Analyzing Motor Vehicle Collisions in the USA: Insights from the Crash Investigation Sampling System (CISS)

Group Two (2):

Emmanuel Blay Armah

Avinash Bunga

Kwadwo Fosu Appiah

Master of Science in Information Systems and Business Analytics

PARK UNIVERSITY

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Professor Robert Kao

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Abstract

This project, titled "Factors Affecting Crash Severity and Injury Outcomes in the United States," tackled the urgent issue of nationwide traffic crashes. It sought to analyze daily and temporal crash patterns, investigate the impact of tire tread depth on crash occurrence, and predict crash trends for 2022. Utilizing quantitative and statistical methods, including a one-sample t-test and regression analysis, the project unveiled distinct temporal trends in daily crashes, revealing peak occurrences during specific hours. Additionally, it discerned variations in crash frequencies between weekdays and weekends, while monthly and seasonal analyses demonstrated fluctuating patterns throughout the year. The one-sample t-test findings underscored a significant discrepancy between expert-recommended tire tread depth limits (6.35) and the mean tread depth of crash-involved vehicles (6.19), highlighting a concerning trend potentially contributing to accidents. Furthermore, regression analysis shed light on the relationship between tire tread depth and crash occurrence. By employing historical crash data to forecast 2022 trends, this research provides essential insights for policymakers, transportation agencies, and healthcare providers. It emphasizes the necessity for comprehensive safety measures and identifies potential areas for intervention to mitigate the human and economic toll of traffic crashes in the United States.

Keywords: traffic crashes, crash severity, tire tread depth, temporal patterns, forecasting, safety, measures

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Acknowledgments

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Emmanuel Blay Armah, Avinash Bunga and Kwadwo Fosu Appiah

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Introduction

The National Highway Traffic Safety Administration (NHTSA) in the United States has collected and analyzed comprehensive crash data since the early 1970s to enhance road safety and reduce motor vehicle accidents, injuries, and fatalities. A pivotal component of this effort is the Crash Investigation Sampling System (CISS), succeeding the long-standing National Automotive Sampling System Crashworthiness Data System (NASS CDS).

Motor accidents are a major public health issue that causes significant mortality and morbidity worldwide. According to the World Health Organization (WHO), road traffic injuries are one of the top ten causes of death worldwide., with the highest incidence among individuals aged 5-29 (WHO, 2021). In 2020, the United States reported 35,766 fatal car crashes, 1,593,390 injury crashes, and 3,621,681 property damage crashes, resulting in 5,250,837 collisions (Forbes Advisor, 2023). Driving while intoxicated with alcohol or other substances significantly contributes to car accidents. Driving Under the Influence (DUI) accounted for 35% of all fatal motor vehicle accidents in the U.S. in 2020, causing 13,695 deaths (Forbes Advisor, 2023). Montana had the highest DUI-related fatalities, with 51% of fatal crashes involving intoxicated drivers (Forbes Advisor, 2023).

Extensive collaboration with law enforcement agencies, medical institutions, insurance companies, repair facilities, and accident-involved individuals enables CISS to access critical information, including police crash reports, medical records, and vehicle-related data. This information is instrumental in understanding crash circumstances, identifying road safety issues, assessing vehicle safety system performance, and gauging the severity of crash-related injuries. Additionally, it contributes to evaluating motor vehicle standards and highway safety programs.

Various entities, such as federal agencies, state and local governments, universities, industries, and the public, utilize CISS data to facilitate informed decision-making and enhance road safety.

Problem statement

The problem statement for this project is to investigate the car crash data and analyze the potential correlations and implications of tire tread depth, vehicle type, and vehicle body type. To understand how these factors contribute to accident frequency, severity, and associated risks, ultimately informing safety measures and interventions in the context of road traffic accidents.

Project Objectives and Goals

The project aims to analyze crash patterns over time, examine the impact of tire tread depth on crashes, and predict crash trends in 2022. By achieving these objectives, we aim to highlight critical aspects of traffic safety and contribute to informed decision-making in accident prevention and mitigation.

Research Questions or Hypotheses

To guide our research, we have formulated the following questions and hypotheses:

- What are the daily and temporal patterns of traffic crashes in the United States?
- Is there a significant difference between expert-recommended tire tread depth limits and the actual tread depth of vehicles involved in crashes?
- Can historical crash data effectively forecast traffic crash trends for 2022?

Literature Review

Road accidents remain a pressing public health and safety concern in the United States, resulting in thousands of fatalities and injuries annually. Road accident prevention and intervention strategies require a comprehensive understanding of their causes and contributing factors. However, the inherent complexity and diversity of road accidents pose substantial challenges to data collection and analysis. Thus, there is a critical need for reliable and extensive data sources to capture the intricate details and contextual circumstances surrounding road accidents and their outcomes.

One such invaluable data source is the Crash Investigation Sampling System (CISS), an extensive nationwide survey of road crashes involving light passenger vehicles administered by the National Highway Traffic Safety Administration (NHTSA). CISS systematically collects detailed information concerning crashes involving at least one towed passenger vehicle, spanning minor incidents to severe and fatal collisions. The dataset encompasses a wealth of information, including crash scene details, vehicle descriptions, occupant injuries, pre-crash events, critical reasons for the accident, and contributing factors. Trained crash technicians are deployed to accident sites to inspect vehicles, conduct victim interviews, and review medical records, meticulously compiling CISS data. Researchers and stakeholders can access CISS data through a user-friendly web-based case viewer and a comprehensive data file repository.

CISS data has served various purposes, including identifying crash patterns and trends, evaluating vehicle safety performance and emerging technologies, assessing injury mechanisms and severity, scrutinizing human factors and driving behaviors, and formulating countermeasures and recommendations. Factors such as vehicle size, age, and type have influenced crash outcomes, and studies have relied on CISS data to investigate this pivotal role.

The sample of crashes used to gather data may only partially represent some accidents in the US. Therefore, appropriate weighting and sampling techniques are essential when using data from the Crash Injury Research and Engineering Network (CIREN) to ensure accurate and applicable results. Additionally, CISS data is susceptible to errors and biases stemming from diverse sources, including incomplete or inaccurate police reports, missing or inconsistent medical records, recall inaccuracies or reticence on the part of crash victims, measurement errors, subjective judgments by crash technicians, data entry staff coding errors or inconsistencies, and quality control concerns or data processing delays. It is imperative to implement meticulous data cleaning and validation techniques to safeguard the quality and reliability of the dataset.

In summation, CISS data is an invaluable resource for analyzing factors contributing to road accidents in the United States. Its richness and granularity provide a comprehensive view of various facets of road accidents, offering researchers and stakeholders profound insights into the causes and repercussions of these incidents and the development of pragmatic solutions for their mitigation. Nevertheless, the limitations inherent to CISS data necessitate scrupulous data handling and analysis practices to yield valid and substantiated findings of substantial societal and practical importance.

Methodology

Introduction

The methodology section of this report outlines the research design, data collection methods, and data analysis techniques employed to investigate the factors affecting crash severity and injury outcomes in the United States, utilizing the Crash Investigation Sampling System (CISS) dataset. The primary research objective is to identify and analyzing the key variables influencing crash severity and injury outcomes to inform safety interventions and policies.

Research Design

This study utilizes a quantitative research design, precisely a cross-sectional observational approach. This design allows for examining a wide range of factors simultaneously within the CISS dataset, providing a comprehensive understanding of the relationships between variables.

