PARTS
PARTNERSHIP FOR ANALYTICS RESEARCH IN TRAFFIC SAFETY

Real-world Effectiveness of Advanced Driver Assistance Systems on Injury Crashes for Model Year 2015-2023 Vehicles

November 2025

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1 Executive Summary

According to the National Highway Traffic Safety Administration (NHTSA), an estimated 2.4 million people were injured in traffic crashes and 40,901 people lost their lives on our nation's roadways in 2023 [1]. Advanced Driver Assistance Systems (ADAS) in motor vehicles have the potential to reduce crashes, prevent serious injuries, and save thousands of lives on our roadways each year. As automobile manufacturers increasingly equip vehicles with ADAS [2], there is a growing need to study and understand the safety benefits and opportunities to improve these technologies.

To address this need, the Partnership for Analytics Research in Traffic Safety (PARTS) was formed in 2018 as an independent, voluntary data sharing and analysis partnership among automobile manufacturers, the United States Department of Transportation (USDOT) Volpe Center, NHTSA, and The MITRE Corporation (MITRE), which operates PARTS as an independent third party. Eleven original equipment manufacturers (OEM) currently participate in PARTS, including American Honda Motor Company, Ford Motor Company, General Motors LLC (GM), Hyundai Motor America, Kia America, Mazda North American Operations, Mitsubishi Motors R&D of America, Nissan North America, Stellantis (Fiat Chrysler Automobiles U.S. LLC), Subaru Corporation, and Toyota Motor North America. Nine OEMs contributed data for the current study, and MITRE conducted the analysis at the direction of and in collaboration with PARTS partners.

This study expands on the 2025 PARTS [3] study by examining the effectiveness of the following five ADAS features in preventing or mitigating system-relevant injury crashes: automatic emergency braking (AEB), pedestrian automatic emergency braking (PAEB), lane departure warning (LDW), lane keeping assistance (LKA), and lane centering assistance (LCA). The study used police-reported crash data and vehicle equipment data contributed by PARTS partners, covering 98 million vehicles from 10 vehicle segments for model years 2015-2023. When combined with police-reported crash data from 16 states, covering crash years 2016-2023, this provided a data set of 7.7 million crash-involved partner vehicles.

This study categorized system-relevant crashes as front-to-rear crashes for AEB; single-vehicle frontal crashes with non-motorists for PAEB; and single-vehicle road-departure crashes for LDW, LKA, and LCA. Of the identified crash-involved vehicles, 2.1 million were classified as system-relevant for purposes of this study.

Injury crashes were identified using the KABCO score recorded in police-reported crash data (NHTSA, 2017). These scores include K = fatal injury, A = serious injury, B = minor to moderate injury, C = possible injury, and O = no injury. Estimated ADAS effectiveness was analyzed for nested sets of crashes based on the highest reported severity of any participant in the crash. The nested sets included the following: all crashes[1], moderate or worse injury crashes (KABCO score of K, A, or B), and fatal or serious crashes (KABCO score of K or A). ADAS effectiveness estimates were defined as the percentage reduction in system-relevant crashes with estimates considered statistically significant when the 95% confidence interval did not cover zero.

In addition to assessing the extent to which ADAS features reduced system-relevant injury crashes, the study assessed whether a given feature's effectiveness changed under different driver, environmental, crash, or vehicle conditions and quantified the magnitude of that change where appropriate. The study also evaluated if the effectiveness changed for different injury levels or over time.

[1] The "all crashes" set for AEB and lane assistance crashes included events with any KABCO score, while the PAEB analyses limited "all crashes" to those with a KABCO score of K, A, B, or C due to known underreporting of non-injury VRU crashes.

For AEB, the study found that system effectiveness (i.e., reduction in front to rear striking crashes) improved from 49.1% in all crash scenarios to 55.3% in cases involving moderate or worse injuries. Additionally, analysis showed a statistically significant increase in effectiveness from 44% to 53% for all crashes with newer generations of AEB technology.

This study measured a significant 8.5% reduction in single-vehicle frontal crashes with non-motorists[2] for vehicles equipped with PAEB systems. When narrowed to crashes with moderate or worse injury severity, the effectiveness of PAEB is estimated at 7.9%, and for fatal or serious injury crashes it is 10.0%. Analyses of PAEB effectiveness across injury levels or over time show wide confidence intervals and a lack of statistical significance, especially for the fatal or serious injury group, due to relatively low sample sizes.

Analysis of lateral assistance features for reducing single vehicle road departure crashes yielded mixed results. Vehicles equipped with LDW alone did not show a significant reduction in crashes for any injury group. In contrast, vehicles with LDW + LKA (without LCA) demonstrated significant increase in effectiveness of 5.3% in all crashes and 9.2% in those involving moderate or worse injuries, while LDW + LKA + LCA equipped vehicles estimated effectiveness was 4.4% for all crashes and 10.6% for moderate or worse injury crashes. Effectiveness did not vary significantly across injury levels or over time.

This cross-industry analysis included features with a range of capabilities and parameters that vary by OEM, vehicle model, model year, and even trimline-specific design and specification. This study considers whether a vehicle is equipped with a given ADAS feature at the time of manufacture and not whether that feature was on or engaged at the time of crash as this data is unavailable.

Section 2 provides additional background on PARTS and this study. Section 3 outlines the study data and analysis methodology. Section 4 presents the analysis results, and Section 5 discusses the findings and their limitations.

2 Background

The automobile industry has developed and deployed many innovative solutions over the past decade to improve traffic safety, including ADAS. The goal of these systems is to reduce the number and severity of traffic crashes, thereby preventing injuries and saving lives. Today, automobile OEMs equip their vehicles with an increasing number of ADAS features with evolving capabilities. As ADAS technologies and the vehicle fleet change, there is a continued need to evaluate associated safety benefits and identify opportunities for improvement.

PARTS was formed to address this need through a collaborative data sharing and analysis approach. By combining equipment data from 98 million vehicles with 21.2 million crash reports, PARTS recently completed an in-depth analysis of ADAS effectiveness in reducing crashes [3]. Building on that work, this study presents the effectiveness of ADAS in reducing injurious crashes. Specifically, this study examined if injury crash frequency reduced when vehicles were equipped with the following ADAS features: AEB, PAEB, LDW, LKA, and LCA. PARTS conducted this study to further a collective, improved understanding of how these ADAS technologies perform in operation to drive innovation and continuous

[2] Non-motorists include pedestrians, pedalcyclists, and non-motorists on personal conveyances (e.g. scooters or wheelchairs)

improvements in safety performance, thereby further reducing crashes, serious injuries, and fatalities on roadways.

2.1 PARTS Overview

PARTS, established in 2018, is a public-private partnership between automobile manufacturers and NHTSA. The goal of this government-industry collaboration is to advance traffic safety through the collaborative analysis of automotive safety technologies, with partners voluntarily sharing safety-related data for joint analysis. MITRE operates PARTS as an independent third party (ITP).

Of the 11 OEMs participating in PARTS (see Figure 1), nine provided vehicle data for this study, accounting for more than 80% of the 2023 United States (U.S.) passenger car and light truck market sales [4].

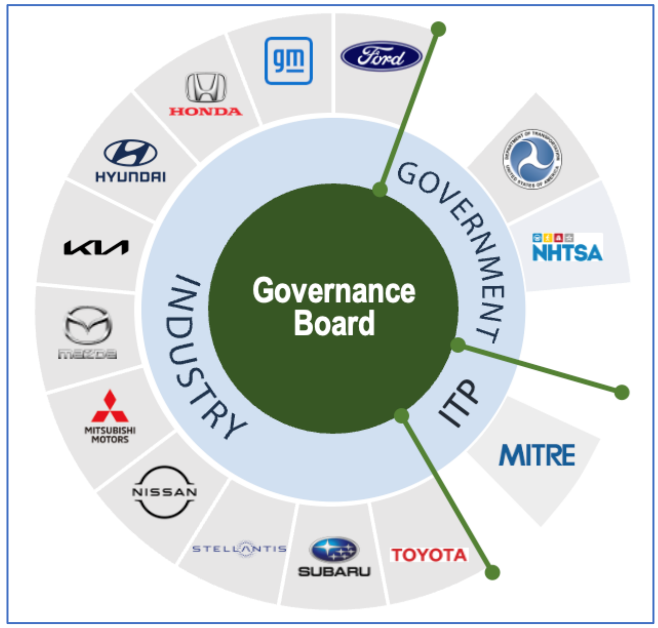


Figure 1. PARTS Participation

2.2 Study Overview

NHTSA estimates the societal harm of motor vehicle crashes is nearly $1.4 trillion per year [5] primarily due to medical costs and reductions in quality of life due to injury. A recent NHTSA report shows 40,901 people killed and over 2.4 million injured in traffic crashes in 2023 [6], highlighting increases in injuries for all passenger car categories, pedestrians, and pedalcyclists compared to 2022. While studies assessing insurance claim information suggest some ADAS technologies reduce bodily injury liability claim frequency by up to 24% [7], the societal cost of motor vehicle crashes continues to rise.

Using a large, linked dataset of vehicle equipment and police-reported crashes (explained in Section 3) this study estimated how well current ADAS prevent or mitigate system-relevant injury crashes. The analysis considers occupant, environmental, crash, and vehicle covariates and models crash rates for distinct injury-severity groups. Specific research questions included:

- To what extent does AEB reduce front-to-rear system relevant injury crashes?
- To what extent does PAEB reduce frontal non-motorist system relevant injury crashes?
- To what extent do lane centering and departure features reduce single vehicle road departure system relevant injury crashes?
- How do different driver, environmental, crash and vehicle conditions change a given ADAS feature's effectiveness in reducing system relevant injury crashes?
- To what extent does the effectiveness of a given ADAS feature in reducing system relevant injury crashes change over time?

3 Methodology

3.1 Data Overview

This study examined the estimated effectiveness of five ADAS features in preventing or mitigating system relevant injurious crashes in passenger vehicles as shown in Figure 2.

