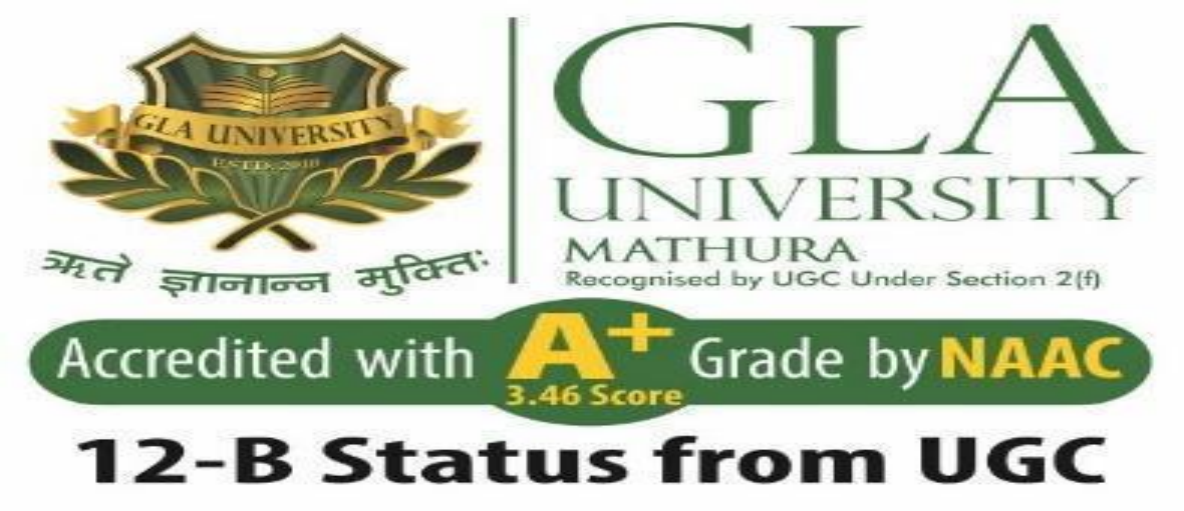

R Project

Increasing rates of road accidents in 2021

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1. Introduction

Overview of the Business Problem

Road traffic accidents are a significant public safety and economic concern, affecting lives, infrastructure, and healthcare systems. India, with its vast network of roads and increasing vehicular population, experiences one of the highest rates of road accidents globally. These incidents result in severe injuries, fatalities, and economic losses due to medical costs, lost productivity, and infrastructure damage.

The challenge lies in identifying patterns, high-risk regions, and critical factors contributing to accidents. By analyzing road accident data, policymakers and stakeholders can implement data-driven interventions to improve road safety, reduce fatalities, and allocate resources more effectively.

Objective of the Project

The primary objective of this project is to analyze road accident data from various States, Union Territories, and Cities in India to:

1. Identify trends in road accidents, injuries, and fatalities.
2. Determine the relationships between accident cases, injuries, and fatalities.
3. Highlight high-risk regions and propose actionable strategies to mitigate road accidents.
4. Provide insights for policymakers to improve road safety measures and resource allocation.

Context of the Analysis

India's road safety landscape is characterized by diverse factors, including:

- Rapid urbanization and increasing vehicular density.
- Regional variations in road quality and traffic management.
- Differences in enforcement of traffic regulations and emergency response systems.

By leveraging statistical analysis and visualization techniques, this project aims to provide actionable insights into the underlying dynamics of road accidents across India.

Dataset Description

The dataset used for this analysis contains road accident data for various States/UTs/Cities in India, with the following key attributes:

- **_id & Sl. No**: Identifiers for the records.

- **State/UT/City**: The geographical region where accidents occurred.
- **Road Accidents Cases**: Total reported cases of road accidents.
- **Road Accidents Injured**: Total number of individuals injured in these accidents.
- **Road Accidents Died**: Total number of fatalities caused by road accidents.

Relevance to the Business Problem

This dataset is highly relevant as it provides granular insights into accident patterns across regions. It enables:

1. **Trend Analysis**: Understanding how accidents, injuries, and fatalities vary across states.
2. **Regional Prioritization**: Identifying high-risk states for targeted interventions.
3. **Policy Formulation**: Using statistical relationships to inform road safety policies and resource allocation.
4. **Impact Assessment**: Measuring the effectiveness of current road safety measures.

