Electric Vehicles vs. Internal Combustion Engine Vehicles: A Comparative Study of Non-Motorist Crash Injury Severity

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1. BACKGROUND

- Electric vehicles (EVs), driven by electric engines, demonstrate distinct dynamic characteristics that could result in varying crash characteristics and outcomes, in contrast to traditional vehicles powered by internal combustion engines (ICEVs).
- However, there are limited studies on on how crashes involving EVs differ from those with traditional gas-powered cars.
- This study is important for improving safety and developing regulations for EVs.

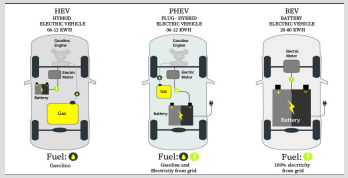


Figure 1 EV Types

Source: Rady, M., Rabigh, K. S. A., Almatrafi, E., Darwish, M., Abbod, M., & Lai, C. S. Development of Mechanical Engineers Skills for an Emerging Electric Vehicles Industry.

2. OBJECTIVE

- Assess the characteristics and severity outcomes of crashes involving electric vehicles (EVs) and internal combustion engine vehicles (ICEVs).
- The comparison between EVs and ICEVs focuses on crashes involving non-motorists.

3. METHODOLOGY & DATA

3.1. Google Street View Images for Environmental Factor Analysis

Google Street View Images

The Google Street View (GSV) API is used to get panoramic 360-degree views of each EV crash location. This involves stitching together four images, each covering a 90-degree field of vision, at the specific latitude and longitude coordinates of the crashes, providing a comprehensive horizontal visual perspective of each site.

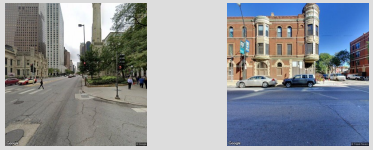


Figure 2 Example Images obtained through GSV API

Analysis of Images

- **Utilization of Segformer**: an advanced Transformer-based model, Segformer, is integrated for semantic segmentation of street view images.
- **Visual Examination**: concentrates on ten key environmental factors in GSV images, including crosswalks, traffic lights, signage, types of crosswalks, lane count, traffic flow direction, intersection proximity, lane divisions, and general area type.

3.2. Spatial & Temporal Buffer Analysis

- **Vehicle Classification**: Vehicles are categorized as either EVs or ICEVs based on make, model, and year, due to the absence of VINs or other explicit identifiers. Selection of ICEVs is limited to model years 2010 to 2022 to match the timeframe of the EVs being studied, ensuring fair comparison despite differences in vehicle years and safety technologies.
- **Buffer Analysis**: The study employs buffer analysis using a 50-meter geographical buffer, seasonal, and time-period criteria to select relevant ICEV crashes near EV crash sites, considering geographical and temporal factors and segmenting the day into six time periods for comprehensive crash analysis.

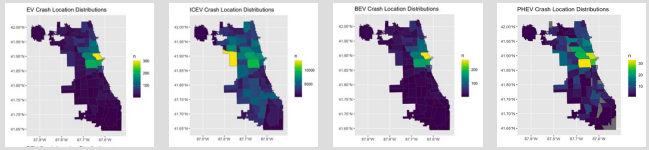
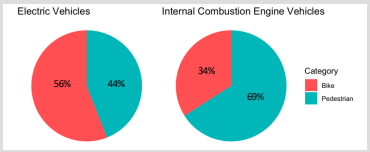
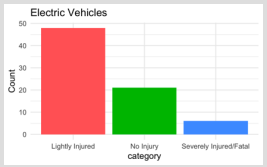


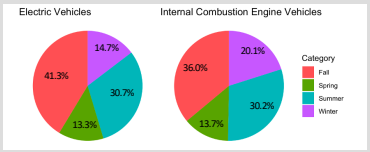
Figure 3 Crash Distribution for Different Vehicle Types

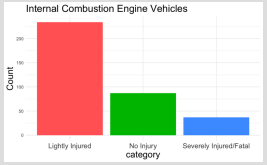
3.3. Crash Data Overview

- Crashes involving EVs and cyclists are higher compared to those for ICEVs.
- ICEVs are more commonly involved in crashes with pedestrians.
- The rate of non-motorist crashes involving EVs decreases in snowy or icy conditions. Reduced EV usage in winter, likely due to concerns over battery range and performance in the cold, may explain this trend.
- No significant difference in distribution of count per injury level.