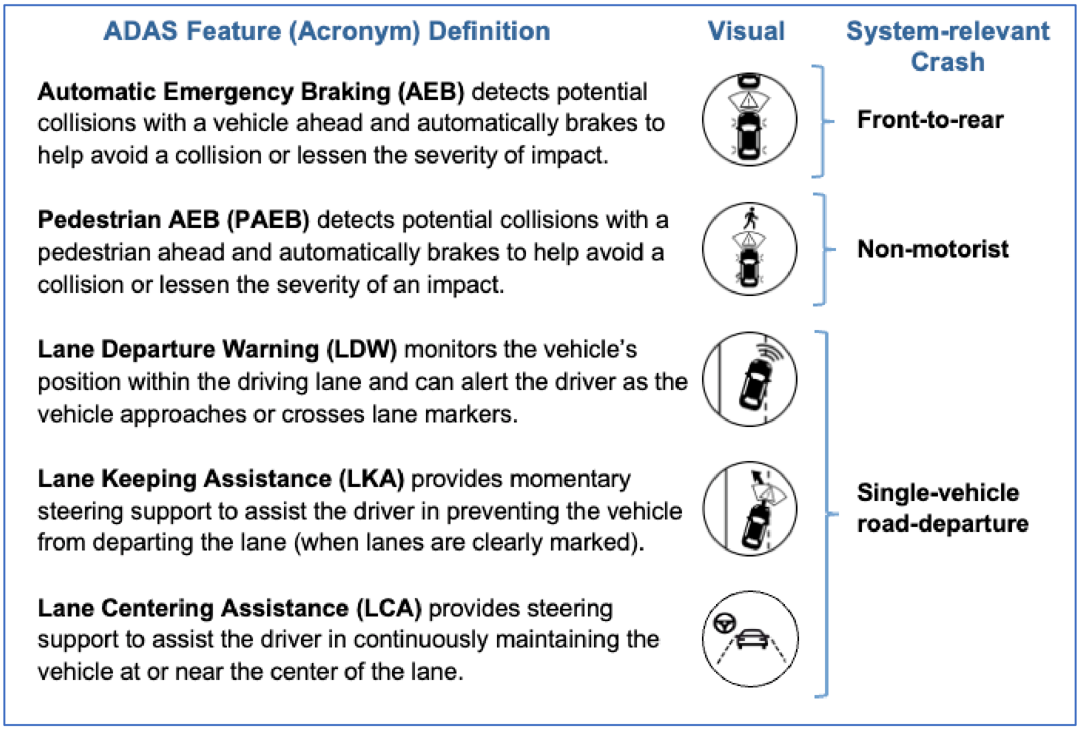


Figure 2. Five ADAS Features Included in this PARTS Study

The study used OEM partner provided data on 98 million passenger vehicles sold in the U.S., encompassing 168 vehicle models from model years 2015–2023 across 10 vehicle segments (see Figure 3). This same dataset supported a previous ADAS effectiveness study [3]. Vehicle equipment data allowed for the identification of ADAS features installed at the time of manufacture[3]. This data was combined with police-reported crash data from 16 states, covering crash years 2016-2023, resulting in an initial dataset of 7.7 million crash-involved vehicles. Of these, 2.1 million were classified as system-relevant for the purposes of this study (see Table 1).

[3] The availability or activation of ADAS features at the time of crash was not available for consideration in this study.

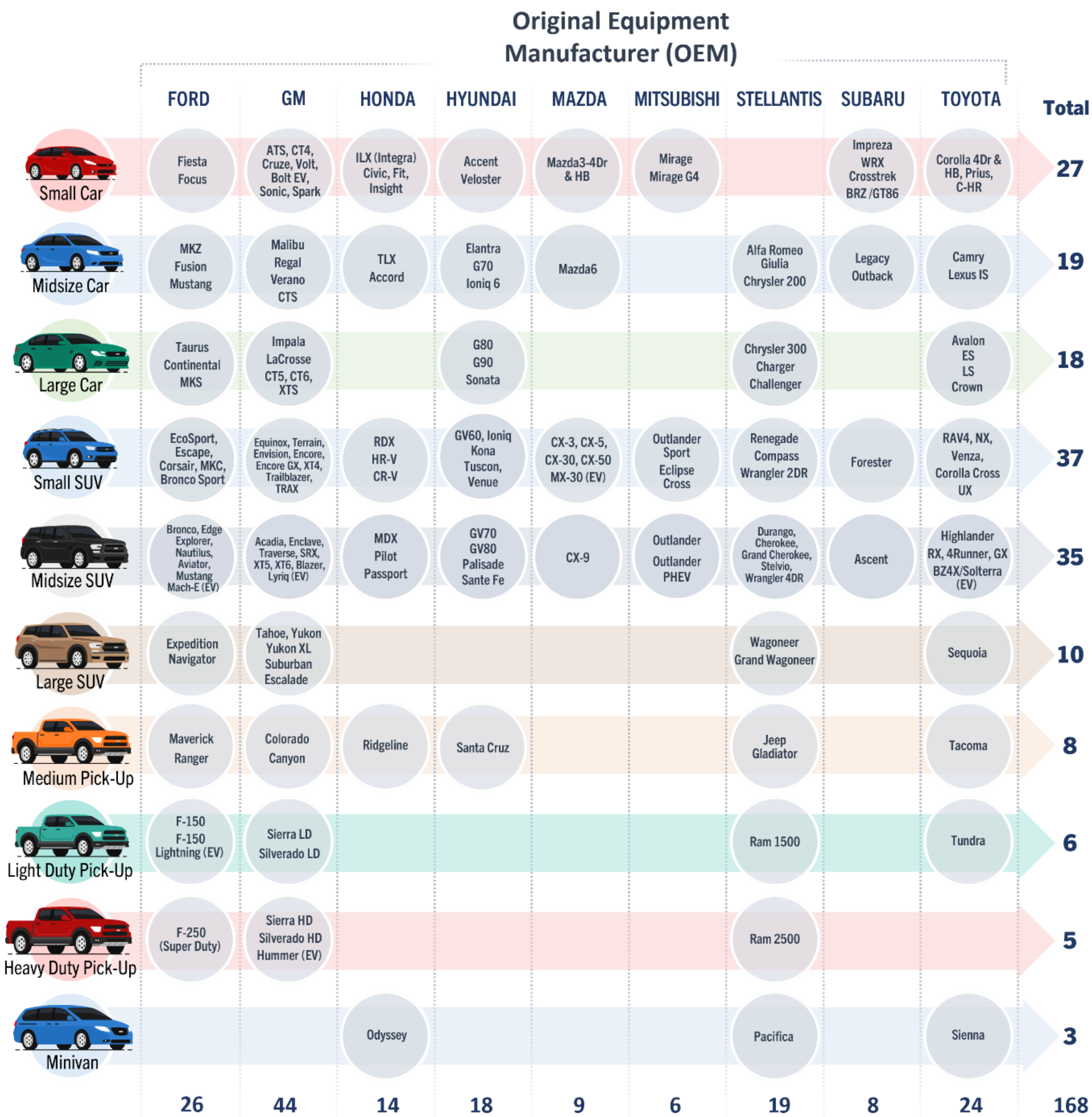


Figure 3. Vehicle Data - Mapping Models to Segments

All vehicles equipped with AEB in this study were also equipped with forward collision warning (FCW). Due to the low rate of newer models equipped solely with FCW, the study focused on vehicles with AEB rather than conducting a separate analysis of vehicles equipped only with FCW.

3.2 Crash Types Studied

Each ADAS feature studied was mapped to a system-relevant crash type, as defined in Table 1. For example, in PAEB, the system-relevant crashes are comprised of single-vehicle frontal crashes with non-motorists involving injury. In lane departure crashes where two vehicles were involved, the study was unable to distinguish which vehicle initially left its lane. As such, this study focused on the effectiveness of LDW, LKA, and LCA in single-vehicle road-departure injury crashes rather than in sideswipe crashes involving vehicles traveling in the same or opposite directions.

This study used quasi-induced exposure [8] (QIE) as the primary method to measure ADAS effectiveness. QIE compares vehicles equipped with the set of ADAS features under study against vehicles without those features by looking at the number of system-relevant and control crashes for both populations. A control crash is argued to be to be system irrelevant, meaning independent from and not related to the ADAS feature it is intended to measure [9]. The control crash was the same (front-to-rear struck) for all ADAS features; it is described in the last row of Table 1. The system-relevant crash types and control crash type are the same as those used in the 2022 PARTS Study [10] and 2025 ADAS Effectiveness Study [3][4]. The argument for these control crashes being system irrelevant is supported by comparative evaluations using specific vehicle miles travelled [11].

Table 1. ADAS Feature System-relevant Crash Type and Control Crash Definitions

ADAS Features	System-Relevant Crash Type	Definition
AEB	Front-to-rear Striking	Manner of Crash = Front-to-rear AND Initial Contact Point[5] = [1, 12, 11] AND Motor Vehicle Maneuver Action NOT (backing or parked) AND Crash Vehicle Count = 2
PAEB	Single-vehicle Frontal Crashes with Non-motorists	Crash Pedestrian Count > 0 AND Crash Vehicle Count = 1 AND First Event or First Harmful Event = Pedestrian or Non-motorist AND Initial Contact Point = [1, 12, 11] AND Motor Vehicle Maneuver Action NOT (backing or parked)
Lateral (LDW, LKA, LCA)	Single-vehicle Road Departure	Crash Vehicle Count = 1 AND First Event or First Harmful Event = Ran Off Road, Cross Centerline, Cross Median, Collision with Fixed Objects, Rollover AND Vehicle Maneuver Action = any of {Going Straight, Negotiating a Curve, Leaving Traffic Lane, Ran Off Road}
Control	Front-to-rear Struck	Manner of Crash = Front-to-rear AND Initial Contact Point = [5, 6, 7] AND Motor Vehicle Maneuver Action NOT (backing or parked) AND Crash Vehicle Count = 2

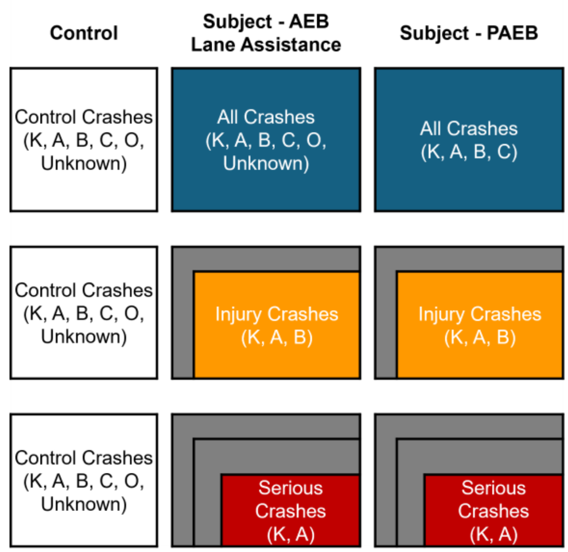
[4] The control crash type is the standard choice for these systems for QIE studies: [9], [14], [15].