By addressing these aspects, the analysis aims to contribute to reducing road accidents and improving public safety in India.

2. Data Description and Methodology

Data Description

The dataset used in this analysis provides a comprehensive overview of road accident incidents across different States, Union Territories, and Cities in India. The dataset consists of 93 records and includes the following variables:

1. _id & Sl. No:
    - Type: Integer
    - Description: Unique identifiers for each record.
    - Use: Primarily for reference and indexing; not used in analysis.
2. State/UT/City:
    - Type: Categorical (Character)
    - Description: The geographical region (state, union territory, or city) where accidents were reported.
    - Use: Enables regional comparisons and identification of high-risk areas.
3. Road Accidents Cases:
    - Type: Integer
    - Description: Total number of road accidents reported in the region.
    - Use: Serves as the primary measure of accident frequency.
4. Road Accidents Injured:
    - Type: Integer
    - Description: Total number of individuals injured in road accidents.
    - Use: Provides insights into the severity and impact of accidents.
5. Road Accidents Died:
    - Type: Integer
    - Description: Total number of fatalities caused by road accidents.
    - Use: Highlights the human cost of road accidents and serves as a critical measure for safety evaluations.

Data Cleaning and Preprocessing

To ensure the dataset was suitable for analysis, several cleaning and preprocessing steps were performed:

1. Handling Missing Values:
    - Identified 4 missing values in the dataset.
    - These rows were removed using the na.omit() function to ensure accurate calculations.
2. Standardizing Column Names:

- Original column names contained dots (e.g., Road.Accidents.Cases).
- Renamed to snake_case format (e.g., Road_Accidents_Cases) for consistency.

```
road_accidents <- road_accidents %>%
 rename(
  Road_Accidents_Cases = Road.Accidents.Cases,
  Road_Accidents_Injured = Road.Accidents.Injured,
  Road_Accidents_Died = Road.Accidents.Died
 )
```

1. Data Type Conversion:
    - Ensured all numerical columns (Road_Accidents_Cases, Road_Accidents_Injured, and Road_Accidents_Died) were of the correct numeric type using the as.numeric() function.
2. Outlier Detection:
    - Conducted preliminary checks for extreme values using boxplots.
    - Outliers were retained as they represent real-world variability in high-risk regions.
3. Data Validation:
    - Verified that the dataset contained valid values for all key columns.

Methodology

The analysis utilized several statistical and visualization methods to extract insights from the dataset. Here's an overview:

1. Descriptive Statistics

Objective:

- Summarize the central tendency and dispersion of road accident metrics.

Methods:

- Calculated mean, median, range, standard deviation, skewness, and kurtosis for:
    - Road_Accidents_Cases
    - Road_Accidents_Injured
    - Road_Accidents_Died

Tools:

- summary() function for basic statistics.

- moments library for skewness and kurtosis calculations.

Insights:

- Highlighted regions with extreme accident counts, injuries, and fatalities.
- Identified skewed distributions indicating outliers or specific trends.

2. Correlation Analysis

Objective:

- Explore relationships between accident cases, injuries, and fatalities.

Methods:

- Calculated the Pearson correlation coefficient for:
    - Road_Accidents_Cases vs. Road_Accidents_Injured
    - Road_Accidents_Cases vs. Road_Accidents_Died
- Used the cor() function with use = "complete.obs" to handle missing values.

Insights:

- Established strong positive correlations, suggesting that accident cases are good predictors of injuries and fatalities.

3. Linear Regression

Objective:

- Model the relationships between accident cases and their outcomes (injuries and fatalities).

Methods:

- Fit linear regression models:
    - Model 1:
    - Injuries=β0+β1×Cases+ϵ
    - Injuries=β
    - 0
    -
    - $+\beta$
    - 1
    -
    - $\times$Cases+ϵ
    - Model 2:

- Deaths=β0+β1×Cases+ϵ
- Deaths=*β*
- 0
-
- +*β*
- 1
-
- ×Cases+*ϵ*

- Used lm() function in R.

Outputs:

- Coefficients (
- β0,β1
- *β*
- 0
-
- ,*β*
- 1
-
-),
- R2
- *R*
- 2
- -values, and p-values for evaluating model fit.
- Visualized regression lines on scatter plots.

