Predicting & Analyzing DUI with Statistical Modeling

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Project Web Page

Introduction

Despite ongoing campaigns and legal efforts, drunk driving remains a major cause of fatalities in the U.S. Traditional prevention methods often lack adaptability and fail to address root risk factors. This research explores the use of predictive analytics and machine learning to identify high-risk DUI patterns based on demographic and geographic data. By analyzing factors such as age, income, and location, the project aims to uncover meaningful trends that contribute to impaired driving. The model will integrate both historical and real-time data to assess risk and support early intervention. Ultimately, the goal is to develop a scalable, data-driven tool that empowers communities, policymakers, and law enforcement to take proactive action and reduce DUI-related incidents.

Research Question

What are the limitations of current DUI prevention methods in effectively reducing impaired driving incidents, and how can predictive modeling and data analytics be used to improve these approaches? Can our new discoveries lead to better methods of tackling this global DUI issue?

Current Solutions

1. Blood Alcohol Concentration (BAC) Limits
2. Alcohol Screening and Brief Interventions
3. Alternative Transportation Programs
4. High-Visibility Saturation Patrols
5. Mass Media Campaigns
6. Sobriety Checkpoints
7. DWI Courts

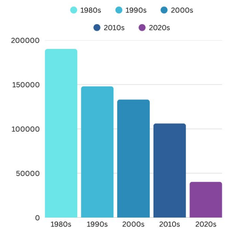
BLOOD ALCOHOL CONTENT (BAC)
Table for Male (M) / Female (F)

Number of Drinks		Body Weight in Pounds								Driving Condition
		100	120	140	160	180	200	220	240	
0	M	.00	.00	.00	.00	.00	.00	.00	.00	Only Safe Driving Limit
	F	.00	.00	.00	.00	.00	.00	.00	.00	
1	M	.06	.05	.04	.04	.03	.03	.03	.02	Driving Skills Impaired
	F	.07	.06	.05	.04	.04	.03	.03	.03	
2	M	.12	.10	.09	.07	.07	.06	.05	.05	
	F	.13	.11	.09	.08	.07	.07	.06	.06	
3	M	.18	.15	.13	.11	.10	.09	.08	.07	Legally Intoxicated
	F	.20	.17	.14	.12	.11	.10	.09	.08	
4	M	.24	.20	.17	.15	.13	.12	.11	.10	
	F	.26	.22	.19	.17	.15	.13	.12	.11	
5	M	.30	.25	.21	.19	.17	.15	.14	.12	
	F	.33	.28	.24	.21	.18	.17	.15	.14	

Subtract .01% for each 40 minutes that lapse between drinks.
1 drink = 1.5 oz. 80 proof liquor, 12 oz. 5% beer, or 5 oz. 12% wine.
Fewer than 5 persons out of 100 will exceed these values.

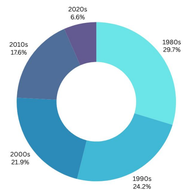
Data Analysis

Figure 1. Bar graph of DUI related fatalities per decade



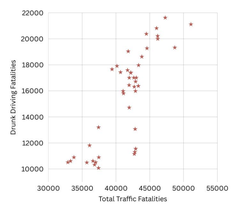
This bar graph shows the amount of people that have passed away per decade due to a DUI related incident. This aids in showing the trends of severity and helps keep in mind that we only have data of fatalities up until the year 2022. The 2020s section only depicts data within the 3 years after 2020 happened

Figure 2. Donut Charts of percentage of DUI related fatalities to motor vehicle fatalities per decade



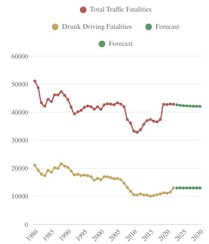
This donut chart depicts the percentage of DUI related fatalities there are per motor vehicle fatalities. This is of importance because it allows us to see whether or not there has been an improvement in solving the motor vehicle safety crisis or the DUI crisis

Figure 3. Scatter plot of total DUI related fatalities in total traffic fatalities



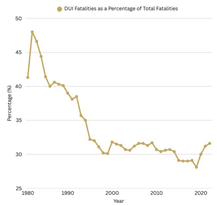
This scatter plot shows us the correlation between the total number of traffic fatalities that have ever occured and the drunk driving fatalities. This proves that there genuinely is a correlation between the two sets of data proving that DUI issues aren't random, but have real world effects.

Figure 5. Past and future trends in total traffic fatalities and DUI fatalities in the U.S. (1980-2030)



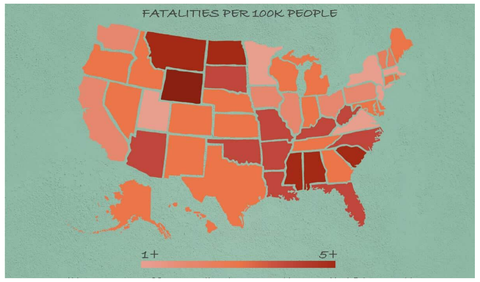
This graph shows historical and forecasted trends in total traffic fatalities and drunk driving fatalities in the U.S. from 1980 to 2030. It highlights a general decline in fatalities over time and projects stable rates in the near future.

Figure 4. Line graph of DUI fatalities as a percentage of total fatalities



This line graph shows us how the percentage of drunk driving fatalities in total traffic fatalities correlate. As we notice on the graph, there has been a big decrease, which means that we have gotten better at stopping DUI related accidents, but we have been on the rise since 2020.