[5] Most states included in this study use clock coordinates to indicate initial point of contact for crashes (where the front center of a vehicle is 12 o'clock). PARTS considered values of 5, 6, or 7 o'clock to be rear. Some states used descriptions such as "rear," "right rear bumper," and "rear – left." PARTS mapped related phrases and clock coordinates to the construct of "rear." PARTS used a similar mapping technique to harmonize the construct of "front" given varied state crash data.

3.3 Injury Types Studied

PARTS assessed each ADAS feature for three nested sets of crash types (Figure 4) based on the severity of injury of any participant in the crash. This nesting uses injury data based on KABCO scores recorded in the police reported crash data [12]. The sets are as follows:

- **All Crashes AEB and Lane Assistance:** System-relevant crashes that involve property damage only, have unknown injury level, or an injury of any severity (i.e., KABCO score of K, A, B, C, O, or unknown).
- **All Crashes PAEB:** System-relevant crashes that involve possible or suspected injuries or fatality (i.e. KABCO score of K, A, B, or C).
- **Moderate or Worse Injury Crashes:** System-relevant crashes that involve a suspected injury or fatality (i.e., KABCO score of K, A, or B).
- **Fatal or Serious Injury Crashes:** System-relevant crashes that involve a suspected serious or fatal injury (i.e., KABCO score of K or A).



Code	Definition
K	Fatal Injury
A	Suspected Serious Injury
B	Suspected Minor Injury
C	Possible Injury
O	No Apparent Injury

Figure 4. Nested Injury Structure

The definition of all crashes for PAEB system-relevant scenarios was adjusted to exclude No Apparent Injury (O) and Unknown because over 90% of pedestrian collisions in the crash database involved an injury of some severity as shown in Figure 7. This is likely due to most pedestrian-involved crashes resulting in injuries, combined with reporting biases for crashes involving pedestrians.

Property damage only and unknown injury codes were excluded from all PAEB analyses. If property damage only crashes are measured together with injury crashes, then the effectiveness estimate for all crashes is essentially that of crashes involving an injury.

3.4 Summary of the Dataset

This PARTS study used the following two primary data sources:

- **Vehicle Equipment Data** included OEM-provided data on all passenger vehicles from model years 2015–2023 sold in the U.S. that met the selection guidance (see Section 3.4.1)
- **Crash Data** included police-reported crash data from 2016–2023 from 16 states (see Section 3.4.2).

Table 2 below provides a high-level summary of the size and scope of the baseline dataset.

Table 2. Summary of Study Size and Scope

Number of vehicles	98 million sold in the U.S.
Total number of crash-involved vehicles	7.7 million crash-involved vehicles
System-relevant crash-involved vehicles	2.1 million crash-involved vehicles
System-relevant crash-involved injuries	184,286
Number of OEMs providing data	9
Number of vehicle models and vehicle segments	168 across 10 vehicle segments
Model years	2015–2023
Number of states and timeframe	16 states providing crash data from 2016–2023

3.4.1 Vehicle Equipment Data

As detailed in the PARTS 2025 study [3], OEM-supplied vehicle data included the ADAS features on each vehicle, build date, sold or customer delivery date, sales market (used to filter U.S.-only car market), and sale type (retail or fleet). This study's results are based on data from the following OEM partners:

- American Honda Motor Company – includes the Honda and Acura brands
- Ford Motor Company – includes the Ford and Lincoln brands
- General Motors LLC – includes the Buick, Cadillac, Chevrolet, and GMC brands
- Hyundai Motor Company – includes the Hyundai and Genesis brands
- Mazda North American Operations
- Mitsubishi Motors R&D of America
- Stellantis (Fiat Chrysler Automobiles U.S. LLC) – includes the Alfa Romeo, Chrysler, Dodge, Fiat, Jeep, and Ram brands
- Subaru Corporation
- Toyota Motor North America – includes the Toyota and Lexus brands

Vehicles were categorized into 10 segments based on their size and intended use, as shown in Figure 3. PARTS determined these vehicle segments using the Insurance Institute for Highway Safety (IIHS)-Highway Loss Data Institute (HLDI) vehicle segment definitions, with some modifications.[6]

Vehicle models were selected for inclusion are based on the following guidelines:

- **Sufficient Sample Size:** A minimum sales threshold of 5,000 units per model per year helped ensure a sufficient sample size for analysis.
- **ADAS Feature Equipage:** At least one model year for each model was required to have at least one ADAS feature in scope for the analysis.

[6] Modifications adjusted the segments to ensure there were at least three models within a segment; assigned model twins to the same segment when vehicle specifications were sufficiently similar based on OEM input about vehicle mass, structure, or other commonalities; and adjusted the midsize Sport Utility Vehicle (SUV) criteria, which had the effect of moving some three-row SUVs from the small SUV to the midsize SUV segment.

- **Passenger Vehicle Study Scope:** Gross Vehicle Weight Rating (GVWR) was limited to less than 10,000 pounds to target passenger vehicle populations.
- **Non-attribution:** Among other data protection measures, PARTS required vehicle models from at least three OEMs in a vehicle segment to maintain anonymity of the results.

The resulting dataset included 98 million vehicles from 168 models, covering model years 2015–2023, manufactured on or before July 31, 2023.

3.4.2 Crash Data

This study used police-reported crash data from 16 states. Data from 15 of these states was provided by NHTSA through its Consolidated State Crash (CSC) database, which consolidates police-reported crashes received from states through the new Electronic Data Transfer (EDT) process. In addition to the CSC data, Michigan crash data was provided by the University of Michigan Transportation Research Institute (UMTRI) with permission from the Michigan State Police. The data used in each case was a census of all police-reported crashes in those states. Data was limited by what was available in the original state-level crash report. Specific fields and data elements varied by state, as did reporting timelines as shown in Figure 5. The crash data encompassed a total of 21.2 million crashes involving 36.8 million vehicles across the 16 states.

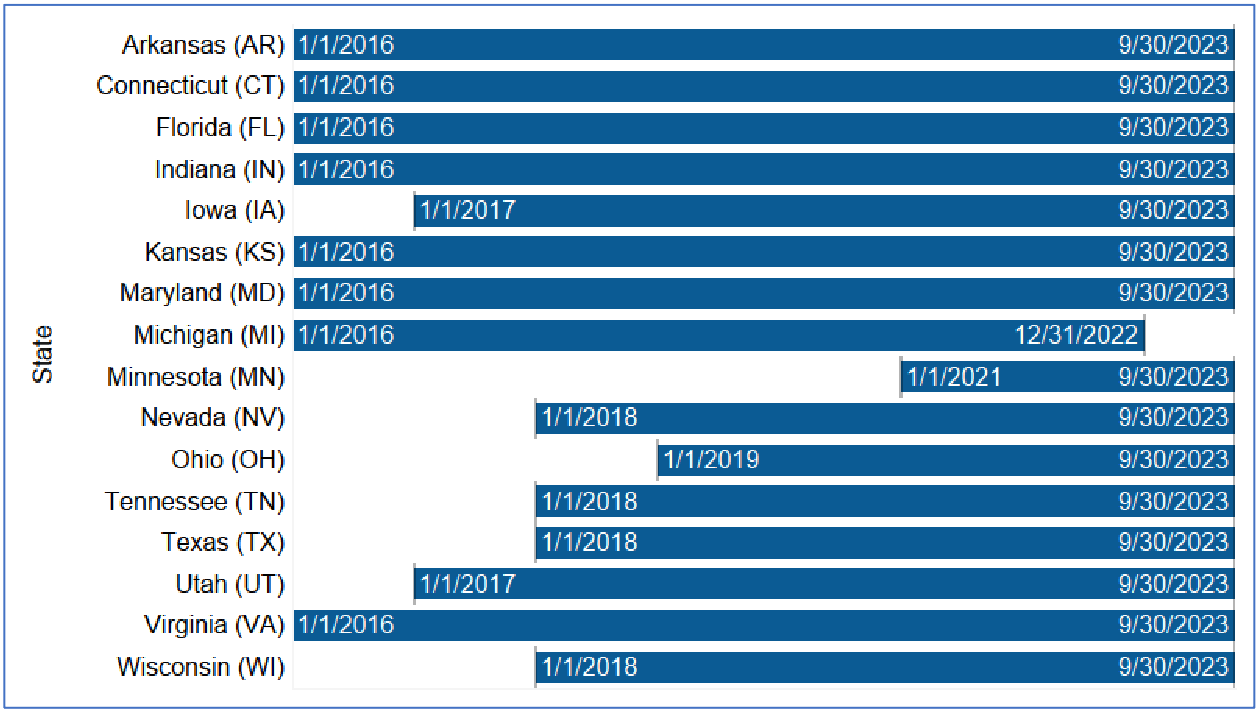


Figure 5. Crash Data by State and Time Period Covered

3.4.3 Preparing and Linking Data Sources

The data linkage process involved harmonization of crash and vehicle equipment datasets to enable comprehensive analysis. For crash data, raw values from police reports and state formats were mapped to standardized values, such as using a clock-face reference for vehicle initial contact points. This process also added additional derived fields such as crash type and whether a vehicle was striking or struck. For vehicle equipment data, MITRE worked directly with OEMs to map their Vehicle Identification Number (VIN)-level records to standardized ADAS features, ensuring accuracy through consistent definitions and quality checks. The standardized datasets were then linked using the 17-digit VIN, resulting in a dataset with records for each crash-involved vehicle that matched the OEM-provided build data, totaling 7.7 million crash-involved vehicles, 2.1 million of which were relevant to the ADAS features studied.