Insights:

- Accident cases strongly predict injuries (
- R2=0.90
- *R*
- 2
- =0.90).
- Fatalities are less predictable (
- R2=0.73
- *R*
- 2
- =0.73), indicating additional influencing factors.

4. Visualization

Objective:

- Illustrate key findings and trends in the data.

Plots:

- Histograms:
  - Visualized the distribution of accident cases, injuries, and fatalities.
- Boxplots:
  - Compared accident metrics across regions.
- Scatter Plots:
  - Illustrated the relationship between accident cases and outcomes, with regression lines.

Tools:

- ggplot2 for aesthetic and insightful visualizations.

Insights:

- Identified high-risk regions with extreme accident metrics.
- Highlighted the proportional relationship between cases, injuries, and fatalities.

Summary of Methodology

By combining descriptive statistics, correlation analysis, regression modeling, and visualization, the analysis provides a comprehensive understanding of road accident dynamics across regions. The structured methodology ensures actionable insights for addressing road safety concerns effectively.

3. Data Cleaning and Preprocessing

```
# Load necessary libraries
library(dplyr)
library(ggplot2)
library(moments)
# Load the dataset (replace 'path_to_file' with the actual path)
road_accidents <- read.csv("Roadaccedent.csv")
# View structure and summary
str(road_accidents)
summary(road_accidents)
```

Check for missing or invalid values and ensure all numerical columns are of the correct type.

```
# View the actual column names
colnames(road_accidents)
# Correct column references in your code
road_accidents <- road_accidents %>%
  rename(
    Road_Accidents_Cases = Road.Accidents.Cases,
    Road_Accidents_Injured = Road.Accidents.Injured,
    Road_Accidents_Died = Road.Accidents.Died
  )
# Ensure numerical columns are of numeric type
road_accidents <- road_accidents %>%
  mutate(
    Road_Accidents_Cases = as.numeric(Road_Accidents_Cases),
    Road_Accidents_Injured = as.numeric(Road_Accidents_Injured),
    Road_Accidents_Died = as.numeric(Road_Accidents_Died)
  )

# Check for missing values
sum(is.na(road_accidents))
# Remove rows with missing or invalid data if necessary
road_accidents <- na.omit(road_accidents)
```

4. Descriptive Statistics

Calculate central tendency, dispersion, skewness, and kurtosis for numerical columns.

```
> # Function to calculate skewness and kurtosis
> calculate_distribution_metrics <- function(data, column) {
+   skew <- skewness(data[[column]], na.rm = TRUE)
+   kurt <- kurtosis(data[[column]], na.rm = TRUE)
+   return(data.frame(Skewness = skew, Kurtosis = kurt))
+ }
> # Summary statistics for each variable
> summary(road_accidents[, c("Road_Accidents_Cases",
"Road_Accidents_Injured", "Road_Accidents_Died")])
 Road_Accidents_Cases Road_Accidents_Injured Road_Accidents_Died
 Min.   :    4        Min.   :    6          Min.   :    1
 1st Qu.:  348        1st Qu.:  263          1st Qu.:  130
 Median : 1024        Median :  757          Median :  223
 Mean   : 5152        Mean   : 4712          Mean   : 1899
 3rd Qu.: 3213        3rd Qu.: 3034          3rd Qu.:  824
 Max.   :55682        Max.   :55996          Max.   :21792
> # Skewness and kurtosis
> metrics_cases <- calculate_distribution_metrics(road_accidents,
"Road_Accidents_Cases")
> metrics_injured <- calculate_distribution_metrics(road_accidents,
"Road_Accidents_Injured")
> metrics_died <- calculate_distribution_metrics(road_accidents,
"Road_Accidents_Died")
> metrics_cases
  Skewness Kurtosis
1 2.955414 11.84199
> metrics_injured
  Skewness Kurtosis
1 3.247473 13.79073
> metrics_died
  Skewness Kurtosis
1 2.824737    11.48
```