Figure 6. [15] 2017 Heat Map



Results

The charts above are a few out of many that firmly point out the issues we are facing as a country with DUI. As we see in figure 1 and figure 2 (bar graph, donut chart), the number of DUI related accidents seem to fit the criteria of the downward trend we have been facing for the past few decades, but this isn't the case. [1] NHTSA has only given us the data until the year 2022, meaning that 70% of this decades data is missing. This shows us that although we have been on a decline, the numbers depict a rise in DUI related deaths in recent years. figure 4 (line graph) shows us the figure 2 in a more retrospective way. It more accurately shows us the upward trajectory we are going towards since the year 2020. Finally figure 5 (ARIMA model) shows us the future trends based on past data. This shows us a very steady forecast showing us a stable and healthy future, although even a slight change in the graph means hundreds of fatalities.

Trends

From 1980 to 2022, DUI-related fatalities in the U.S. have shown a clear long-term decline, especially from the mid-1980s to the early 2000s. This reduction can largely be attributed to stronger public awareness campaigns, stricter DUI laws, increased law enforcement, and improvements in vehicle safety. However, starting around the 2010s, the decline began to plateau, and in the early 2020s—particularly during the COVID-19 pandemic—fatalities experienced a slight uptick due to reduced police patrols, increased substance use, and mental health challenges. The ARIMA model reflects these historical patterns and uses them to forecast future values. Because ARIMA relies heavily on past trends and seasonality, it projects a relatively smooth and steady trajectory rather than sudden spikes or drops. This suggests that, unless major new interventions are introduced or unforeseen societal disruptions occur, DUI fatalities are expected to remain relatively stable or continue a slow decline. The model essentially mirrors the momentum of past policy and behavioral shifts, reinforcing the idea that meaningful change requires proactive, data-informed efforts—not just hope for natural regression.This projection underscores the importance of not becoming complacent, as statistical models can only predict based on the past, not prevent future tragedies. So based on this insight, all we can do is hope that there isn't a major global event that changes the course of our history like the Covid-19 virus or a lockdown.

Future Possible Solutions

Creating harsher punishments for DUI offenders seems like a viable option, but why wait until later after the possibility of an occurrence? Some methods are being tested and used in some areas such as the following:

1. Ignition Interlock Devices: Requires all DUI offenders (even first-timers) to install breathalyzer-activated ignition locks in their vehicles.
2. Integrated DUI education in school health curriculums
3. Improve public transportation
4. Limit alcohol sales during late-night hours or near highways (similar to us in Arizona)

These methods are effective, but are heavily outdated, so i've come up with several solutions that can be used with current technological advancements. Here are a few:

1. Eye-Tracking and reaction time analysis
2. AI powered Driving Behavior Monitoring Apps
3. Smarter City Integration
4. Forcing alcohol companies to depict consequences like cigarette brands

References

[1] National Highway Traffic Safety Administration (NHTSA): "Drunk Driving | Statistics and Resources." https://www.nhtsa.gov/risky-driving/drunk-driving [2] Federal Bureau of Investigation (FBI): "Crime Data Explorer (CDE)." https://cde.fbi.gov/cde [3] Centers for Disease Control and Prevention (CDC): "Impaired Driving Facts." https://www.cdc.gov/impaired-driving/facts/index.html [4] U.S. Census Bureau: "DUI Top Gun - Census Bureau Tables." https://data.census.gov/all/tables/?q=Dui+Top+Gun [5] Ikigai Labs: "How to Choose the Best Model for Time Series Forecasting: ARIMA, Prophet, or nSSa." https://www.ikigailabs.io/blog/how-to-choose-the-best-model-for-time-series-forecasting-arima-prophet-or-nssa [6] AIP Conference Proceedings: Misengo, E. E., Prastyo, D. D., & Kuswanto, H. "Modeling and Forecasting Monthly Tourist Arrivals to the United States and Indonesia Using ARIMA Hybrids of Multilayer Perceptron Models." https://pubs.aip.org/aip/acp/article/2540/1/080001/2873558/Modeling-and-forecasting-monthly-tourist-arrivals [7] ResearchGate: "Prediction of Motor Vehicle Insurance Claims Using ARIMA-GARCH Models." https://www.researchgate.net/publication/384444947_Prediction_of_Motor_Vehicle_Insurance_Claims_Using_ARIMA-GARCH_Models [8] CDC: "Risk Factors for Impaired Driving." https://www.cdc.gov/impaired-driving/risk-factors/index.html [9] NHTSA: "Drug and Alcohol Crash Risk Study Databases." https://www.nhtsa.gov/drug-and-alcohol-crash-risk-study/drug-and-alcohol-crash-risk-study-databases [10] NHTSA: "Buzzed Driving Is Drunk Driving." https://www.nhtsa.gov/campaign/buzzed-driving [11] CDC: "Driving Under the Influence of Marijuana and Illicit Drugs." https://www.cdc.gov/mmwr/volumes/68/wr/mm6850a1.htm [12] NHTSA: "Drive Sober or Get Pulled Over | Drunk Driving." https://www.nhtsa.gov/campaign/drive-sober-or-get-pulled-over [13] CDC: "Increasing Alcohol Ignition Interlock Use." https://www.cdc.gov/impaired-driving/ignition-interlock/index.html [14] CDC: "Alcohol-Impaired Driving Among Adults — United States, 2012." https://www.cdc.gov/mmwr/preview/mmwrhtml/mm6430a2.htm [15] CDC: "Alcohol-Related Traffic Fatalities -- United States, 1982-1993." https://www.cdc.gov/mmwr/preview/mmwrhtml/00032780.htm

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