Participants or Samples

The participants in this study are not individuals but rather cases of police-reported crashes involving at least one passenger vehicle. The dataset comprises a nationally representative sample of such cases, ensuring diversity and generalizability.

Data Collection

Instruments

The primary data source for this research is the CISS dataset, obtained from the National Highway Traffic Safety Administration (NHTSA). The dataset contains detailed information on various aspects of each crash, including crash characteristics, vehicle damage, occupant injuries, driver behavior, environmental factors, and safety systems.

Procedures

Data collection involved accessing and downloading the CISS dataset from the NHTSA's official data repository. Once obtained, the data was cleaned and organized for analysis. Variables of interest were selected for further investigation.

Data Sources

This study relies on secondary data sources, specifically the CISS dataset, a comprehensive compilation of police-reported crash data.

Data Analysis

Statistical Methods

Quantitative dataset analysis was conducted using statistical software (Tableau and Excel). Descriptive statistics were used to summarize critical variables, and inferential statistics, such as linear regression, were employed to assess relationships and identify factors associated with crash severity and injury outcomes.

Validity and Reliability

To enhance the validity and reliability of the findings, efforts were made to ensure data quality and accuracy during the cleaning and preparation stages.

Ethical Considerations

Ethical considerations involved the responsible and lawful use of the CISS dataset, which is publicly available and de-identified. No direct contact with human subjects was involved, mitigating potential ethical concerns. The study adhered to the American Psychological Association (APA) 's ethical guidelines.

Limitations

Limitations include potential biases in the dataset due to underreporting, the lack of real-time data, and potential missing variables. Additionally, the cross-sectional design limits causal inference, and the dataset may not capture all possible factors influencing crash severity and injury outcomes.

Alternative Approaches

While other research methodologies, such as qualitative interviews with crash survivors or on-site observations, could provide valuable insights, the large-scale quantitative analysis of the CISS dataset was chosen for its ability to efficiently analyze a wide range of factors across a nationally representative sample.

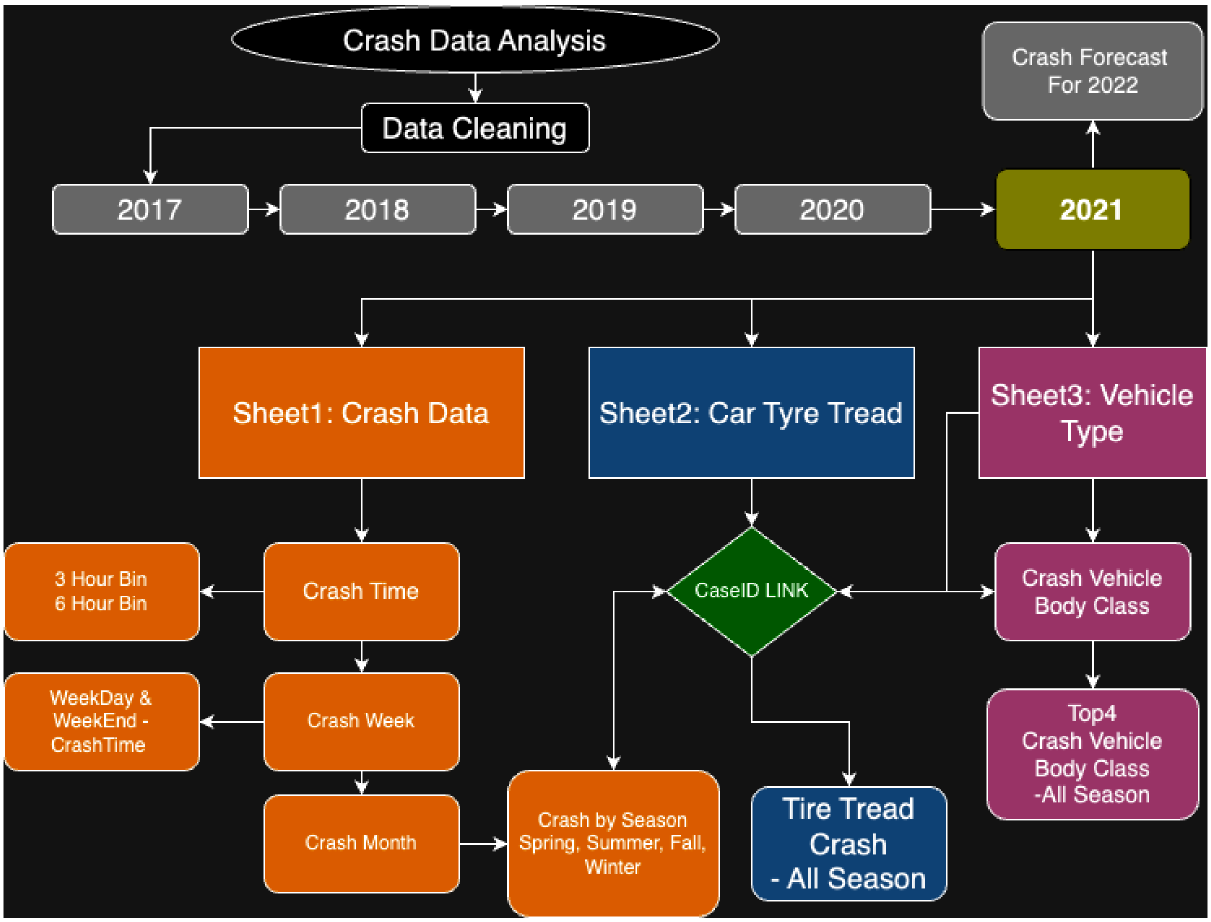
Conclusion

The chosen research methodology, involving the quantitative analysis of the CISS dataset, is well-suited to address the research objectives of this study, allowing for a comprehensive examination of factors affecting crash severity and injury outcomes in the United States.

Data Analysis

Description of the Flow Chart

Figure 1 Data Processing Workflow



Caption: This flowchart illustrates the step-by-step data processing workflow used in the project.

Data Cleaning

The initial dataset underwent rigorous cleaning, identifying and removing outliers and missing data cells.

Descriptive Statistics

Yearly Breakdown

Data was segmented annually from 2017 to 2021.

Detailed Analysis for 2021

Sheet1.

Crash Data. Focus on specific metrics such as:

- Crash Time: Analyzed in two bins, 3-hour- and 6-hour intervals.
- Crash Week: Further segmented into weekdays and weekends.
- Crash Month: This data was expanded to include seasonal analysis, with the months grouped as Spring, Summer, Fall, and Winter.

Case ID:

A common attribute across all sheets connecting disparate datasets for cohesive analysis.

Sheet2: Crash Tyre Tread:

Focused on the analysis of tire thread patterns across all seasons

Sheet3: Vehicle Type:

Crash Vehicle Body Class Analysis: Delve deeper into the specific types of vehicle bodies involved in crashes.

Top 4 Crash Vehicle Body Class - All Seasons: Highlighting the four most frequent vehicle body classes involved in crashes.