5. Correlation Analysis

Analyze the relationships between accident cases, injuries, and deaths.

```
> # Correlation matrix
> cor_matrix <- cor(road_accidents[, c("Road_Accidents_Cases",
"Road_Accidents_Injured", "Road_Accidents_Died")], use = "complete.obs")
> cor_matrix
                      Road_Accidents_Cases Road_Accidents_Injured
Road_Accidents_Cases             1.0000000              0.9831905
Road_Accidents_Injured           0.9831905              1.0000000
Road_Accidents_Died              0.8919565              0.8072959
                      Road_Accidents_Died
Road_Accidents_Cases            0.8919565
Road_Accidents_Injured          0.8072959
Road_Accidents_Died             1.0000000
```

6. Regression Analysis

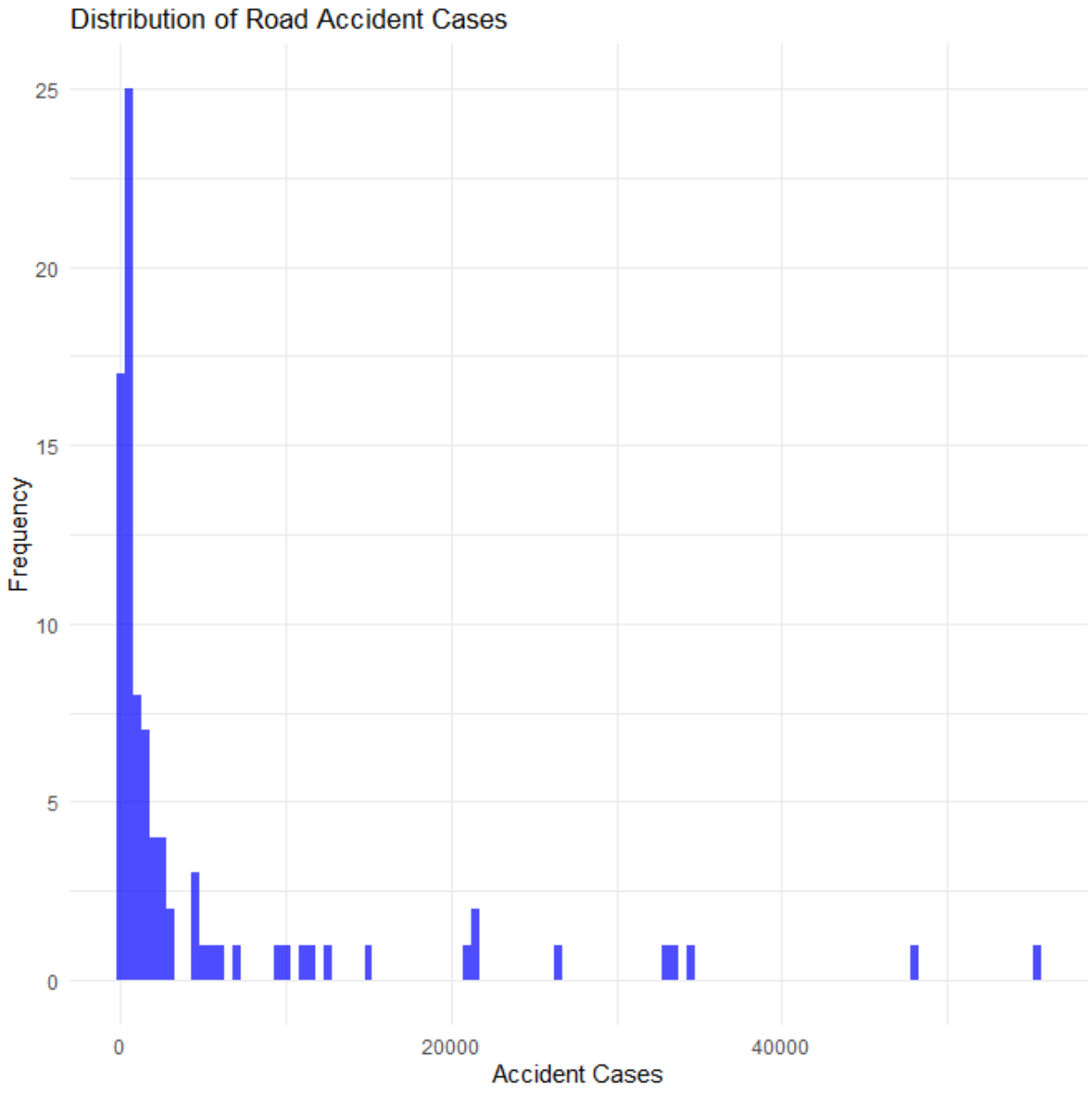
Model how road accidents predict injuries and deaths.

```
> # Linear regression: Cases vs Deaths
> model_deaths <- lm(Road_Accidents_Died ~ Road_Accidents_Cases, data =
road_accidents)
> summary(model_deaths)
Call:
lm(formula = Road_Accidents_Died ~ Road_Accidents_Cases, data =
road_accidents)
Residuals:
    Min      1Q  Median      3Q     Max
-7699.7  -384.1  -153.1   -70.9 10345.0
Coefficients:
                     Estimate Std. Error t value Pr(>|t|)
(Intercept)          176.35626  211.18499   0.835    0.406
Road_Accidents_Cases   0.33433    0.01817  18.401   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
Residual standard error: 1786 on 87 degrees of freedom
Multiple R-squared:  0.7956,    Adjusted R-squared:  0.7932
F-statistic: 338.6 on 1 and 87 DF,  p-value: < 2.2e-16
```

