical variables, while accident counts are shown as percentages of total accidents.

Out of what we can control, the chart reveals that driver distraction is the most common cause, suggesting the need for public awareness campaigns and stricter penalties for distracted driving. We will break down the analysis of each of these causes in our next visualizations.

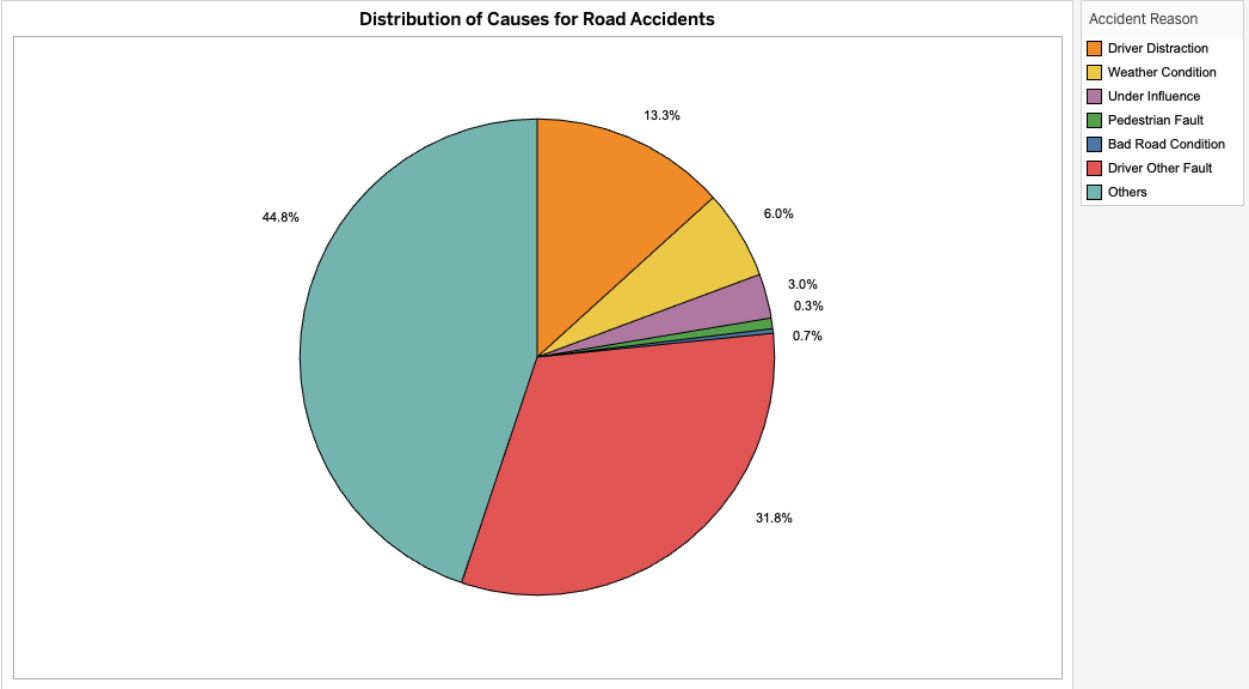


Fig.1.7.

Fig 1.8: Yearly Breakdown of Driver Distraction in Road Accidents

The **stacked bar chart** illustrates the yearly breakdown of different types of driver distractions contributing to road accidents from 2021 to 2024, using the Montgomery dataset. The dataset can be **divided into 2 levels where either the drivers are at fault or the pedestrians**. Considering the **first level of detail as the accidents where the driver was at fault** and using the distracted by variable to **filter** the reasons for driver distractions who were at fault.

The majority of accidents, over 94% each year, are caused by inattentiveness, a factor that is difficult to control directly. However, the remaining 5% of distractions, including device use, eating or drinking, and smoking-related activities, represent areas where targeted interventions could make a significant impact. By focusing on these controllable causes, such as promoting the use of hands-free devices and discouraging eating or smoking while driving, we aim to mitigate accidents and enhance overall road safety. This approach allows for more focused safety campaigns and enforcement efforts that could help reduce the total number of distraction-related accidents.