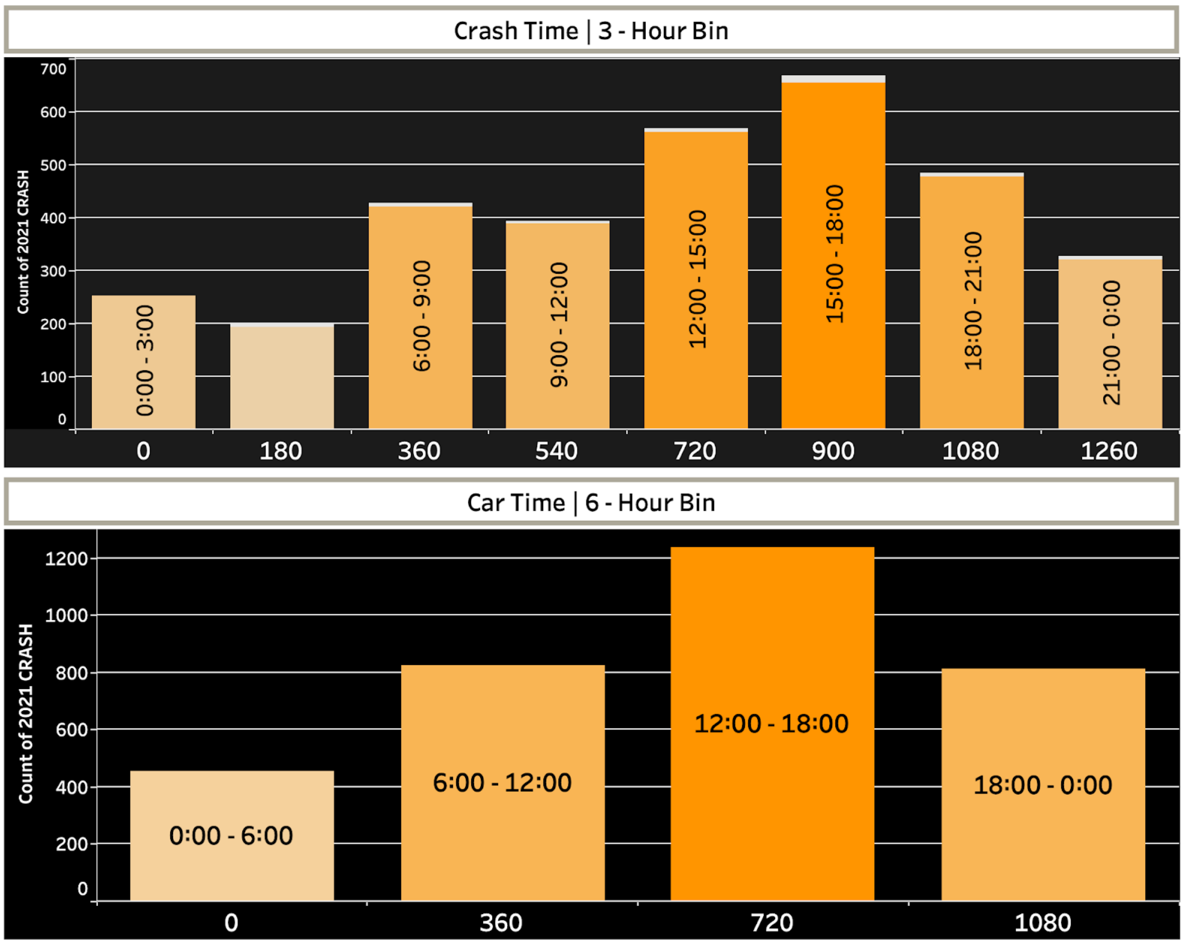
Forecasting - Crash Forecast for 2022

Using the data and trends observed from 2017 through 2021, a predictive model will be developed to forecast the potential crash scenarios in 2022. This would provide insights into potential preventative measures and strategies that might be implemented to reduce crash incidents in the forecasted year.

Graph 1: Crash Time Analysis | 3 and 6 Hour Bin

Daily Crash Patterns

Figure 2 Daily crash trend by time



- **Top Bar Graph:** Highlights the Crash Time Analysis in a 3-hour bin format.
- **Bottom Bar Graph:** Presents the Crash Time Analysis using a 6-hour bin.
- **Key Insight:** The highest crash trend is observed between 12:00 to 6:00.

The diagram illustrates a crash time analysis of motorway accidents in 2021, categorized into 3-hour and 6-hour bins. Most accidents occurred between 15:00-18:00 in the 3-hour bin, attributed to high traffic and commuter activity during these hours. The 6-hour bin showed a similar pattern, with accidents concentrated from 12:00-18:00, again due to increased vehicle volume and human activity.

Graph 2: Comprehensive Week Analysis

Weekday vs. Weekend Trends

Figure 3 Weekday vs Weekend Trends

- **Top Bar Graph:** Showcases the Crash Week Analysis. Notably, Saturdays witness the highest crash occurrences.
- **Bottom Left Graph:** Depicts the WeekDay Crash Time Analysis.

- **Bottom Right Graph:** Portrays the WeekEnd Crash Time Ana

The graphs depict a 2021 weekly analysis of motorway accidents, revealing a notable surge in weekend accidents. Moreover, most accidents occurred between 12:00 and 18:00 on weekdays and weekends.

Several factors contribute to this pattern. Firstly, weekends often see increased recreational Moreover, long-distance travel leads to higher traffic volumes and a greater accident risk. Secondly, the 12:00 to 18:00 timeframe coincides with the afternoon rush hour, when commuting and various activities peak. This period combines traffic density, potential driver fatigue, and distractions, heightening the likelihood of accidents.

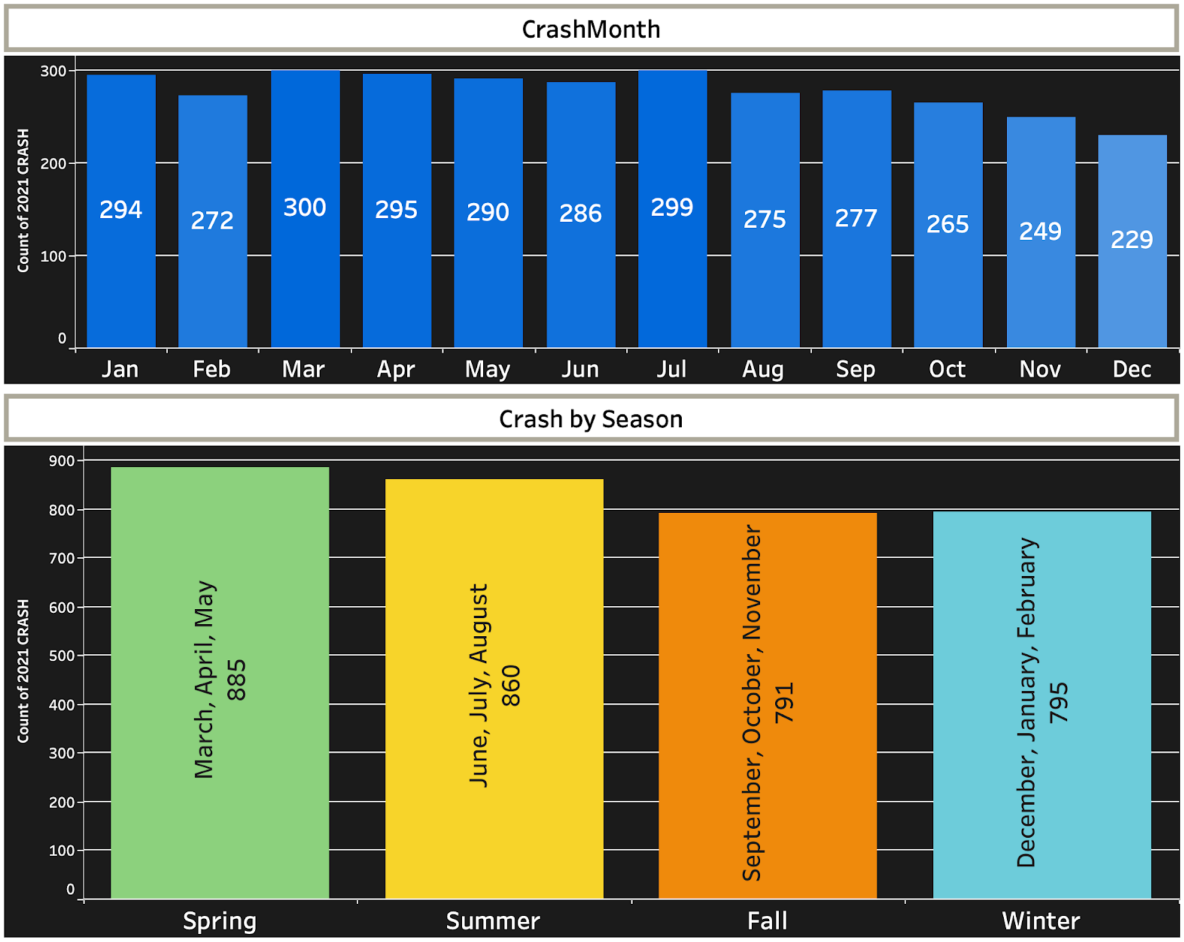
Furthermore, daylight hours in this timeframe encourage more people to be on the road, whether for work on weekdays or leisure on weekends, increasing overall activity and accident risk.