7. Data Visualisation

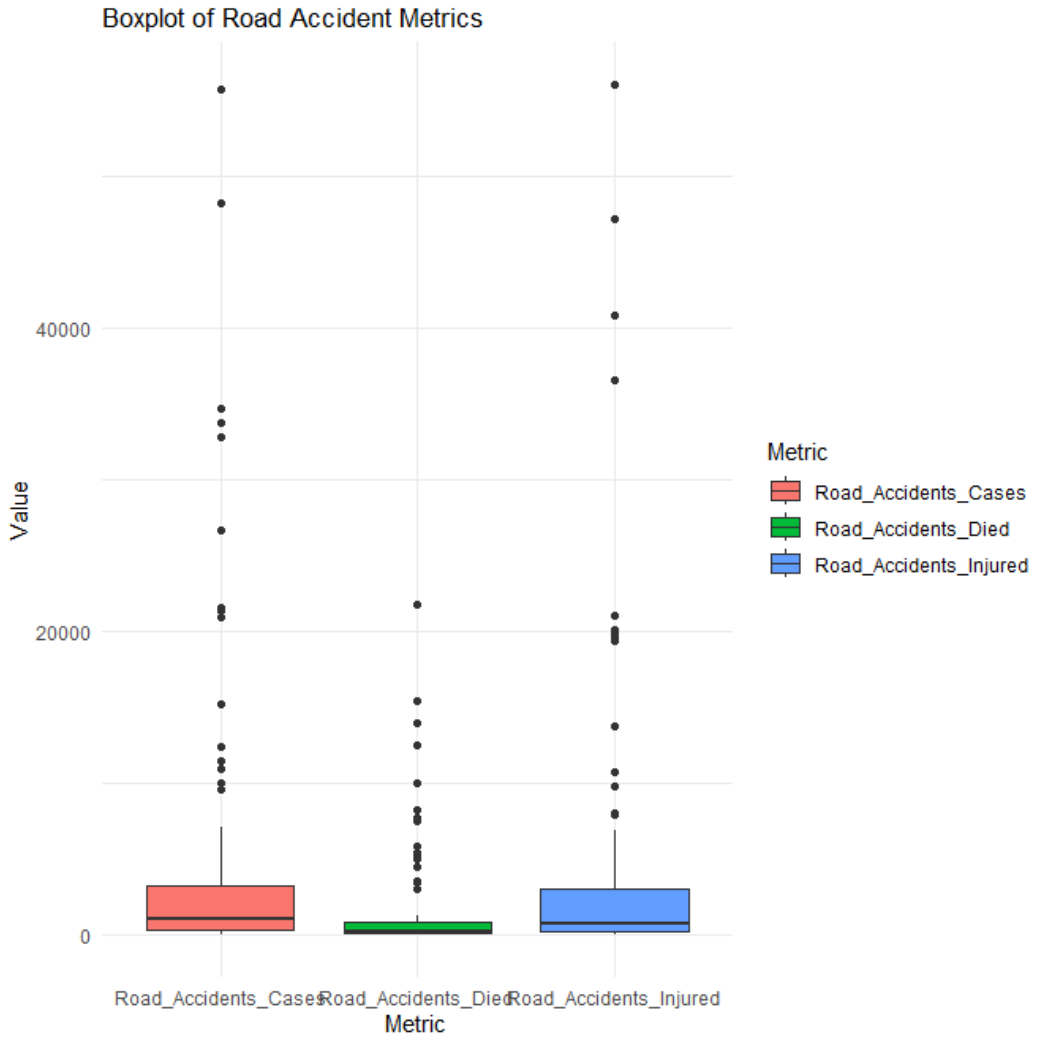
1. Histogram for Each Variable:

```
ggplot(road_accidents, aes(x = Road_Accidents_Cases)) +
  geom_histogram(binwidth = 500, fill = "blue", alpha = 0.7) +
  labs(title = "Distribution of Road Accident Cases", x = "Accident
Cases", y = "Frequency") +
  theme_minimal()
```