3.5 Descriptive Statistics of the Study Dataset

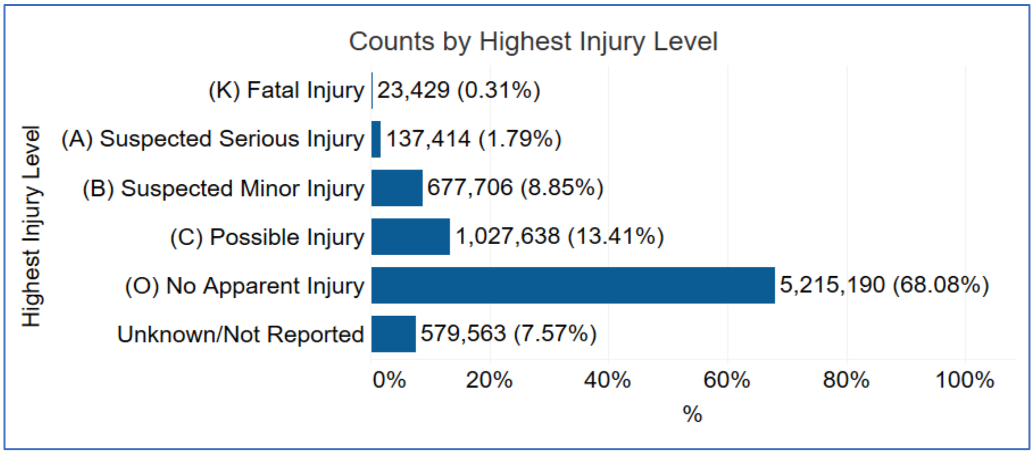


Figure 6. Distribution of Highest Injury in Crash-Involved Vehicle

Summary statistics of the linked data set are provided in the PARTS 2025 report [3].This section highlights a portion of those descriptive statistics that are relevant to the injury analyses. Figure 6 describes the distribution of crash-involved vehicles by the highest reported KABCO injury severity. The majority of crashes (68%) have no apparent injury, while only 2.1% of the crashes have severe or fatal injury. This distribution varies based on crash type, as shown in Figure 7. The unique distribution shift to higher injury severity in frontal pedestrian crashes is of note.

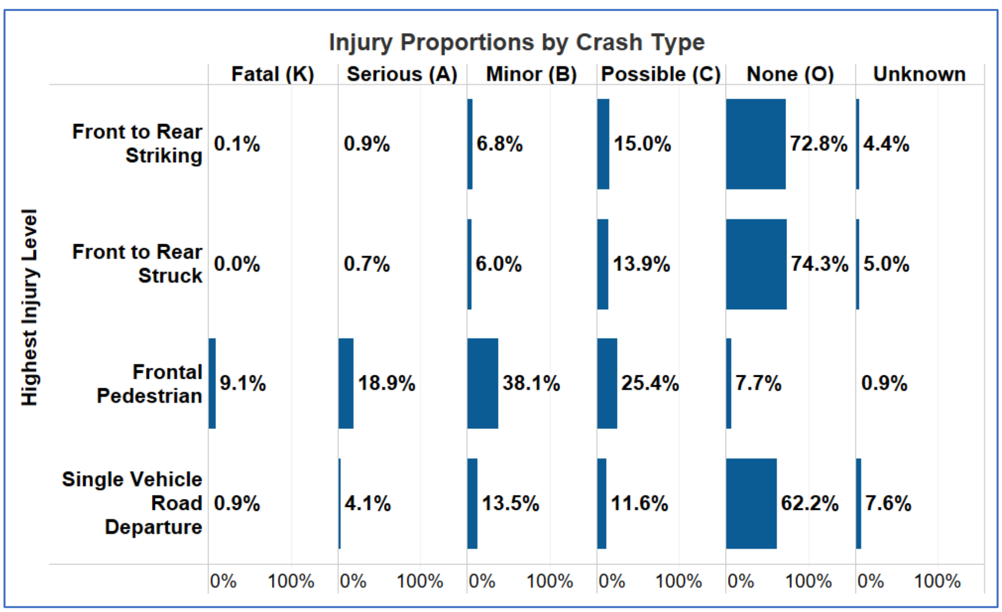


Figure 7. Injury Distribution by System Relevant Crash Type

The penetration of ADAS features in linked crash-involved vehicles increased with model year progression, as shown in Figure 8. Although overall LDW equipage increased during the study period, the proportion of vehicles equipped with only LDW (lightest blue) decreased for newer vehicle models.

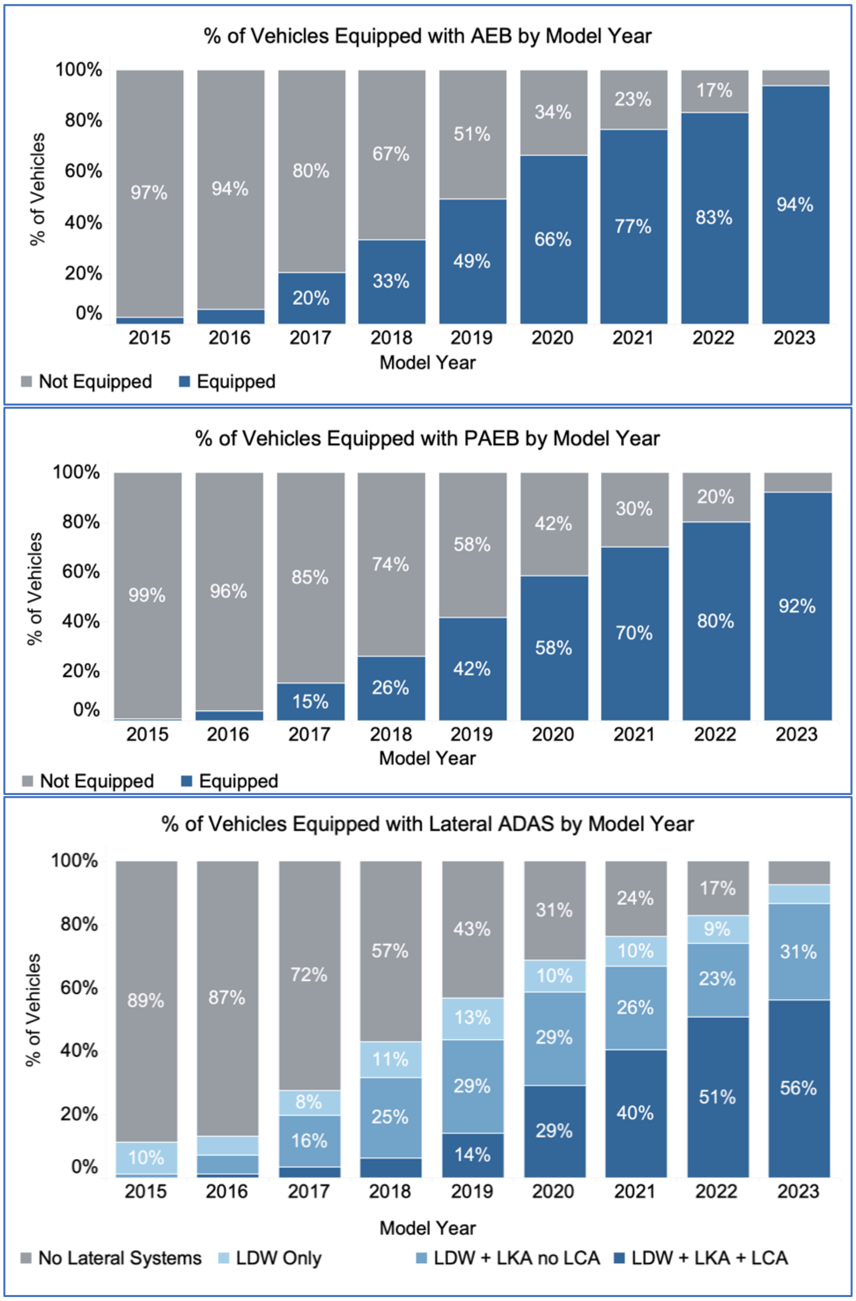


Figure 8. Percentage of Linked Vehicles Equipped by Model Year

Specific crash types necessary to perform analyses are shown in Figure 9 and Figure 10, summarized by crash year and model year. The number of crash-involved vehicles from the linked dataset generally increases for more recent crash years and decreases for newer model years.

Figure 9

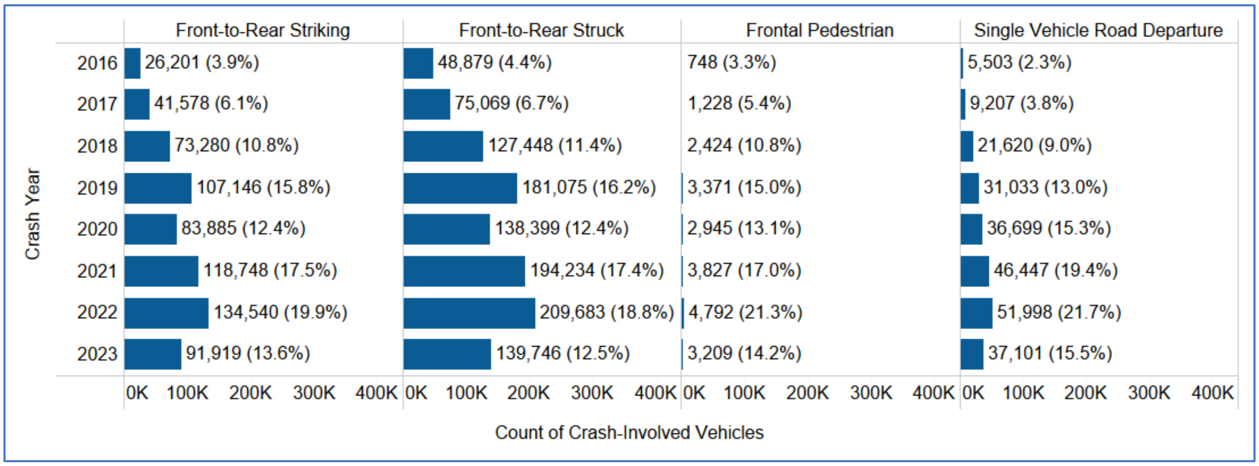


Figure 9. Linked Crash-involved Vehicle Counts for Studied Crash Types by Crash Year