In conclusion, understanding these trends is crucial for formulating strategies to improve road safety during weekends and the 12:00 to 18:00 window on both weekdays and weekends.

Monthly and Seasonal Trends

Graph 3: Monthly and Seasonal Crash Analysis

Figure 4 Monthly and Seasonal Trends



Top Bar Graph: Presents the Crash Month Analysis.

Bottom Bar Graph: Provides insights into the Crash trends by Season.

The provided data reveals a consistent pattern of motorway accidents throughout 2021, with minimal month-to-month variation. However, when considering seasons, spring is the season with the highest accident cases, closely followed by summer. Conversely, fall and winter show relatively stable accident counts.

The underlying factors behind these seasonal trends are noteworthy. In late fall and winter, cold weather often discourages commuting to work, potentially reducing overall traffic.

Additionally, adverse weather conditions, like snow and ice, make road travel perilous, prompting people to choose alternative transportation methods such as air travel. These factors combined lead to fewer cars on the road during these seasons and fewer road accidents.

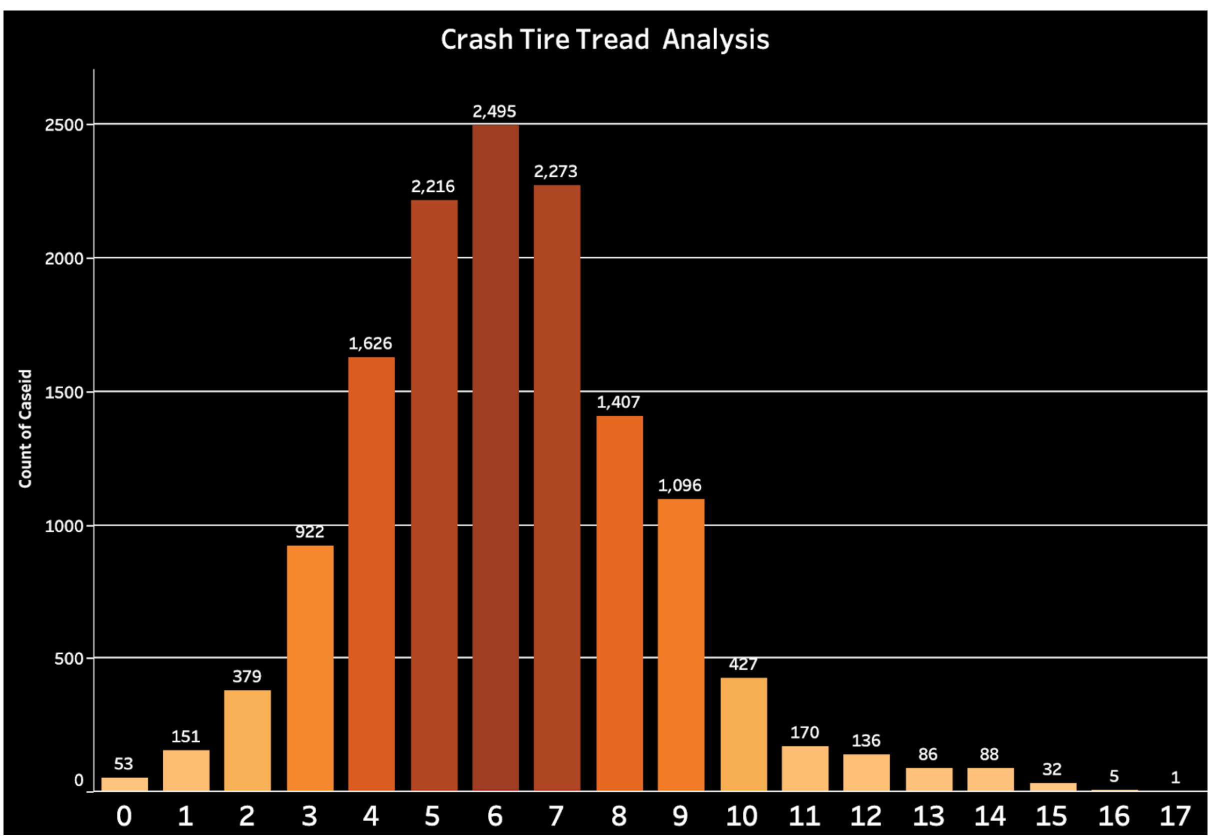
Snow and ice on road surfaces are a natural deterrent, limiting road users' driving ability. This decrease in road usage due to weather conditions contributes to a reduction in accidents.

Understanding these seasonal trends and the influence of weather on road usage and accident rates can be invaluable for shaping effective traffic management strategies and enhancing road safety, particularly during spring and summer when accident rates tend to be higher.