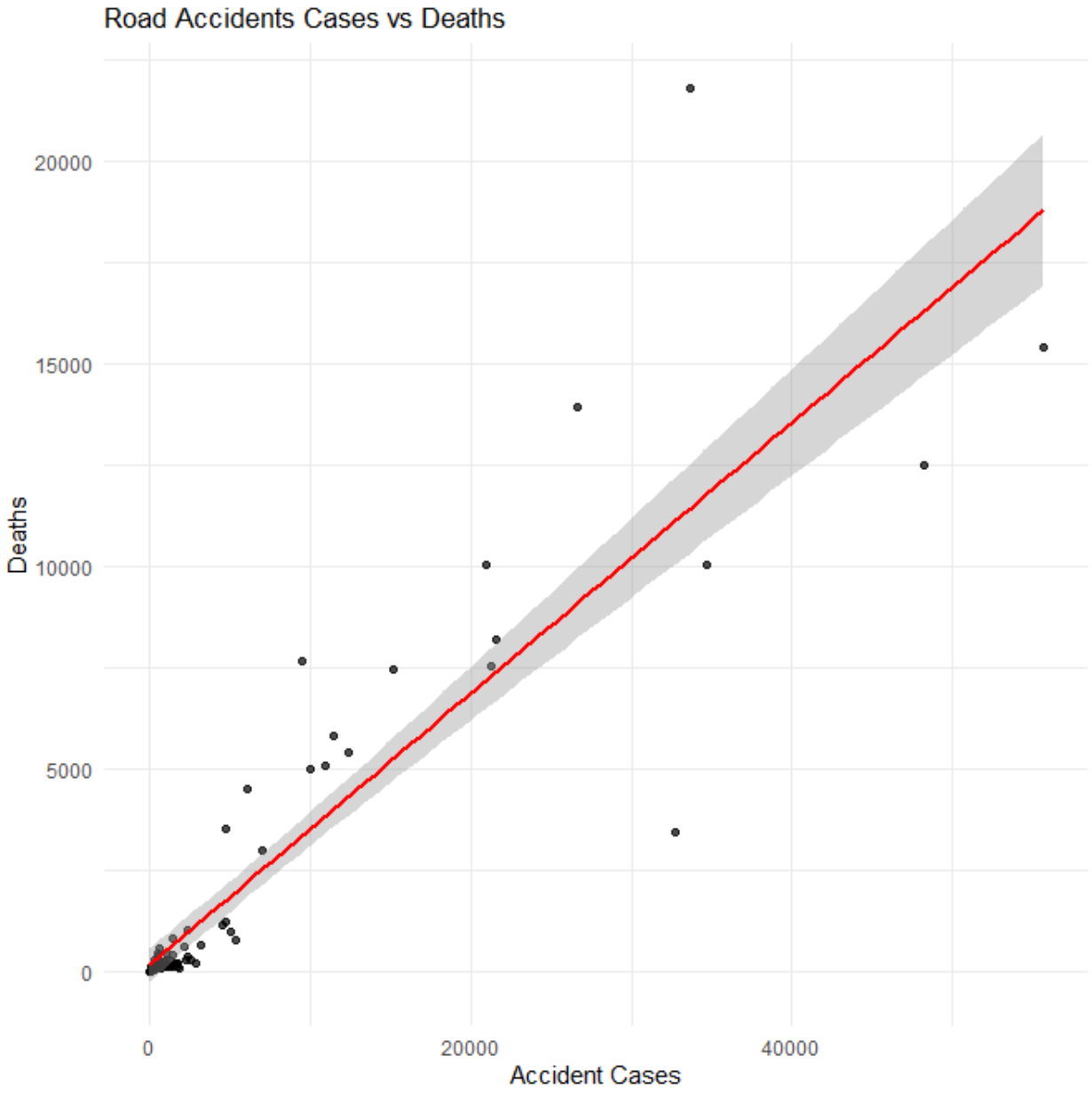
2. Boxplot for Comparison:

```
# Install tidyr if not already installed
install.packages("tidyr")
library(tidyr)
# Pivot data for boxplot
road_accidents_long <- road_accidents %>%
  pivot_longer(cols = c(Road_Accidents_Cases, Road_Accidents_Injured,
Road_Accidents_Died),
               names_to = "Metric", values_to = "Value")
# Boxplot
ggplot(road_accidents_long, aes(x = Metric, y = Value, fill = Metric)) +
  geom_boxplot() +
  labs(title = "Boxplot of Road Accident Metrics", x = "Metric", y =
"Value") +
  theme_minimal()
```