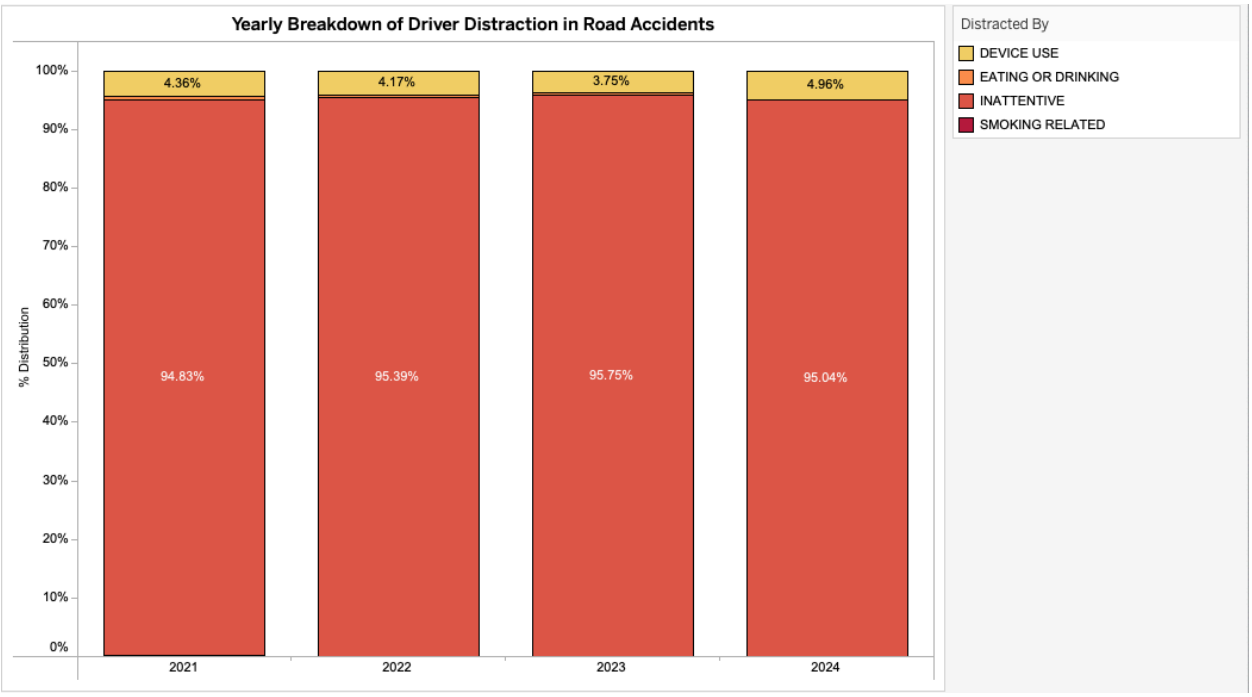


Fig.1.8.

Fig 1.9: Monthly Trend of Substance Abuse-Related Crashes in Montgomery

The **line chart** depicts the monthly trend of substance abuse-related crashes in Montgomery County from November 2020 to May 2024, **with the second level of details as substance abuse** flag true in the Montgomery Accident Dataset.

The number of crashes fluctuates across the period, with several peaks above the average monthly crash rate of approximately 50 incidents. Notable spikes can be seen in mid-2021 and late 2022, where crashes rose above 70 incidents per month. The chart shows an overall inconsistent pattern, with periods of both significant increases and decreases in substance

abuse-related crashes. This visualization suggests that while substance abuse-related crashes remain a persistent issue, there is potential for targeted enforcement and public health campaigns during peak periods to reduce the frequency of these incidents.