Tire Tread Depth Analysis

Graph 4: Crash Tire Tread Overview

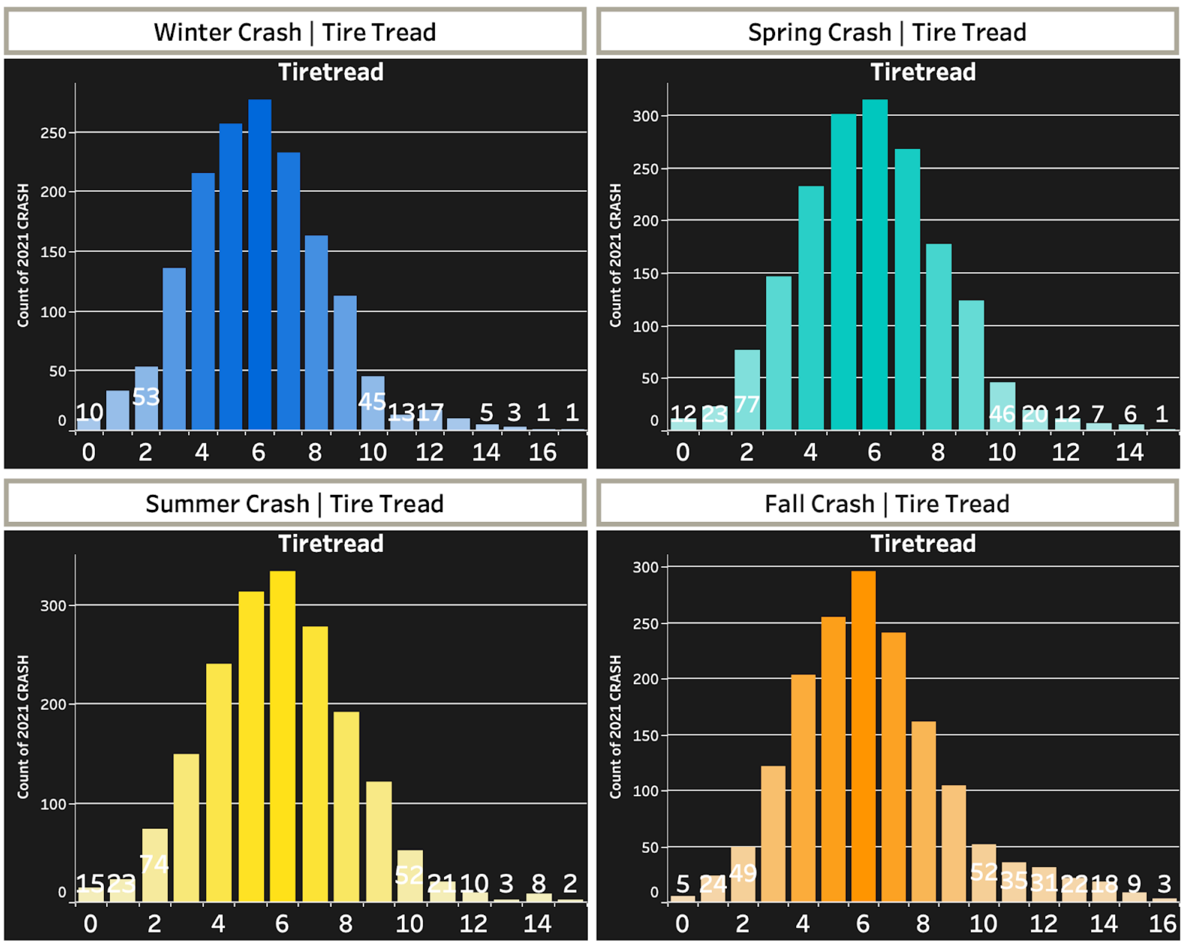
Figure 5 Crash Tire Tread Analysis



- **Bar Graph:** Delves into Crash Tire Tread Analysis.
- **Key Insight:** Tyre size 6 carries the highest crash risk.

Graph 5: Seasonal Tire Tread Analysis

Figure 6 Seasonal Tire Tread Depth Trends



Displays crash trends based on tire treads across different seasons:

- Winter Crash
- Spring Crash
- Summer Crash
- Fall Crash

Crash tire tread analysis

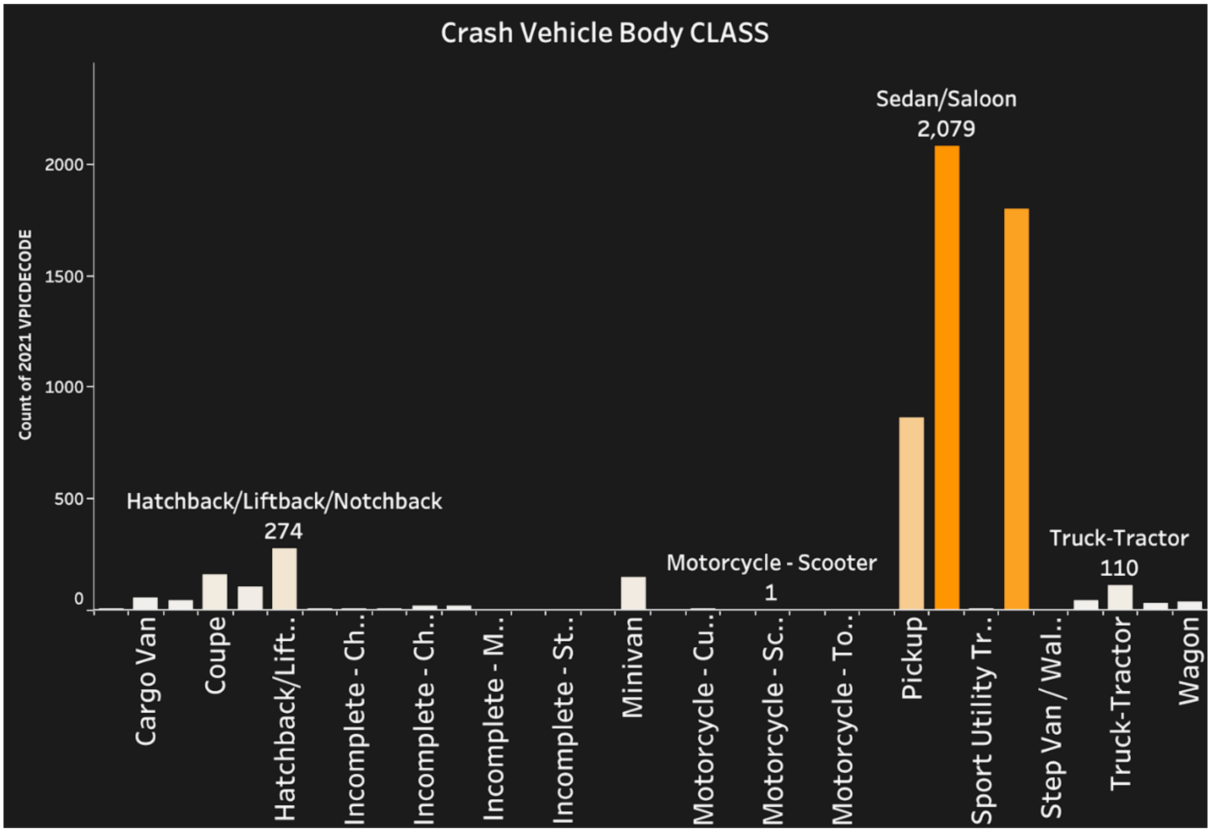
The figure analyzes tire tread depth in motorway accidents during 2021. Notably, most accidents involved vehicles with standard tread depth, though other factors like hydroplaning could have played a role. Drivers, road conditions, and vehicle maintenance all play a role in influencing accidents, not just tread depth.

Interestingly, the number of accidents remained relatively consistent across different tire tread depths throughout the seasons. Broader road safety factors influence accidents, not just tread depth.

While standard tire tread depth was typical in accident-involved vehicles, a more holistic approach to road safety, addressing factors beyond tread depth, may be necessary to reduce accident rates.