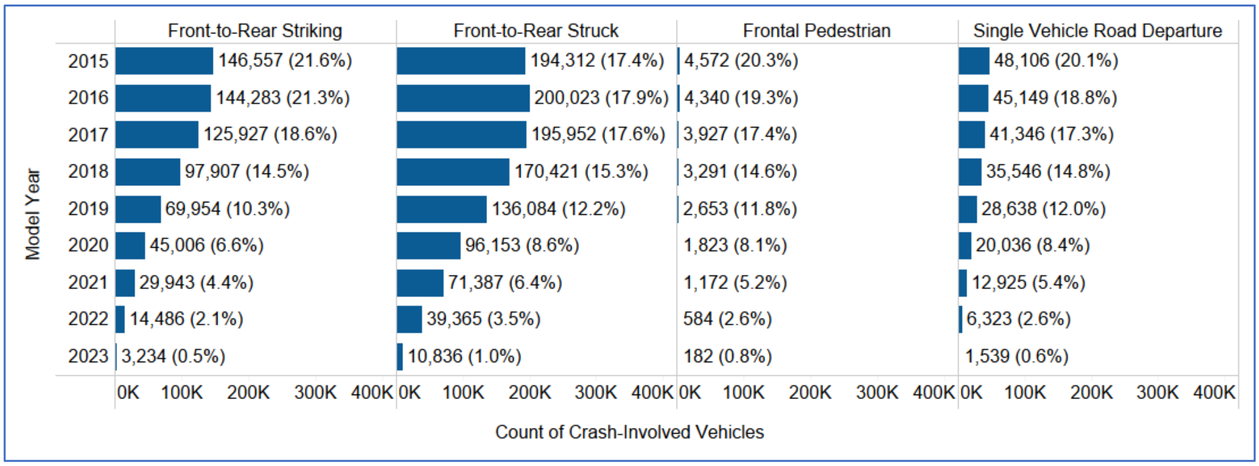


Figure 10. Linked Crash-involved Vehicle Counts for Studied Crash Types by Model Year

3.6 Methodology Overview

This study applied a similar methodology to the 2025 PARTS Study [3]. It used QIE with logistic regression to estimate the reduction in system-relevant injury crashes for vehicles equipped with ADAS. The ADAS effectiveness in this study was measured by estimating the reduction in system-relevant injury crashes due to the presence of vehicles equipped with these systems. QIE measures crash rates relying only on crash data by using a control crash that is irrelevant to the equipage of the ADAS feature to account for potential exposure differences (See Appendix A Quasi-Induced Exposure Calculations). As with the 2025 PARTS Study, the methodology was modified to apply an adjustment for newer model year vehicles (2020 and later) due to the limited number of unequipped vehicles resulting from high equipage rates. Details of this adjustment are provided in Appendix B Details of Adjustment for Model Years 2020+.

The covariates included in this study are listed in Table 3.

Table 3. Covariates Included in the Study

Occupant	Environment	Crash	Vehicle
• Driver Age • Alcohol/Drugs • Distracted Driver • Driver Gender • Restraint Use* • Presence of Elderly in Vehicle*	• Weather • Road Surface Condition • Light Condition • Roadway Alignment • Intersection	• Crash State • Crash Year • Speed Limit	• Sales Type (Fleet vs. Retail) • Vehicle Segment • Vehicle Model Year • Automatic High Beams (AHB) in Dark Unlit (for PAEB)

The covariates included were the same as those used in the 2025 PARTS Study, with two additional factors noted by asterisks in Table 3 above: (1) restraint (seatbelt) use at the crash level and (2) the presence of at least one occupant aged over 65.

The covariates were selected based on past research literature [9] [13] [14] [15] to identify key factors influencing ADAS effectiveness, as well as discussions with partners to uncover other potential factors. Data quality and availability were also considered. The new covariates were specifically added to control for injury likelihood and severity, rather than ADAS effectiveness.

Additionally, changes in ADAS effectiveness were examined by assessing interactions between each covariate and the binary ADAS variable. Each covariate was individually incorporated as an interaction with the ADAS feature in the logistic regression. Bayesian Information Criteria (BIC) was used to identify whether the interaction added statistically meaningful information to the model (i.e., BIC is lower for logistic regression with interaction than without). BIC is known to be conservative in detecting changes in effectiveness (see the Discussion Section in the 2022 PARTS report [10]), which helps minimize false positives but may also overlook some true differences. If BIC indicated a meaningful interaction, estimates for each level were examined using a 95% confidence interval (CI), with Bonferroni[7] adjustment applied to control the false positive rate according to the number of levels within the covariate.

Since the covariates were included as interactions with the ADAS system separately, the differences identified could be confounded by another factor (measured or unmeasured) if strong correlations exist between covariates (e.g., inclement weather and wet roads tend to be correlated).

3.6.1 Estimating Effectiveness when Limited Unequipped Vehicles Exist

New vehicles that have a high penetration of ADAS features tend to get into fewer crashes overall, which can lead to an overestimation of ADAS effectiveness. While model year is controlled for in the logistic regression, it can be difficult to separate model year effects from ADAS feature effects when minimal unequipped vehicles exist in the population. To ensure that ADAS effectiveness overestimation did not occur, an adjustment factor was subtracted from the ADAS feature logistic regression coefficients for newer vehicle models (model years 2020+) to directly remove model year effects. This strategy (subtracting an adjustment factor for newer vehicles) is identical to the strategy used in the

[7] A method for controlling for Type I (α) error due to multiple comparisons whereby α is divided by the number of comparisons for each individual comparison.

2025 PARTS Study [3]. For detailed information on the methodology, see Appendix A Quasi-Induced Exposure Calculations.

3.6.2 Injury Level Analysis

Each nested set of system-relevant crashes was compared against the same set of control crashes, which include all injury levels (i.e., control crashes can have a KABCO score of K, A, B, C, O, or unknown). The set of control crashes remains constant because it is simply meant to represent general exposure. It would not be appropriate to compare serious crashes of unequipped vehicles to serious crashes of equipped vehicles because, in cases with equipped vehicles, some crashes that would have been serious crashes were likely either mitigated (become minor or no-injury crashes) or completely prevented.

For each set of ADAS features, PARTS conducted separate logistic regression analyses for each of the three nested system-relevant injury groups, as well as the corresponding control crash sets, using identical model specifications. This approach enabled the assessment of ADAS effectiveness across different injury levels for the purpose of estimating combined injury crash prevention and mitigation.

4 Results

This section presents the results of the analysis on the reduction of system-relevant crashes involving injury for the following ADAS features and crash types: AEB for front-to-rear crashes, PAEB for frontal crashes involving non-motorists, and lateral features (LDW/LKA/LCA) for single-vehicle road-departure crashes. For each group, the overall effectiveness is presented for each injury level, along with the effectiveness of different model year subsets to assess changes over time and variations in effectiveness based on covariates.

4.1 Automatic Emergency Braking Injury Reduction in Front-to-rear Crashes

4.1.1 Automatic Emergency Braking Injury Level Results

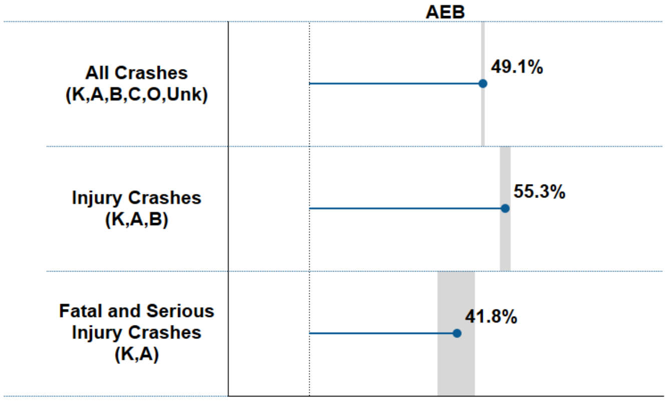
AEB system effectiveness was assessed across three injury severity levels: All Crashes (KABCO), Injury Crashes (KAB), and Fatal or Serious Injury Crashes (KA). For each level, the team estimated the percent reduction in system-relevant front-to-rear crashes for vehicles equipped with AEB, along with 95% confidence intervals and sample sizes. These results are summarized in Figure 11.

KABCO (All Crashes):
For all system-relevant front-to-rear crashes, AEB-equipped vehicles experienced a 49.1% reduction in crash rates compared to unequipped vehicles (95% CI: 48.5%, 49.7%), based on 115,223 system-relevant equipped crashes and 467,498 unequipped crashes.

KAB (Moderate or Worse Injury Crashes):
For crashes resulting in moderate or worse injury (KAB), the estimated reduction was 55.3% (95% CI: 53.8%, 56.8%), with 8,375 system-relevant equipped crashes and 37,663 unequipped crashes. This higher reduction compared to all crashes suggests AEB is particularly effective at preventing or mitigating crashes with injury outcome.

KA (Fatal or Serious Injury Crashes):
For the most serious injury crashes (KA), AEB was associated with a 41.8% reduction (95% CI: 36.2%, 46.9%), based on 1,064 system-relevant equipped crashes and 4,680 unequipped crashes. While the reduction is substantial and statistically significant, it is lower than the reduction observed for all crashes and for injury crashes (KAB). To better understand this difference, an additional analysis was conducted for suspected minor injury crashes (B), as detailed in Appendix C. The results estimated a 57.0% reduction (95% CI: 55.4%, 58.5%) in suspected minor injury (B) crashes, based on 7,311 equipped and

32,983 unequipped crashes. This supports the data shown in Figure 7 that suspected minor injury crashes make up nearly 90% of injury (KAB) crashes and indicates that suspected minor injury crashes are largely responsible for the higher effectiveness observed for injury crashes (KAB) compared to fatal or serious injury crashes (KA).



Group	Equipped	Unequipped
Control	364,209	617,942
System-Relevant	115,223	467,498
Control	364,203	617,942
System-Relevant	8,375	37,663
Control	361,410	617,273
System-Relevant	1,064	4,680

Figure 11. AEB Crash Reduction Estimates by Injury Level

4.1.2 Automatic Emergency Braking Injury Reduction Over Time

The effectiveness of AEB was further examined across vehicle model year groupings to assess whether crash reduction benefits have changed over time. Analyses were conducted for three groups: 2015–2017, 2018–2020, and 2021–2023. Results are summarized in Figure 12.

For All Crashes, the estimated effectiveness of AEB increased modestly over time, from a 45.5% effectiveness for model years 2015–2017 to 51.6% for 2021–2023. A similar trend was observed for KAB injury crashes, with effectiveness rising from 49.1% to 58.5% across the same periods. For fatal or serious injury crashes (KA)**,** the estimated reduction also increased over time, from 36.1% in the earliest group to 44.3% in the most recent group, though confidence intervals are wider due to smaller sample sizes.