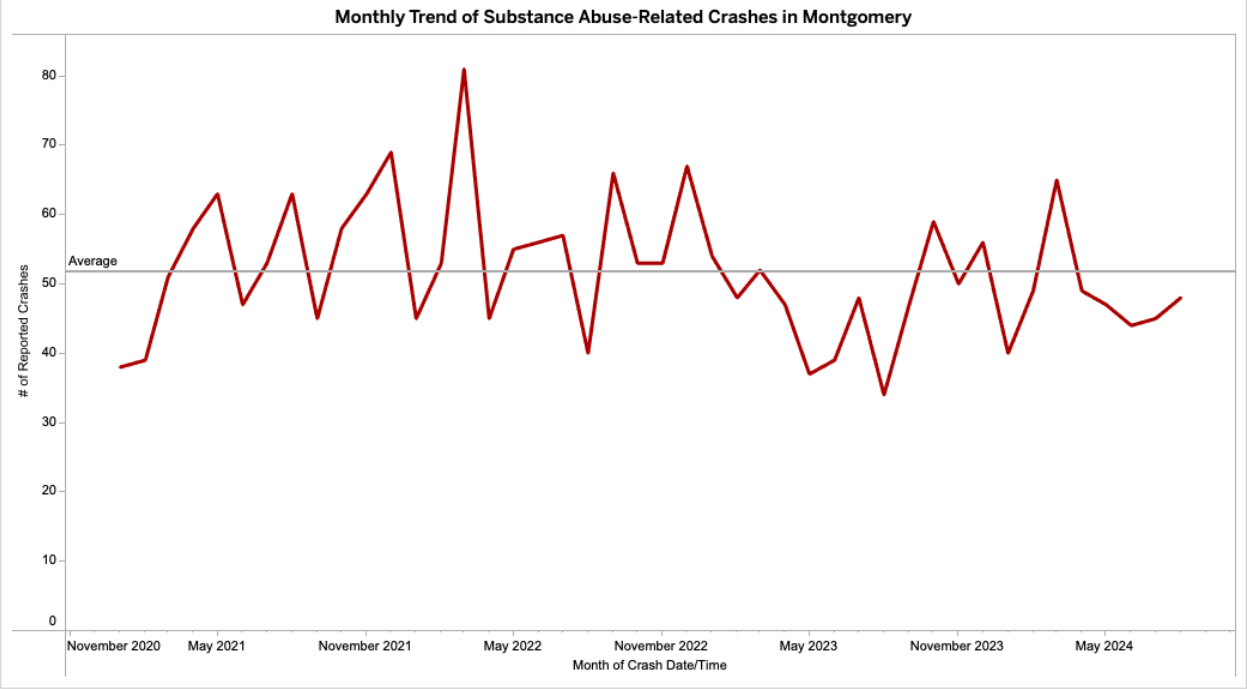


Fig.1.9.

Fig 1.10: Top 5 Pedestrian Actions Leading to Accidents in Montgomery

This **bar chart** displays the top five pedestrian actions that contribute to accidents in Montgomery County. Moving towards the **pedestrians at fault part level of detail**, **grouped the pedestrian actions into different categories and filtered the top 5** based on the count of accidents, using the Montgomery Accident Dataset.

The most frequent cause, "In Roadway Improperly," accounts for the highest number of incidents, with over 150 reported cases. This is followed by "Failure to Yield Right-Of-Way," "Inattentive," "Failure to Obey Traffic Signs," and "Not Visible" (such as wearing dark clothing or walking in poorly lit areas). These findings highlight the need for targeted pedestrian safety measures, including public education campaigns on proper roadway behavior and improving visibility, as well as stricter enforcement of traffic sign obedience. Addressing these issues could significantly reduce the number of pedestrian-involved accidents.