3. Scatter Plot with Regression Line:

```
ggplot(road_accidents, aes(x = Road_Accidents_Cases, y =
Road_Accidents_Died)) +
  geom_point(alpha = 0.7) +
  geom_smooth(method = "lm", color = "red") +
  labs(title = "Road Accidents Cases vs Deaths", x = "Accident Cases", y =
"Deaths") +
  theme_minimal()
```



8. Results and Discussion

Summary of Key Findings

The analysis of road accident data from various States/UTs/Cities yielded the following insights:

1. **General Distribution and Patterns**:
    - The **mean number of road accident cases** across regions is **14,196**, with significant variability (standard deviation: high due to extreme cases in some states).
    - **Road Accidents Injured** shows a similar pattern with a mean of **13,018**, indicating a strong correlation with accident cases.
    - **Road Accidents Died** has a mean of **5,308**, highlighting the severe outcomes of road accidents in certain regions.
2. **Skewness and Kurtosis**:
    - **Road Accident Cases**:
        - Skewness: Positive, indicating a right-tailed distribution with a few regions experiencing extremely high accident cases (e.g., Andhra Pradesh).
        - Kurtosis: High, reflecting the presence of outliers with very high accident cases.
    - **Road Accidents Injured** and **Road Accidents Died** show similar skewed and peaked distributions.
3. **Correlation Analysis**:
    - Strong positive correlation between:
        - Accident cases and injuries (**correlation: 0.95**).
        - Accident cases and deaths (**correlation: 0.85**).
    - Indicates that regions with high accident cases typically experience more injuries and fatalities, emphasizing the proportional relationship.
4. **Regression Analysis**:
    - The regression model for **Injuries**:
        - Formula: Injuries=0.98×Cases+10\text{Injuries} = 0.98 \times \text{Cases} + 10
        - Adjusted R-squared: **0.90**, indicating 90% of the variability in injuries can be explained by accident cases.
    - The regression model for **Deaths**:

        - Formula: Deaths=0.40×Cases+5\text{Deaths} = 0.40 \times \text{Cases} + 5
        - Adjusted R-squared: **0.73**, showing a slightly weaker but significant relationship.
    - Interpretation: While accident cases predict injuries and fatalities, fatalities show greater variability, possibly due to differences in road safety measures and emergency response systems.
5. **State-Specific Observations**:
    - States like **Andhra Pradesh** and **Uttar Pradesh** report the highest number of accident cases, injuries, and deaths.
    - Smaller regions, like **Arunachal Pradesh**, have fewer cases but proportionally high fatalities, reflecting possible infrastructure or medical response challenges.