Statistical testing of differences between model year groups found that for All Crashes, the increases in effectiveness over time are statistically significant, suggesting that newer vehicles have more effective AEB systems. For KAB and KA injury crashes, while the point estimates suggest increased effectiveness, the differences across the years are not statistically significant at the Bonferroni corrected 0.05 level.

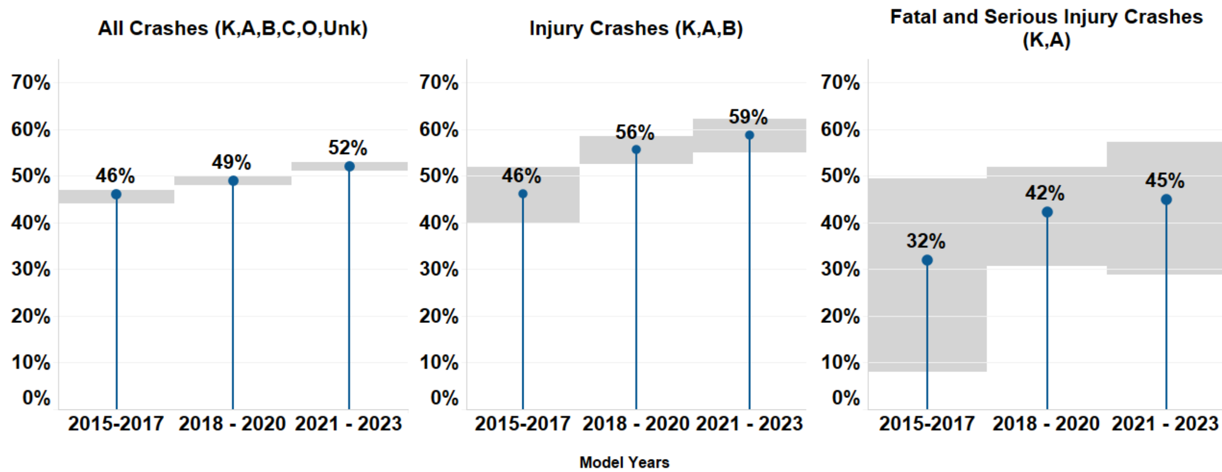


Figure 12. AEB Effectiveness Over Time by Injury Level

4.1.3 Automatic Emergency Braking Injury Reduction by Occupant, Environment, Crash, and Vehicle Conditions

To assess whether AEB effectiveness varies by occupant, environment, crash, or vehicle characteristics, PARTS investigated whether there are differences in AEB effectiveness by covariates using BIC (i.e., if logistic regression including covariate interaction with AEB had lower BIC, as described in Section 3.6). Covariates identified as driving differences in AEB effectiveness are noted with green checkmark in Table 4 while covariates that were not identified as significant interactions are identified with a gray X.

For additional details on the effectiveness by covariate, see Appendix D AEB Identified Interactions.

Table 4. BIC Identified AEB Significant Covariates by Injury Level

Covariates		All Crashes (K,A,B,C,O,Unk)	Injury Crashes (K,A,B)	Fatal and Serious Injury Crashes (K,A)
Crash	Crash State	✓	✗	✗
	Crash Year	✗	✗	✗
	Occupants Over 65	✓	✓	✗
	Posted Speed Limit	✓	✗	✗
	Restraint Use	✗	✗	✗
Driver	Driver Age Groups	✓	✗	✗
	Driver Distracted	✗	✗	✗
	Driver Gender	✓	✓	✗
	Driver Impaired	✗	✗	✗
Environment	Intersection	✓	✗	✗
	Light Condition	✓	✓	✗
	Road Alignment	✓	✓	✗
	Road Surface Condition	✓	✓	✗
	Weather Condition	✓	✓	✗
Vehicle Control Factors	Sale Type	✓	✓	✗
	Vehicle Segment	✓	✗	✗

KABCO (All Crashes):
Across all system-relevant crashes, AEB effectiveness varied significantly by a wide range of covariates, including driver age, alcohol/drug involvement, gender, weather, road surface, light condition, roadway alignment, intersection presence, speed limit, fleet status, vehicle segment, and crash state. Unlike the 2025 PARTS Study [3], Crash State now indicates differences in AEB effectiveness across covariate levels, where previously no difference was observed. This is potentially related to the slightly different crash populations and the addition of belt use and occupant age covariates. Additionally, the new covariate indicating the presence of occupants over age 65 in the vehicle was identified by the BIC criterion.

KAB (Moderate or Worse Injury Crashes):
For injury crashes (KAB), fewer covariates were identified as having differences in AEB effectiveness as compared to All Crashes. In particular, Crash State, Driver Age, Intersection, Speed Limit, and Vehicle Segment did not pass the BIC criterion and are not considered to produce significantly different levels of AEB effectiveness in reducing moderate or worse injury crashes.

KA (Fatal or Serious Injury Crashes):
For fatal or serious injury crashes, no covariates were identified as having statistically significant differences in AEB effectiveness. This finding reflects the smaller sample size and reduced statistical power contributing to fewer interactions passing statistical thresholds, even if they may exist.

4.2 Pedestrian Automatic Emergency Braking Injury Reduction in Single-vehicle Frontal Crashes with Non-motorists

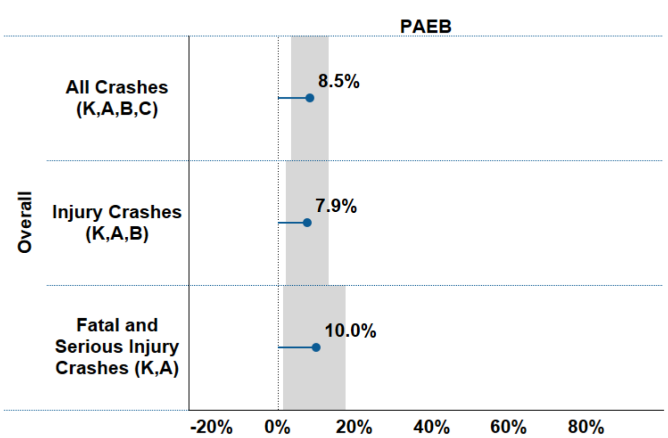
4.2.1 Pedestrian Automatic Emergency Braking Injury Level Results

PAEB effectiveness was evaluated across three injury severity levels: All Crashes (KABC), Moderate or Worse Injury Crashes (KAB), and Fatal or Serious Injury Crashes (KA). Figure 13 summarizes the estimated percent reduction in system-relevant single-vehicle frontal crashes with non-motorists for PAEB-equipped vehicles, along with 95% confidence intervals and sample sizes. Note that, in this study, there were no vehicles that were equipped with PAEB without also having AEB, but there were vehicles equipped with AEB without PAEB. Vehicles equipped with PAEB were compared to those not equipped with PAEB.

KABC (All Crashes):
For crashes with any reported injury (KABC), PAEB-equipped vehicles experienced an estimated 8.5% reduction in system-relevant crashes compared to unequipped vehicles (95% CI: 3.6%, 13.2%), based on 4,173 system-relevant equipped crashes and 13,047 unequipped crashes. Crashes with the KABCO reported injury level of "O" (Not Injured) or "Unknown" were excluded due to known underreporting of incidents involving pedestrians or other non-motorists; see the 2022 PARTS Study report for discussion on the topic [10].

KAB (Moderate or Worse Injury Crashes):
For crashes resulting in moderate or worse injury (KAB), the estimated reduction was 7.9% (95% CI: 2.1%, 13.3%), with 3,077 system-relevant equipped crashes and 9,557 unequipped crashes.

KA (Fatal or Serious Injury Crashes):
For fatal or serious injury crashes (KA), PAEB was associated with a 10.0% reduction (95% CI: 1.5%, 17.8%), based on 1,268 system-relevant equipped crashes and 4,223 unequipped crashes.



Group	Equipped	Unequipped
Control	290,315	667,477
System-Relevant	4,173	13,047
Control	289,994	667,477
System-Relevant	3,077	9,557
Control	289,046	667,477
System-Relevant	1,268	4,223

Figure 13. PAEB Crash Reduction Estimates by Injury Level

4.2.2 Pedestrian Automatic Emergency Braking Injury Reduction Over Time

PAEB effectiveness was further examined by vehicle model year groupings: 2015–2019 and 2020–2023. The model year groupings were adjusted compared to the AEB analysis to maintain deidentification rules and increase sample sizes. Figure 14 summarizes the estimated percent reduction in system-relevant single-vehicle frontal crashes involving non-motorists for PAEB-equipped vehicles, broken down by injury level and model year group.

For all injury levels, PAEB effectiveness estimates were positive for each model year group, with the highest values observed in the most recent group (2020–2023). However, the confidence intervals, particularly for serious or fatal injuries (KA), were wide due to low sample sizes, and in some cases include zero, indicating that the observed increases over time are not statistically significant at the 0.05 level. Statistical testing comparing model year groups did not reveal significant changes in effectiveness over time (p > 0.05 for all pairwise comparisons).

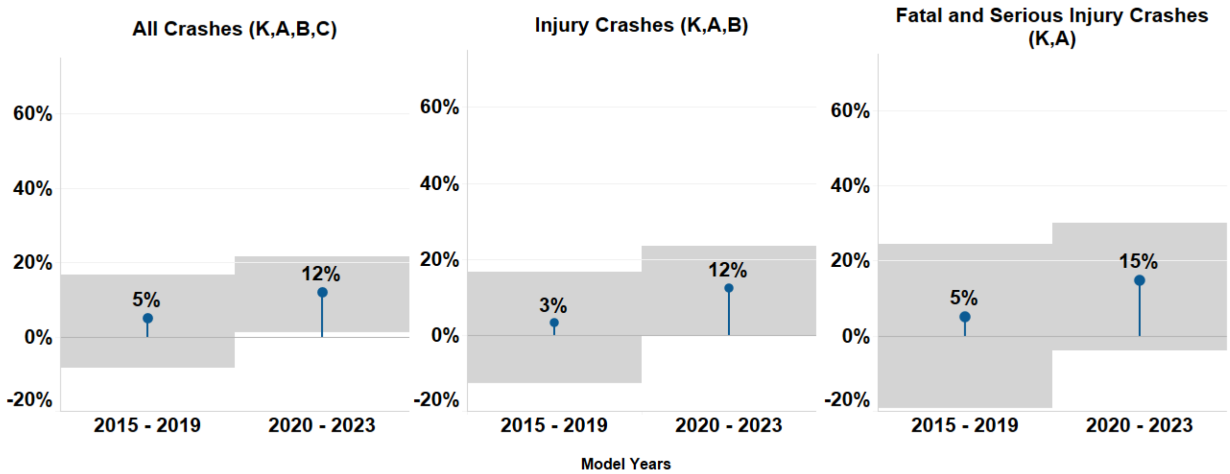


Figure 14. PAEB Effectiveness Over Time by Injury Level

4.2.3 Pedestrian Automatic Emergency Braking Injury Reduction by Occupant, Environment, Crash, and Vehicle Conditions

To assess whether PAEB effectiveness varies by occupant, environment, crash, or vehicle characteristics, the team examined statistical interactions between PAEB and a range of covariates for each injury level using the BIC criterion. Across all injury levels (KABC, KAB, KA), no covariates were identified as statistically significant. This may be because PAEB effectiveness does not vary with respect to these covariates, or it could result from insufficient statistical power—due to limited sample size and the criteria used—to detect differences.