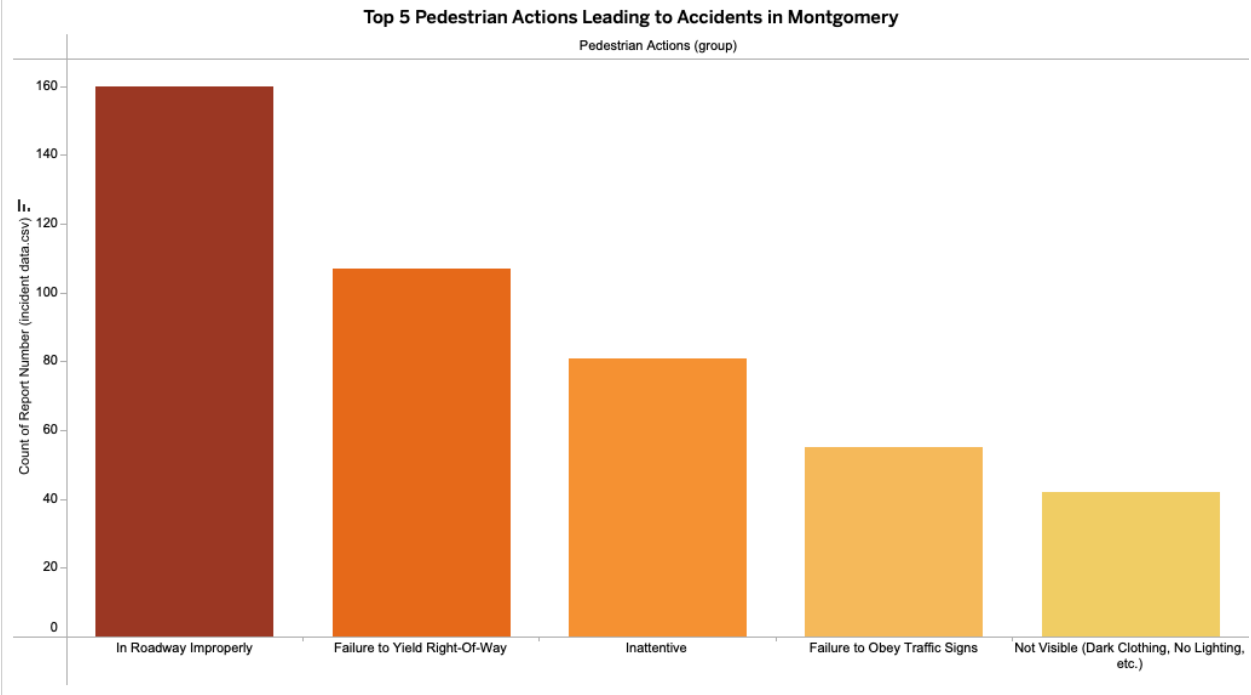


Fig.1.10.

Fig 1.11: Top 5 Road Conditions Contributing to Accidents

The Top 5 Road Conditions Contributing to Accidents **bar chart** categorizes road conditions that lead to accidents, such as potholes, loose surface material, and obstructed views. From the Montgomery Accident dataset, the bad road conditions flag created gives the count of accidents that happened due to the bad infrastructure. **Normalized the data and grouped them into categories**.

We can see from the graph that potholes are the most significant contributing factor. This chart highlights the importance of road maintenance and infrastructure improvements to reduce accidents. Suggestions can be given to the local government to maintain the road conditions and proper infrastructure should be maintained to reduce accidents.