Graph 6: Vehicle Body Class Crash Analysis

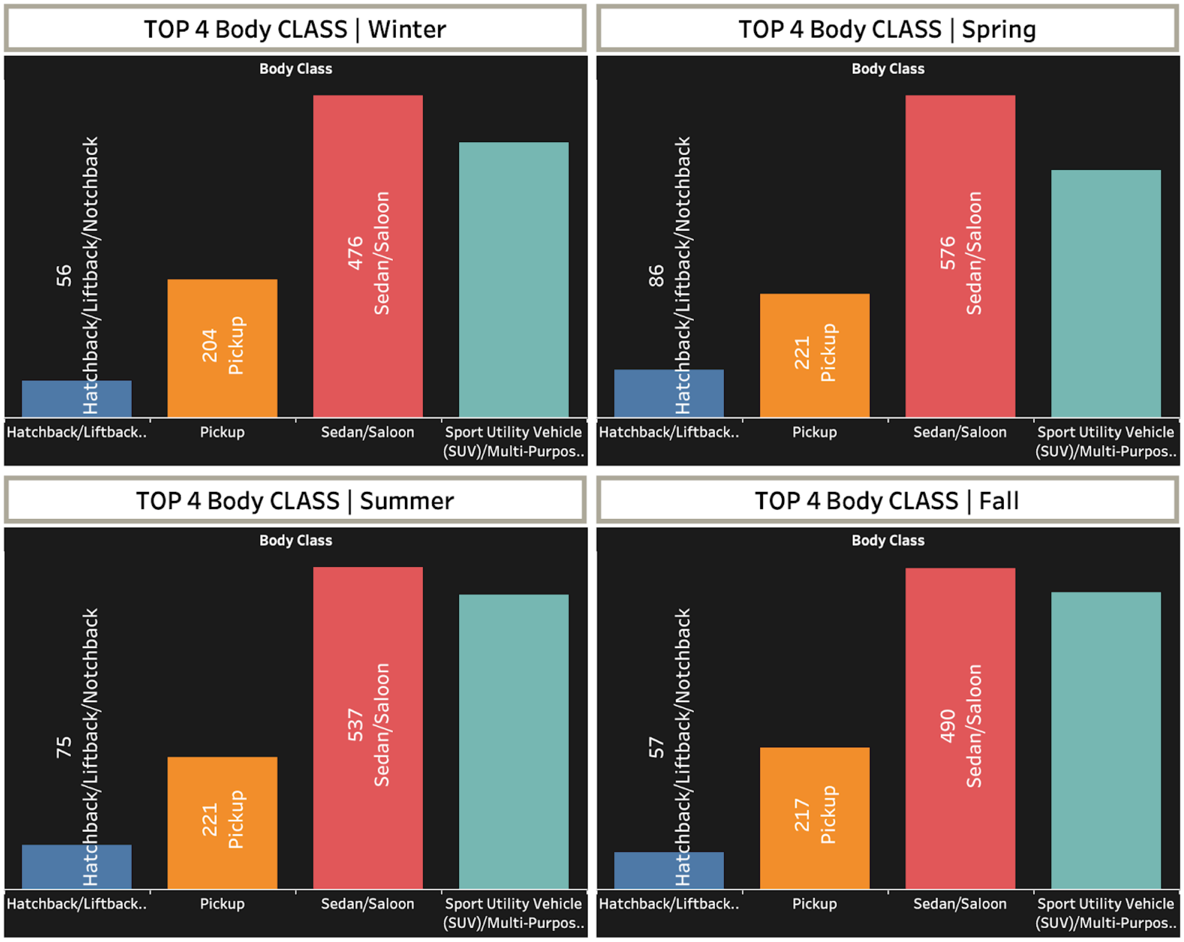
Figure 8 Crash Vehicle Body Class



Bar Graph: Reflects the Crash Vehicle Body Class data.

Key Insight: Sedans/Saloons and SUVs/MUVs are predominantly involved in crashes.

Figure 9 Top 4 Vehicle Body Type in Crash



- Showcases the top 4 vehicle body classes prone to crashes during each season:
  - Winter
  - Spring
  - Summer
  - Fall
- **Key Insight:** Across all seasons, the trend remains consistent with Sedan/Saloon at the forefront, followed by SUV/MUV, Pickup, and then Hatchback.

The graph displays the vehicle body classes involved in accidents in 2021. Sedans and cars were the most common, with overloading contributing to the high accident rate. SUVs/MUVs followed closely, with a similar pattern of accidents due to overloading. On the other hand, wagon cars had the lowest incidence of accidents among the vehicle body classes.

It is worth noting that the accident numbers remained consistent throughout the different seasons, indicating that overloading and tire pressure may not be the only causes of accidents. A comprehensive approach may be necessary to tackle road safety concerns more effectively. The data indicates that sedans and cars have the highest frequency of overloading accidents, followed by SUV/MUV incidents, while wagon cars have several accidents. It is important to emphasize that the accident rates remain consistent throughout the year, highlighting the need for a road safety strategy that considers more than just the type of vehicle.

Tire Tread Depth Analysis: Bridging the Safety Gap

The t-test is a statistical analysis used to determine if there is a significant difference in means between two groups or between one group and a hypothesized mean. (Kim et al., 2015).

The legal criteria for determining the wear and tear of tires vary across different countries. When tires' tread depth falls below 2/32 inches, approximately 1.6mm or 3.2 in the CISS dataset, many countries consider them to have reached the end of their lifespan. In the United States, tires must exhibit visible Tread Wear Indicator bars, which extend from one end of the tread pattern to the other whenever the tread wears down to the minimum legal threshold of 2/32 inches.

We will analyze crash tire tread data to determine if the average tire tread causing an accident significantly differs from the expert-advised tread depths tires should be changed, which is 4/32. It is crucial to change the vehicle's tires when the tread depth reaches 5/32 for winter and 4/32 for all other seasons to guarantee safety and the safety of other road users. (Tire Rack, 2023).

Research Question

Does the average tire tread depth in the Crash Investigation Sampling System dataset differ significantly from the expert-advice tire tread depth of 6.35, based on a one-sample t-test?

Hypothesis

Converting inches to millimeters:

(Quantity in inches) *25.4 = Quantity in mm

Value of tire tread depth in dataset = Quantity in mm * 2

4/32 inches * 25.4 = 3.175

Therefore, 4/32 = = 6.35

- Null Hypothesis (*H*0): The average tire tread of crash vehicles is equal to 6.35 or 4/32 inches
- Alternative Hypothesis (*Ha*): The average tire tread depth is not equal to 6.35 or 4/32 inches

Sample Mean and Sample Standard Deviation

Sample Mean (x)= AVERAGE (tire tread depth column) = 6.190297132

Standard Deviation (s) = STDEV (Tire tread depth column) = 2.352817485

Count (n) = COUNT (Tire tread depth column) = 13563

Standard error of mean (SEM) = Standard deviation/SQRT(Count) = 0.020202744

Degree of Freedom (df) = Count(n) – 1 = 13563 -1 = 13562

Hypothesized mean (μ) = 6.35

t-statistic = (Sample Mean (x) - Hypothesized mean (μ))/ Standard error of the mean (SEM)

= 7.905008797

p-value = TDIST (t-statistic, Degree of freedom,2) = 2.89E-15

Analysis

A one-sample t-test is conducted to determine if the mean tire tread depth in the dataset differs from the expert-advised value of 6.35 (Zach Bobbitt, 2022).

Findings

- The average tire tread depth in the dataset is 6.19.
- The t-statistic is 7.91, and the p-value is 2.89E-15, significantly less than the standard significance level of 0.05.

Interpretation

The low p-value indicates strong evidence to reject the null hypothesis that the average tire tread depth in the dataset is equal to the expert-advised value of 6.35. The positive t-statistic further suggests that the average tread depth in the dataset is significantly lower than the recommended value.

Confidence in Findings

Given the large sample size (n=13563) and the very low p-value, there is high confidence in the finding that the average tire tread depth in the dataset significantly differs from the expert-advised value (Ott et al.; M., 2010).

Potential Bias and Limitations

Sampling Bias

If the dataset does not represent the general population of vehicles, the findings may not apply to all situations (Mondal et al.; S., 2016).

Measurement Bias

If there is variability in how tread depth is measured or recorded in the dataset, it could introduce bias.