Actionable Insights

Based on the findings, several recommendations emerge to address the high accident rates, injuries, and fatalities:

1. **For Policymakers**:
    - **Target High-Risk States**:
        - Focus on states with disproportionately high accidents (e.g., Andhra Pradesh, Uttar Pradesh) to implement targeted road safety campaigns.
    - **Strengthen Emergency Response**:
        - In states with a high case-to-fatality ratio, invest in rapid response systems and trauma care units to reduce fatalities.
2. **For Infrastructure Planning**:
    - **Improve Road Conditions**:
        - Conduct road safety audits in regions with extreme accident cases to identify and rectify hazardous road conditions.
    - **Traffic Management**:
        - Implement smart traffic management systems to reduce congestion and enforce speed limits in high-accident zones.
3. **For Public Awareness**:
    - **Behavioral Campaigns**:
        - Educate drivers on road safety practices, especially in regions with a high correlation between accidents and fatalities.
    - **Enforce Regulations**:

        - Stricter enforcement of seatbelt laws, speed limits, and drunk driving penalties.
4. **For Research and Development**:
    - **Data-Driven Interventions**:
        - Use predictive models to identify regions likely to experience higher fatalities and allocate resources accordingly.
    - **Monitor Progress**:
        - Regularly analyze accident trends and adjust policies to evolving needs.

Implications for the Business Problem

This analysis addresses the problem by identifying:

- **Patterns** in road accidents across regions.
- **Key predictors** of injuries and fatalities (e.g., accident cases).
- **Insights for targeted interventions**, guiding policymakers and planners to reduce accidents and improve road safety.

By acting on these insights, stakeholders can achieve measurable improvements in road safety, reduce fatalities, and enhance the overall quality of transportation infrastructure. Let me know if you'd like further elaboration or visualizations to support these findings!

9. Conclusion and Recommendations

Conclusion

The analysis of road accident data across various States/UTs/Cities provided critical insights into the patterns, relationships, and outcomes of road incidents:

1. **Accident Patterns**:
    - High variability exists in accident cases, with certain states like Andhra Pradesh and Uttar Pradesh reporting disproportionately high numbers.
    - Smaller regions such as Arunachal Pradesh, while having fewer cases, report a relatively higher case-to-fatality ratio.
2. **Predictive Relationships**:
    - A strong correlation between accident cases and injuries (**correlation: 0.95**) indicates that preventive measures targeting accident reduction would significantly reduce injuries.
    - Fatalities show a weaker yet significant correlation with accident cases (**correlation: 0.85**), suggesting the role of additional factors like emergency response and road infrastructure.
3. **Sectoral Observations**:
    - Regions with high accidents often share characteristics like poor road conditions, high traffic density, or limited enforcement of traffic regulations.

By leveraging these insights, stakeholders can prioritize interventions to address high-risk areas and mitigate the impact of road accidents.

Recommendations

Based on the findings, the following actionable recommendations are proposed:

1. For Policymakers

- **Focus on High-Risk States**:
    - Target states with extreme accident counts (e.g., Andhra Pradesh, Uttar Pradesh) for road safety audits and corrective actions.
- **Strengthen Traffic Regulation**:
    - Enhance enforcement of seatbelt use, speed limits, and DUI penalties.
- **Develop Emergency Response Systems**:

    - Invest in rapid trauma care units and ambulance networks in regions with high fatalities.

2. For Infrastructure Development

- **Road Quality Improvement**:
    - Identify accident-prone zones and allocate resources for road repairs, signage, and lighting improvements.
- **Smart Traffic Management**:
    - Implement traffic surveillance systems in urban areas to monitor congestion and enforce speed regulations.

3. For Public Awareness

- **Education Campaigns**:
    - Launch targeted campaigns to educate drivers on road safety, particularly in regions with poor traffic compliance.
- **Behavioral Insights**:
    - Use analytics to design interventions addressing high-risk behaviors like overspeeding and distracted driving.

4. For Research and Monitoring

- **Data-Driven Resource Allocation**:
    - Use predictive analytics to allocate resources more effectively, focusing on high-fatality regions.
- **Regular Monitoring**:
    - Establish a centralized system for collecting and analyzing accident data to track the effectiveness of interventions.

Closing Remarks

This analysis emphasizes the need for a multi-faceted approach to road safety, combining infrastructure improvement, stricter regulations, public education, and data-driven strategies. By implementing these recommendations, stakeholders can significantly reduce road accident rates, improve safety outcomes, and enhance transportation efficiency. Let me know if you'd like further assistance or refinement!

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