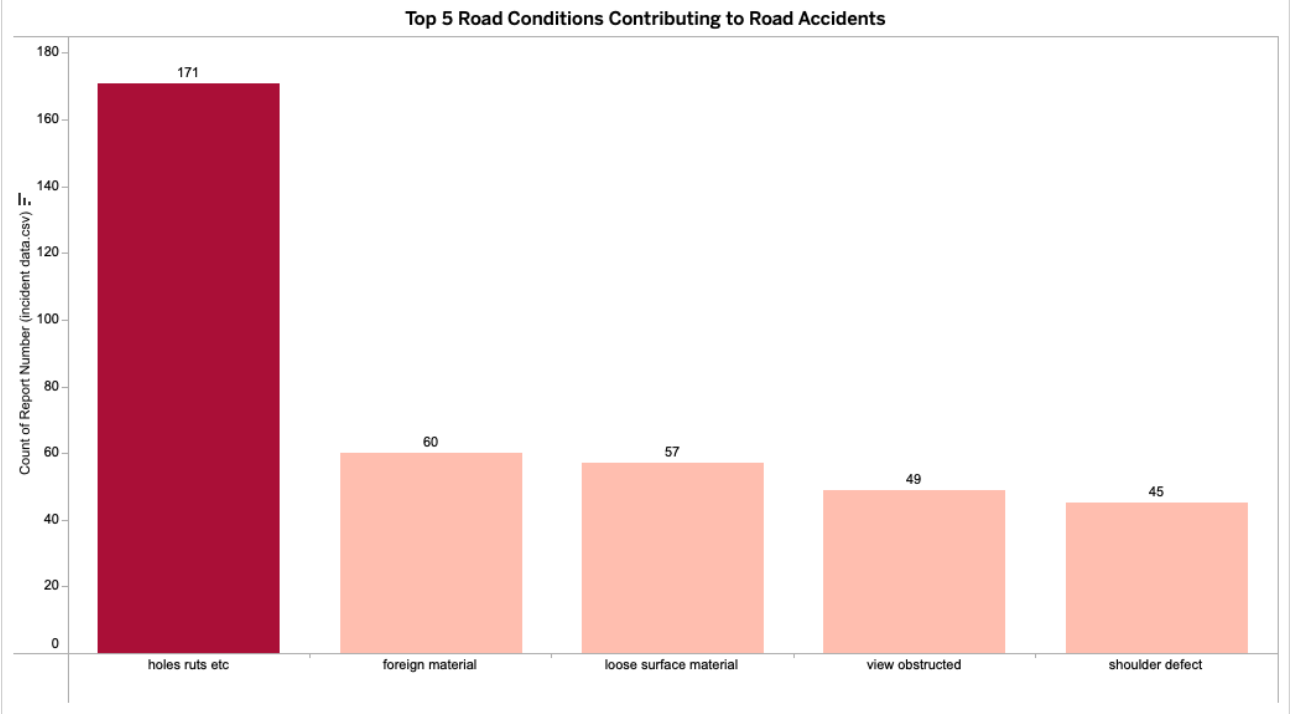
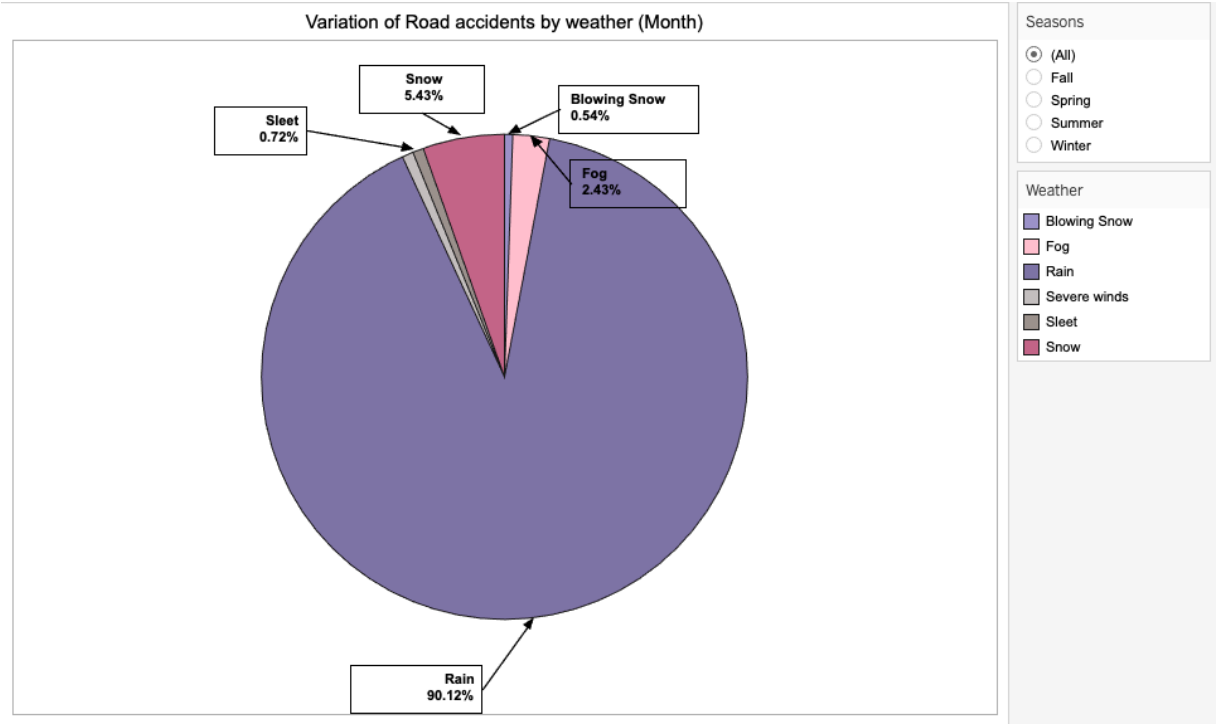