Time Bias

If the dataset is not recent, changes in technology or tire manufacturing standards may affect the relevance of the findings to current situations.

Regression Analysis

Tire Tread Depth	Count of CASEID
0	53
1	151
2	379
3	922
4	1626
5	2216
6	2495
7	2273
8	1407
9	1096
10	427
11	170
12	136
13	86
14	88
15	32
16	5
17	1
Grand Total	**13563**

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.523746
R Square	0.274309
Adjusted R Square	0.22593
Standard Error	782.3938
Observations	17

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	3470814	3470814	5.669967	0.030942
Residual	15	9182101	612140.1		
Total	16	12652916			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1624.801	396.9081	4.093646	0.000959	778.8118	2470.791	778.8118	2470.791
0	-92.2328	38.73427	-2.38117	0.030942	-174.793	-9.67271	-174.793	-9.67271

The provided regression output presents the regression analysis results between tire tread depth and the number of cases. Let us analyze the output, discuss its limitations, and address the issue of statistical significance:

Limitations of the Model

Low R-Squared Value

The R-squared value, which measures the proportion of variance in the dependent variable (number of cases) explained by the independent variable (tire tread depth), is 0.2743. This indicates that approximately 27.43% of the variability in cases can be attributed to tire tread depth. While this suggests a relationship, it also means that a significant portion of the variation remains unexplained by the model.

Small Sample Size

The analysis is based on a relatively small sample size of 17 observations. With a small sample, the results may not represent the larger population, and the model's estimates may be less stable.

Outliers or Influential Observations

The model may be sensitive to outliers or influential observations. It is essential to examine whether any data points disproportionately affect the results.

Assumptions of Linear Regression

The regression assumes that the relationship between the variables is linear, that the errors are normally distributed, and that there is no multicollinearity (high correlation between predictors). These assumptions should be checked and met for valid results.

Interpretation of P-value

In this case, the p-value associated with the tire tread depth variable is 0.0309, which is less than the commonly used significance level of 0.05. This suggests that the tire tread depth variable is statistically significant, meaning that there is evidence to suggest that it affects the number of cases. However, statistical significance does not necessarily equate to practical or meaningful significance.

Proposed Improvements and Additional Data

To improve the quality of the model and address its limitations, consider the following:

Include More Variables

The model may benefit from including additional variables that could explain a more significant proportion of the variance in the number of cases. For example, road conditions, weather, driver behavior, or vehicle types may be relevant factors.

Larger Sample Size

Expanding the dataset with a larger sample size can improve the model's accuracy and generalizability.

Data Transformation

Explore whether transformations of the variables (e.g., logarithmic transformations) can improve the linearity of the relationship.

Check for Outliers

Examine the data for outliers or influential observations that might affect the results. Consider their impact on the model.

Test Assumptions

Ensure that the assumptions of linear regression are met. This includes checking for linearity, residuals' normality, and multicollinearity's absence.

Domain Knowledge

Consult with experts in the field to identify other relevant variables or potential sources of variation.

In summary, while the p-value suggests a statistically significant relationship between tire tread depth and the number of cases, the model has limitations regarding explanatory power and sample size. Additional variables, data, and further model refinement could enhance the model's quality and predictive capability.

Centered Moving Average Summary

Analysis of Car Crash Cases Based on Tire Tread Depth

The data provides an insightful representation of car crash cases categorized by tire tread depth, which ranges from 0 to 17. The dataset also contains a moving average to help understand the trend.

Raw Counts (Count of Caseid): The number of crash cases starts low at a tread depth of 0 with only 53 cases, gradually increasing to peak at a tread depth of 6 with 2,495 cases. As the tread depth goes beyond 6, there's a noticeable decrease in the number of crash cases.

Centered Moving Average (Direct Centered MA): This derived metric provides a smoothed view of the trend. As per the calculated centered moving average, the highest value is also at the tread depth of 6, indicating a consensus with the raw counts. The moving average further underscores the rise in crash cases as tread depth increases, peaking around the middle of the range, and then decreasing.

The graph provides an essential perspective on the correlation between tire tread depth and the frequency of crashes. It indicates that tires with a tread depth around 6 have been associated with the highest number of crashes. Proper attention to tire maintenance and timely replacements can potentially lead to a reduction in such incidents.

Tiretread	**Direct Centered MA**	**Count of Caseid**
17		1
16	12.66666667	5
15	41.66666667	32
14	68.66666667	88
13	103.3333333	86
12	130.6666667	136
11	244.3333333	170

10	564.3333333	427
9	976.6666667	1096
8	1592	1407
7	2058.333333	2273
6	2328	2495
5	2112.333333	2216
4	1588	1626
3	975.6666667	922
2	484	379
1	194.3333333	151
0		53