4. RESULTS

4.1. Comparative Risk Analysis of Non-Motorist Crash

The Chi-square test results reveal varied insights: a p-value of 0.595 suggests no significant association between vehicle type and crash involvement with motorists or non-motorists, while a p-value of 0.001 indicates a notable difference in the types of non-motorist involved in EV versus ICEV crashes.

	EV	ICEV	χ^2	d.f.	P-value	Cramer V
Non-Motorists	75	358	0.2826	1	0.595	0.003
Motorists	6,192	27,397				
Cyclists	42	122	11.75	1	0.001	0.171
Pedestrians	33	236				

4.2. Regression Model Transferability Analysis

Due to a limited sample size, **Binary Probit Regression** model is used to estimate injury severity, categorizing injuries into two main groups: injury and no injury, where no injury serves as reference group in the regression model.

	EVs		ICEVs	
Variables	Coefficient	Std. Err.	Coefficient	Std. Err.
Constant	0.3222	1.2204	-0.4270	0.3472
Non-Motorist Characteristics				
Male Indicator	-1.1500	0.5211	-0.4471	0.1901
Age	0.0035	0.0183	0.0127	0.0062
Driver Characteristics				
Vision Obscured Indicator	-1.2674	0.7370	0.0723	0.2891
Hit and Run Indicator	0.1970	0.5079	0.3024	0.1874
Traffic Characteristics				
Location				
Sidewalk				
Crosswalk	1.1836	1.0795	0.3383	0.3394
Roadway	0.5247	0.7650	0.1582	0.2295
Bike Lane	1.2166	0.8476	1.5440	0.3931
Traffic Control Present Indicator	-0.2390	0.5636	-0.2832	0.2322
Lane Divided Indicator	1.1823	0.6769	\	\
Intersection Indicator	0.4533	0.6639	0.4229	0.3051
Bidirectional Traffic Indicator	-0.6938	0.5158	\	\
Environmental Characteristics				
Season				
Fall				
Spring	0.3295	0.7112	-0.4782	0.2559
Summer	0.2158	0.5500	0.1611	0.2164
Winter	-0.5741	0.7363	0.2263	0.2623
Surface Condition				
Dry				
Wet	1.6550	0.7363	-0.0497	0.2509
Icy	\	\	-0.7975	0.4279
Urban Indicator	-0.3065	0.5569	\	\

5. CONCLUSIONS

- This study tackles important safety issues arising with the increase of EVs, aiding in the creation of specific safety measures and policies for non-motorists such as pedestrians and cyclists, by incorporating Google Street View images into the analysis.
- This study finds that EV and ICEV crashes involving non-motorists are largely similar.
  - i. The factors that influence the severity of injuries sustained by non-motorists are consistent across both types of vehicles.
  - ii. There is no substantial evidence to suggest that EVs are more prone to crashing with non-motorists compared to ICEVs.
  - iii. Factors like the non-motorist's gender, age, type, involvement in hit-and-run incidents, crash location, and the presence of traffic control devices show no significant differences in their association with injury severity between EV and ICEV crashes.
- Some differences in crash factors such as non-motorist type, hit-and-run incidents, damage level, timing, weather, and road conditions, along with the varying impacts of season and road surface on injury severity, are noted between EV and ICEV crashes, potentially due to differences in driver demographics, vehicle design, and usage.