Fig.1.11.

Fig 1.12(and 1.13): Variation of Road Accidents by Weather Conditions

The Variation of Road Accidents by Weather Conditions **pie chart** presents weather-related accident data, showing that rain is the leading weather condition contributing to accidents, followed by snow and fog. Using Montgomery Accident data, **extracting all the accidents not caused by the fault of drivers or pedestrians and bad weather flag true**. **Grouping** the months from the Crash Month to different seasons. We also **grouped the weather condition,** which is a categorical variable, while accident count is shown as a percentage of total accidents.

This chart underscores the need for enhanced safety measures during adverse weather conditions, such as improved signage and road drainage systems. We can see that rain is the leading cause of accidents in every single season. Even in the winter, the number of accidents due to rain far surpasses the number of accidents due to snow.



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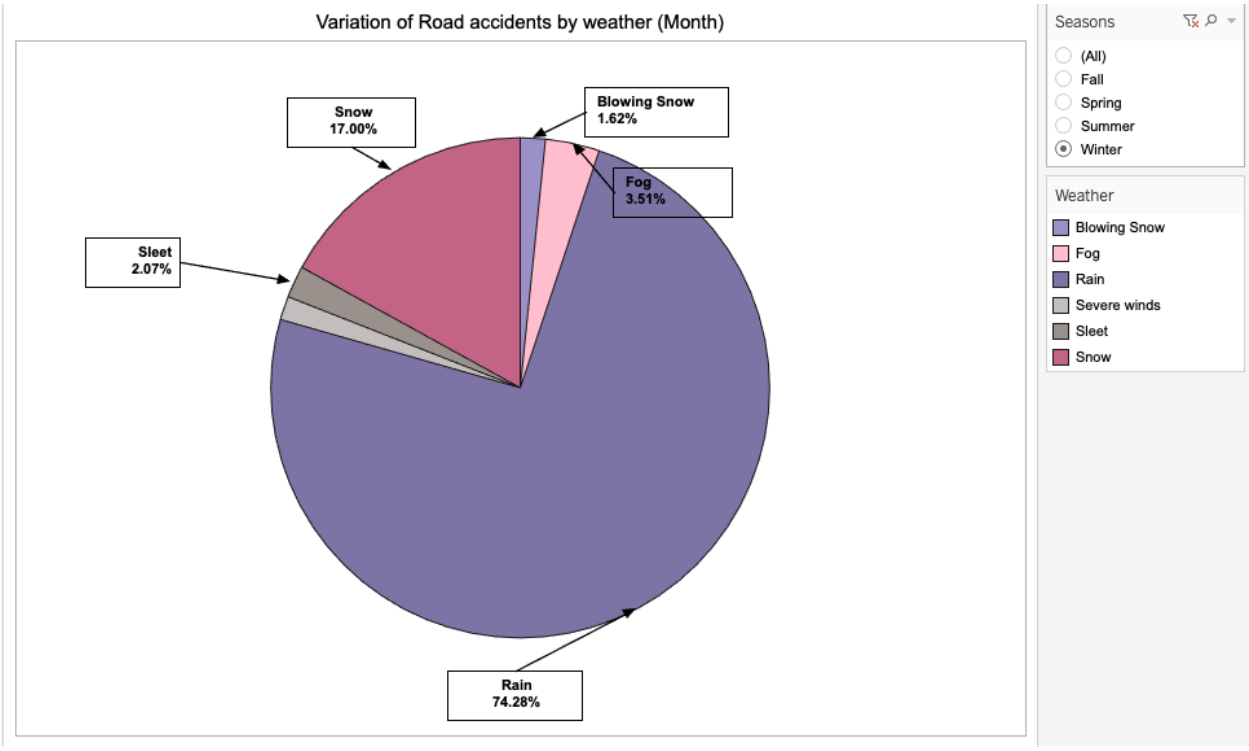