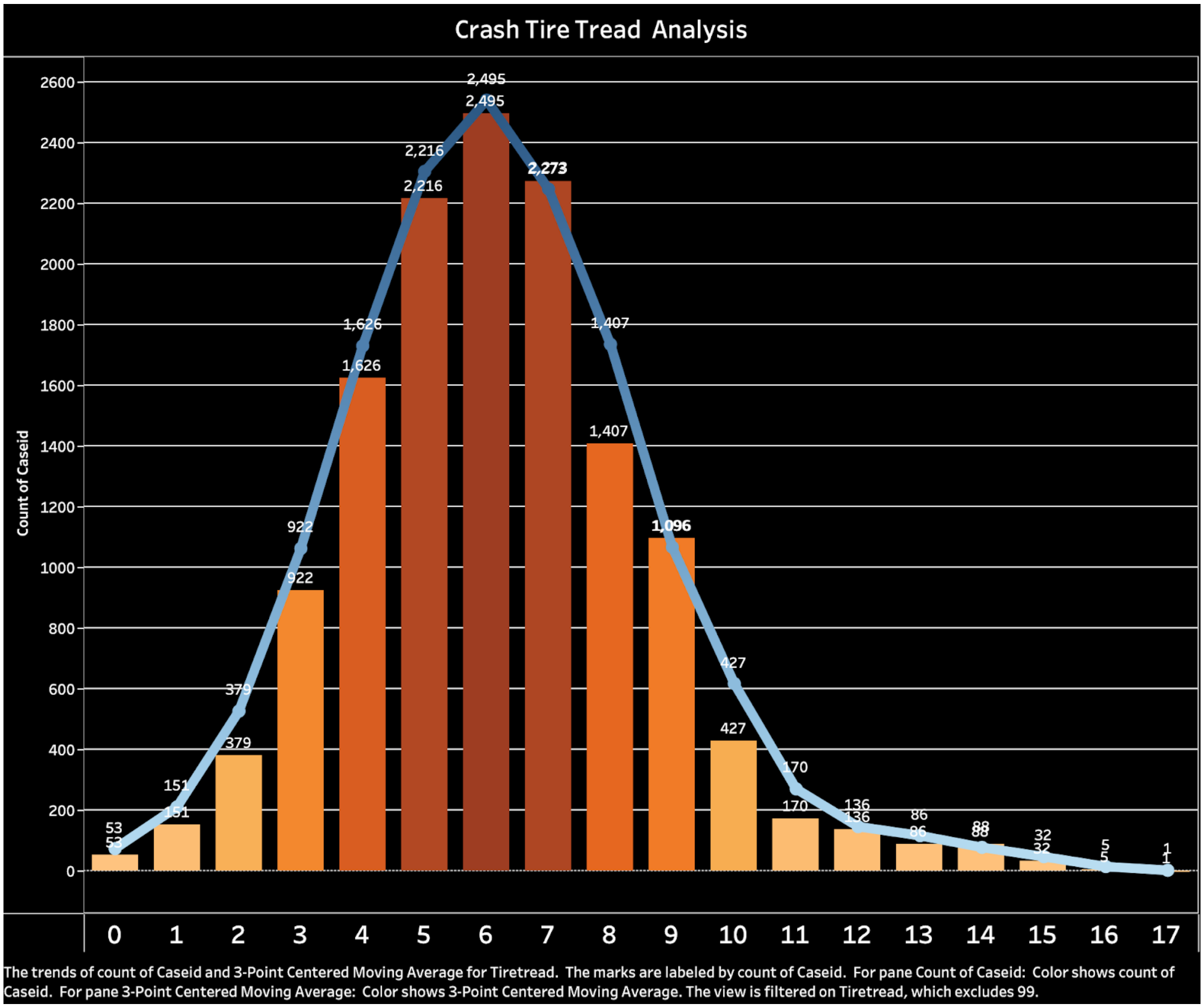
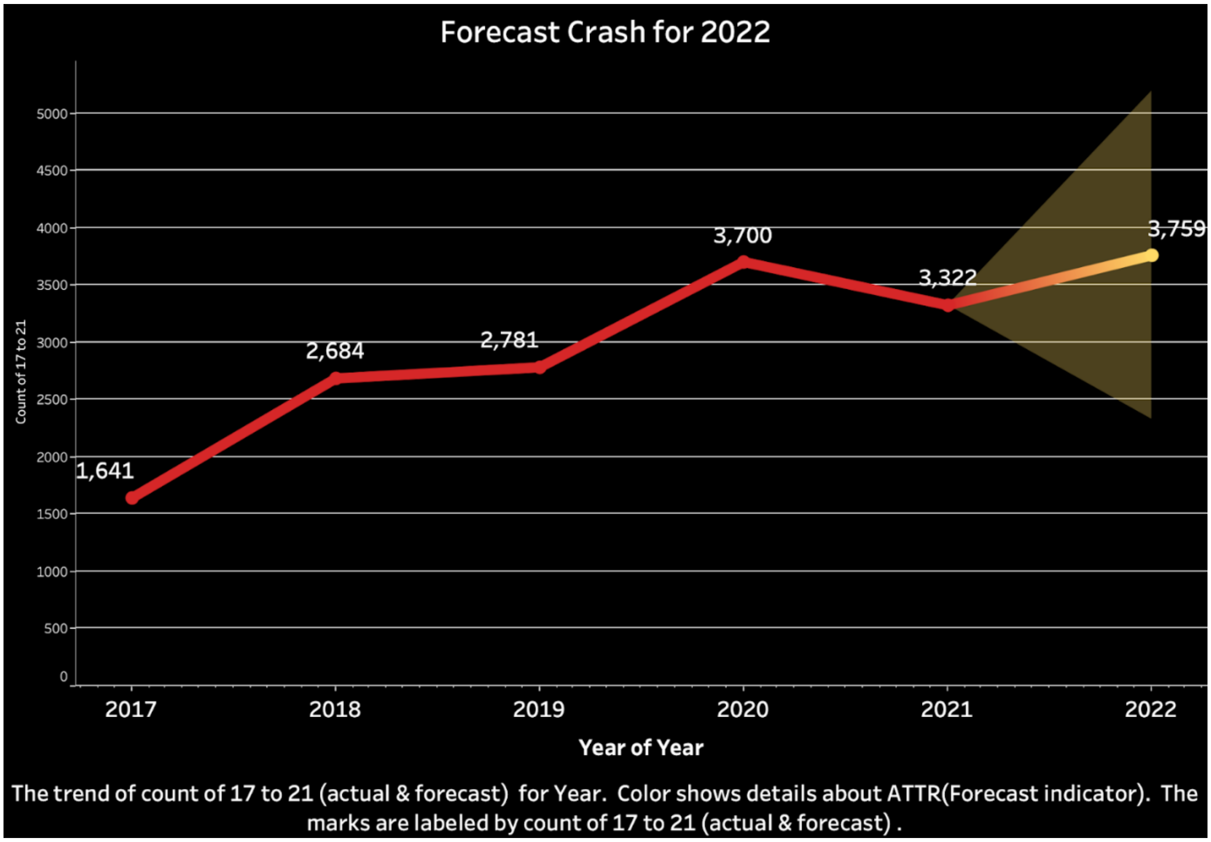


Tableau Formula Used: (LOOKUP(COUNT([Caseid]), -1) + COUNT([Caseid]) + LOOKUP(COUNT([Caseid]), 1)) / 3

Crash Forecasting

Figure 10 Crash Forecast



Graph 8: Crash forecast

Crash Forecasting (2022)

- **Line Graph**: Represents crash data from 2017 to 2021 and provides a forecast for 2022 using Tableau.
- **Forecast Model Overview:**
    - **Model Level and Trend: Additive** – Observes a consistent magnitude of change over time.

Quality Metrics

- **RMSE:** 731 – Measures the average error magnitude between predicted and observed values.
- **MAE:** 551 – Calculates the average absolute difference between predicted and actual values.
- **MASE**: 0.90 – Compares the forecast model's MAE to the naïve benchmark's.
- **MAPE**: 25.9% – Expresses forecast error in percentage terms.
- **AIC**: 76 – Helps in comparing different forecasting models.

Smoothing Coefficients:

Alpha: 0.356 (Level smoothing coefficient) – Dictates the forecast's responsiveness.

Beta: 0.300 (Trend smoothing coefficient) – Concentrates on data trends.

Findings and Implications

The results of the one-sample t-test analysis provide compelling evidence regarding the tire tread depth of vehicles involved in crashes. It is evident that most of these vehicles do not adhere to the expert-recommended tire tread depth of 6.35; instead, they fall below this advised limit. Notably, the mean tire tread depth among the vehicles in the Crash Investigation Sampling System dataset was 6.19, which is lower than the recommended threshold.

Policy Recommendations

The significance of these findings implies that policymakers should consider significant policy implications.:

Revising the Legal Limit

Policymakers should contemplate revising the limit for tire tread depth at which vehicle users must change their tires. The current legal limit, set at 3.175, may not align with safety standards and best practices. Our analysis shows that many vehicles involved in crashes still have tread depths above this legal limit but below the expert-recommended threshold. Policymakers can enhance road safety by increasing the legal limit to match or closely align with the expert-advised value of 6.35.

Incorporating Tread Depth in Vehicle Registration

When registering vehicles, authorities should make it mandatory for them to meet a minimum tire tread depth before being allowed on the road. That will prompt vehicle owners to maintain safe tread depths, ultimately reducing the risk of accidents caused by worn-out tires.

Educational Initiatives

Alongside regulatory changes, educational initiatives should raise awareness among vehicle owners regarding maintaining proper tire tread depth. Public campaigns and information dissemination can foster a culture of tire safety and responsible vehicle maintenance.

Conclusion

In conclusion, this analysis's findings suggest a notable gap between the expert-recommended tire tread depth and the actual tread depth of vehicles involved in crashes. Addressing this issue through policy adjustments and increased awareness can contribute significantly to road safety and reduce the risk of accidents associated with worn-out tires. Policymakers and relevant authorities should carefully consider these recommendations to enhance the safety of road users. The consistent trends highlight afternoon hours as a period of heightened accident risk. Understanding these patterns is crucial for implementing targeted safety measures and traffic management during peak times to enhance road safety.

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