4.3 Lateral Feature Injury Reduction in Single-vehicle Road-departure Crashes

4.3.1 Lateral Feature Injury Level Results

The study estimated the reduction in single-vehicle road-departure crashes when the vehicle was equipped with LDW Only, with LDW + LKA (no LCA), and with LDW + LKA + LCA. These were compared against vehicles equipped with none of these lateral ADAS features. For vehicles equipped with LDW + LKA + LCA, the system may or may not have been integrated with other Society of Automotive Engineers (SAE) Level 2 [16] active systems, depending on the vehicle model and model year that was involved in the crash. The effectiveness of these lateral features was evaluated across three injury severity levels: All Crashes (KABCO), Moderate or Worse Injury Crashes (KAB), and Fatal or Serious Injury Crashes (KA).

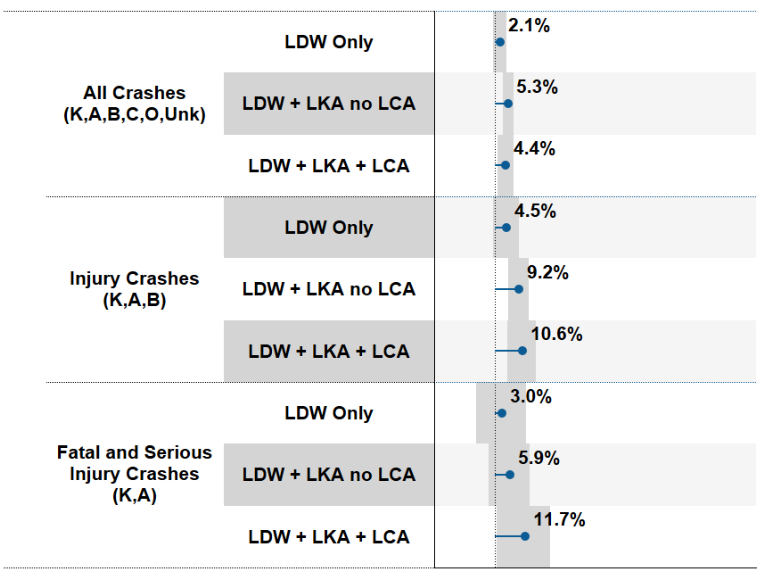
Figure 15 summarizes the estimated percent reduction in system-relevant crashes for each system configuration and injury level, along with 95% confidence intervals and sample sizes.

KABCO (All Crashes):
For all single-vehicle road-departure crashes, LDW Only was not associated with a statistically significant

reduction (2%, 95% CI: -0.5%, 4.7%) based on 19,399 system-relevant equipped crashes and 127,252 unequipped crashes. However, vehicles equipped with LDW+LKA (no LCA) showed a significant 5% reduction (95% CI: 3.1%, 7.4%) with 29,414 equipped crashes and 127,252 unequipped crashes, and those with LDW+LKA+LCA showed a significant 4% reduction (95% CI: 1.3%, 7.4%) using 16,570 equipped crashes and 127,252 unequipped crashes.

KAB (Moderate or Worse Injury):
For moderate or worse injury crashes, LDW Only was not associated with a statistically significant reduction (5%, 95% CI: -0.7%, 9.4%) based on 3,543 system-relevant equipped crashes and 24,807 unequipped crashes. Vehicles equipped with LDW+LKA (no LCA) showed a significant 9% reduction (95% CI: 5.1%, 13.2%) with 5,688 equipped crashes and 24,807 unequipped crashes, and those with LDW+LKA+LCA showed a significant 11% reduction (95% CI: 4.9%, 15.9%) using 3,305 equipped crashes and 24,807 unequipped crashes.

KA (Fatal or Serious Injury):
For fatal or serious injury crashes, only LDW+LKA+LCA was associated with a statistically significant 12% reduction (95% CI: 0.9%, 21.2%) based on 836 system-relevant equipped crashes and 6,750 unequipped crashes.



Group	Equipped	Unequipped
Control	98,328	586,534
System-Relevant	19,399	127,252
Control	202,134	586,534
System-Relevant	29,414	127,252
Control	131,082	586,534
System-Relevant	16,570	127,252
Control	98,328	586,534
System-Relevant	3,543	24,807
Control	202,059	586,534
System-Relevant	5,688	24,807
Control	131,046	586,534
System-Relevant	3,305	24,807
Control	98,293	586,534
System-Relevant	984	6,750
Control	201,756	586,534
System-Relevant	1,503	6,750
Control	129,986	586,534
System-Relevant	836	6,750

Figure 15. Lateral Systems Crash Reduction Estimates by Injury Level

4.3.2 Lateral Feature Injury Reduction Over Time

The effectiveness of nested combinations of the lateral features was estimated for subsets of model years (2015–2019 and 2020–2023), see Figure 16, and tested for differences over time. The model year groupings were again adjusted compared to the AEB analysis to maintain deidentification rules and support sample sizes. Groupings by model year were not statistically different at level 0.05 (with p-values of 0.20, 0.65, and 0.07 respectively), meaning that no change over time was observed. When grouped by model year, the only observed statistically significant crash rate reduction was for LDW + LKA + LCA for Moderate or Worse Injury Crashes (KAB) for 2020–2023 model year vehicles.

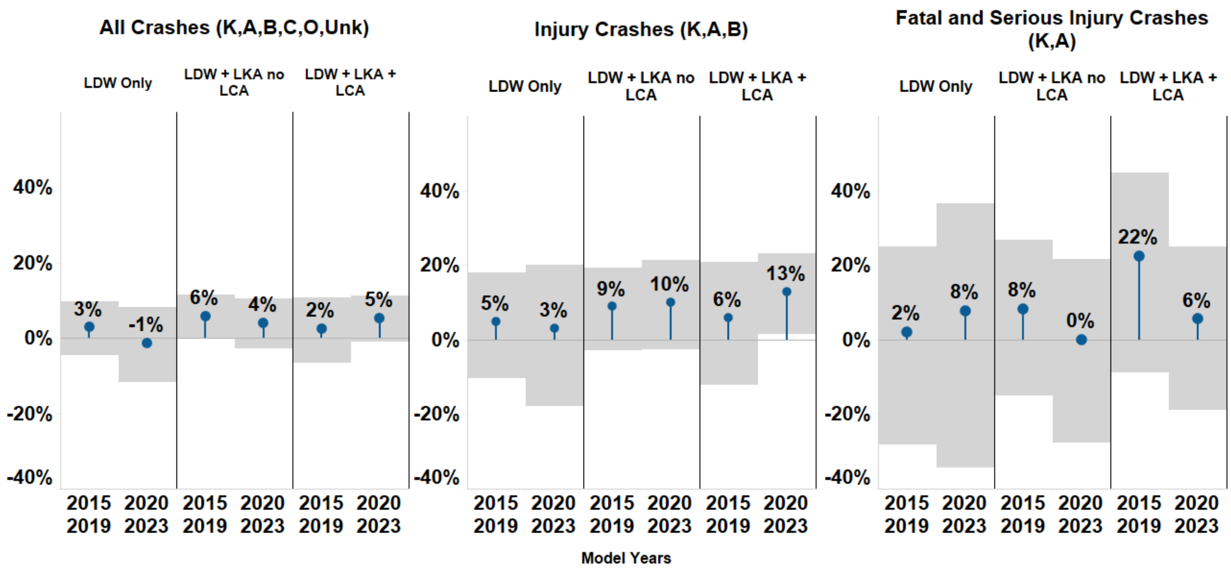


Figure 16. Lateral Systems Effectiveness Over Time by Injury Level

4.3.3 Lateral Feature Injury Reduction by Occupant, Environment, Crash, and Vehicle Conditions

To assess whether the effectiveness of lateral features vary by occupant, environment, crash, or vehicle characteristics, the team examined statistical interactions between equipage levels and a range of covariates for each injury level using the BIC criterion. Across all injury levels (All Crashes, KAB, KA), Sales Type was the only covariate found to have statistically significant differences, with fleet vehicles showing notably lower effectiveness for all three lateral equipage levels. For all other covariates, no statistically significant differences were identified, which may be due to lateral system effectiveness remaining consistent across these factors or insufficient statistical power—such as limited sample size or selection criteria—to detect differences.

5 Discussion

The PARTS 2025 Study produced one of the most comprehensive datasets on ADAS system-relevant crashes. The 2025 dataset was nearly three times the size of the one used in the previous study. It incorporated data from three additional states[8], three new model years, and 75 more vehicle models. The current study extends the use of that data set to estimate the effectiveness of ADAS features in reducing injuries through the combination of crash avoidance and mitigation across three injury severity levels: All Crashes, Moderate or Worse Injury Crashes (KAB), and Fatal or Serious Injury Crashes (KA).

5.1 Automatic Emergency Braking (Front-to-rear Crashes)

As reported in Section 4.1, the estimated effectiveness of AEB is greatest for Moderate or Worse Injury Crashes (KAB), exceeding the reduction observed for All Crashes (KABCO). However, the reduction for Fatal or Serious Injury Crashes (KA) is lower than for both All Crashes and KAB Crashes, indicating that while AEB is highly effective at preventing or mitigating crashes and injuries overall, its relative impact is somewhat less for the most severe injury outcomes. This may be due in part to the extreme nature of KA crashes, which can involve high rates of speed, driver impairment, and other circumstances that AEB

[8] New states added are Kansas, Michigan, Minnesota.

systems are not designed to address. The KA system-relevant crashes also make up less than 1% of the All Crashes population and analysis results show relatively large confidence intervals, indicating potential confounding due to small sample size. A separate analysis was conducted, separating out the K and A injury levels. The model was not stable, and the results were not statistically significant, likely due to the limited number of cases. The partnership plans to conduct an analysis of Fatal crashes using Fatality Analysis Reporting System (FARS) data to further investigate the effectiveness of AEB in preventing the most severe outcomes in the future.