Fig 1.13. Winter specific distribution

5. Summary and Conclusion

In this project, we took a deep dive into road accident patterns in Montgomery County, Maryland, aiming to understand the factors behind these incidents and identify ways to make the roads safer. Using data from the Automated Crash Reporting System (ACRS), we explored where, when, and why these accidents happen, along with the role of traffic violations.

1. **Crash Patterns and Hotspot**: Our analysis showed that certain areas in Montgomery County see higher accident rates, especially during rush hours on weekdays. These insights suggest that interventions should focus on these high-traffic times and places.
2. **Severity and trends**: We looked at accident severity from 2021 to 2024 and found that while property damage incidents are the most common, injuries are also frequent. Thankfully, fatal crashes are relatively rare, but there's room for improvement to reduce both injuries and fatalities.
3. **Traffic Violations and Accidents**: There's a noticeable link between traffic violations (like speeding and DUIs) and accidents. This trend suggests that targeted law enforcement during peak times could help curb the rate of accidents, potentially saving lives.
4. **Accident Causes**: Driver distraction stands out as a major factor in these crashes, with mobile device use being a significant contributor. Public awareness campaigns focused on the dangers of distracted driving, along with stricter penalties, could make a difference.
5. **Impact on Pedestrians and Cyclists**: Non-motorists are often involved in accidents due to visibility issues or improper use of the roadway. There's a clear need for initiatives that promote safe pedestrian behavior and improve road infrastructure to protect these vulnerable groups.
6. **Environmental Factors**: Rain was found to be the most frequent weather condition linked to accidents, which indicates a need for better road drainage and enhanced signage for driving in bad weather.

Conclusion

Our findings highlight that while road accidents are influenced by various uncontrollable factors, there are several practical steps local government, law enforcement, and citizens of Montgomery County can take to improve safety. By focusing on distracted driving, increasing traffic law enforcement during peak times, and making infrastructure improvements, the county can help create safer roads. Simple actions like public safety campaigns, stricter distracted driving laws, and regular road maintenance could make a real impact on reducing accidents and saving lives.

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Contributions

- **Sunny Tanna**: Research, Documentation & Visualization
- **Harkanwar Singh Chadha**: Storytelling, Visualization & Documentation
- **Chhaya Tundwal**: Creation of Data dictionary, Data Preparation & Visualization
- **Prashast Vaish**: Dataset Identification, Data Preparation & Visualizations