Analyses indicate that AEB effectiveness has increased in more recent vehicle model years, suggesting enhanced crash reduction benefits over time. This improvement may be due to advances in AEB technology, broader adoption of more capable systems, or improvements in system calibration and integration. Significant gains were observed for both All Crashes (KABCO) and Moderate or Worse Injury Crashes (KAB) when comparing model year 2015-17 to model year 2021-23 populations. While this trend is not statistically significant for the most severe and fatal injury crashes (KA), the data indicates that substantial benefits have been maintained or improved across all periods.

Analyses of covariates further suggest that AEB effectiveness is influenced by a variety of driver, environmental, and vehicle factors for All Crashes (KABCO) and Moderate or Worse Injury Crashes (KAB). Notably, AEB effectiveness was lower for older drivers, male drivers, vehicles in bad weather or poor road conditions, certain vehicle segments (e.g., full-size pickups), and in fleet vehicles—consistent with findings from the 2025 PARTS Study. For the most severe (KA) injury outcomes, the AEB effectiveness appears relatively consistent across subgroups, though this lack of differentiation may be attributable to small sample size.

5.2 Pedestrian Automatic Emergency Braking (Frontal Crashes with Non-motorists)

Analysis results indicate that PAEB provides a consistent and statistically significant benefit in reducing non-motorist crashes across all KABC injury levels. The highest point estimate of PAEB effectiveness is observed for fatal or serious injury crashes (KA), where the crash reduction rate is estimated to be 10%. Estimates for different levels of injury are not significantly different, however, likely due in part to limited sample size.

Looking across groups of model years, point estimates indicate improved performance of PAEB systems in the most recent model years, particularly for the most severe injuries. However, due to limited sample sizes for newer vehicles and serious injuries, confidence intervals are wide and thus trends should be interpreted with caution.

5.3 Lateral ADAS Features (Single-vehicle Road-departure Crashes)

The greatest and most consistent crash reduction was observed for the most advanced lateral system (LDW+LKA+LCA), and this benefit was statistically significant for all injury levels. The other equipage levels (LDW Only, LDW+LKA) showed smaller and less consistent effects, with statistical significance reached only for LDW+LKA (no LCA) with All Crashes and Injury Crashes. Prior research [17] has shown that usage of lane keeping systems is lower than the other ADAS features examined. Since the current study does not account for feature state at time of crash (i.e., on or off), reported effectiveness levels are likely impacted by customer use. Though not quantifiable in the current study, improvements in system performance are expected to simultaneously improve effectiveness and increase customer acceptance. Further research into customer usage and continued tracking of lateral features will help clarify how implementation factors—such as alert types—affect system performance.

5.4 Study Limitations

As in prior studies [3] [18] [10] [13] [9], the analyses presented here are based on police reported crash data and are therefore subject to several data limitations. Police reports may be incomplete, may include inaccurate information, and may have inconsistencies in reporting across states or jurisdictions. Police reports include limited information on vehicle dynamics (e.g., vehicle pre-crash movement or travel speed), driver visibility, and non-motorist behavior. The injury levels used in this study are derived from police-reported KABCO scores, reflecting injury severities assessed by responding police rather than hospital or medical personnel. As such, injury levels may not reflect actual occupant outcomes.

In addition to limitations of the police report data, vehicle data are limited to the ADAS equipage at the time of manufacture. No data on ADAS feature usage was provided for this study, so effectiveness estimates do not comprehend degradation in performance for features that have been turned off. Data also do not account for differences in driving behavior, including miles traveled, roadways used, time of day, or driving style (e.g., aggressive or conservative). Instead, the quasi-induced exposure method leverages front-to-rear struck crashes as a control crash type, assuming this type of crash is both unrelated to the features being studied and likely to occur with increased driving exposure. This control is widely used in literature but may have limitations in some analyses. These limitations may be more pronounced for single vehicle road departures which tend to occur in different roadway environments than front to rear crashes. For instance, single vehicle road departures occur proportionately more frequently in rural areas with higher posted speed limits compared to front to rear crashes.

There is bias in the analysis due to equipage and exposure. There is a disparity between Front-to-Rear Striking and Front-to-Rear Struck crash involved vehicles (Figure 9 and Figure 10) which is consistent with the disparity seen by previous research [10] [3] [18]. The disparity is due to the differing roles (i.e., striking vs. struck) of PARTS vehicles in these crash types and the distinct characteristics of PARTS vehicles compared to the general vehicle population. For instance, PARTS vehicles are more likely to be equipped with AEB than the general population, which includes older vehicles manufactured before the introduction of AEB, leading to fewer Front-to-Rear Striking crashes. Additionally, PARTS vehicles tend to be newer than those in the general population. Other factors beyond these examples also contribute to the observed disparity. The number of linked crashes generally increased over the calendar years. The exceptions occurred in 2020, due to COVID-related lockdowns, and in 2023, because only part of the year was included in the study. As model years advanced, the number of years available for observing crashes decreased. For instance, a 2015 model year vehicle could be involved in crashes from 2016 to 2023, while a 2023 model year vehicle could only be involved in crashes in 2022 or 2023. As a result, the crash sample used in the effectiveness analysis was biased toward crashes occurring later in the study period and involving older model year vehicles.

When interpreting results, it is important to understand that the variability in ADAS implementations is not captured in the data nor accounted for in the analysis. While overall technology trends were partially captured by analyses over time, differences that may be related to varying calibrations or technology integrations, such as AEB using camera only compared to camera with radar, are not comprehended. Similarly, this study does not consider the operational design domain (ODD) for a given ADAS feature that defines the limits of that feature's functional capability to operate.

The study could not distinguish between injury crashes that were prevented and those that were mitigated (i.e., crashes that still occurred but resulted in lower injury severity or no injury). Current methodology only allows for the comparison of odds ratios for equipped and unequipped vehicles involved in an injury crash. At present, we are unable to differentiate between crashes that were entirely prevented and therefore not captured in our dataset, and those where injury severity was sufficiently mitigated to exclude them from the injury crash populations. This limitation means that various combinations of prevention and mitigation can produce similar effectiveness estimates. Consequently, this study reports the combined impact of both prevention and mitigation when estimating injury crash reduction effectiveness.

This study was unable to assess ADAS system effectiveness for fatal crashes (K) alone due to a limited sample size, which resulted in large confidence intervals and unstable model results for some covariates. Previous literature [19] suggests some of the model instability may also be due to the baseline assumptions of QIE not being satisfied for fatal crashes. To address this limitation, future research will use the FARS dataset, which is nationally representative of all fatal crashes and provides a larger sample size to better assess ADAS effectiveness in fatal crashes, as well as a different exposure metric for analysis.

As a data sharing public-private partnership, PARTS stands out for its innovative and evolving approach to safety collaboration, enabling research that would not be possible without joint efforts. Results of analyses conducted by PARTS provide insights into the benefits of ADAS technologies and opportunities to improve them, which can be used to prioritize future advances in safety performance. PARTS was able to complete this study because of each partner's commitment to sharing data and collaborating on the analysis, which is what makes the partnership truly unique. PARTS partners are advancing their co-developed research roadmap, which includes closing research gaps identified with this study, revisiting findings as ADAS deployment expands, and exploring new research opportunities.

Acronyms

Acronym	Definition
ADAS	Advanced Driver Assistance System
AEB	Automatic Emergency Braking
AHB	Auto-High Beam
BIC	Bayesian Information Criteria
CI	Confidence Interval
CSC	Consolidated State Crash
EDT	Electronic Data Transfer
FARS	Fatality Analysis Reporting System
FCW	Forward Collision Warning
GM	General Motors
GVWR	Gross Vehicle Weight Rating
HLDI	Highway Loss Data Institute
IIHS	Insurance Institute for Highway Safety
ITP	Independent Third Party
LCA	Lane Centering Assistance
LDW	Lane Departure Warning
LKA	Lane Keeping Assistance
MITRE	The MITRE Corporation
NHTSA	National Highway Traffic Safety Administration
ODD	Operational Design Domain
OEM	Original Equipment Manufacturer
PAEB	Pedestrian Automatic Emergency Braking
PARTS	Partnership for Analytics Research in Traffic Safety
QIE	Quasi-Induced Exposure
SAE	Society of Automotive Engineers
SUV	Sport Utility Vehicle
U.S.	United States
UMTRI	University of Michigan Transportation Research Institute
USDOT	United States Department of Transportation
VIN	Vehicle Identification Number
VRU	Vulnerable Road User

References

[1] NHTSA, "Overview of Motor Vehicle Traffic Crashes In 2023," 2025. [Online]. Available: https://crashstats.nhtsa.dot.gov/Api/Public/Publication/813705.

[2] PARTS, "PARTS: Market Penetration of Advanced Driver Assistance Systems (ADAS)," The Partnership for Analytics Research in Traffic Safety, 2024.

[3] PARTS, "A Study in Real-world Effectiveness of Model Year 2015-2023 Advanced Driver Assistance Systems," The Partnership for Analytics Research in Traffic Safety, 2025.

[4] Statista, "Estimated U.S. market share held by selected automotive manufacturers in 2023," 2024. [Online]. Available: https://www.statista.com/statistics/249375/us-market-share-of-selected-automobile-manufacturers/. [Accessed 10 August 2022].

[5] L. Blincoe, T. Miller, J.-S. Wang, D. Swedler, T. Coughlin, B. Lawrence, F. Guo, S. Klauer and T. Dingus, "The Economic and Societal Impact of Motor Vehicle Crashes, 2019 (Revised)," National Center for Statistics and Analysis, 2023.

[6] National Highway Traffic Safety Administration, "Traffic Safety Facts," US Department of Transportation, 2025.

[7] Highway Loss Data Institute, "Compendium of HLDI Collision Avoidance Research," Highway Loss Data Institute, 2023.

[8] M. Keall and S. Newstead, "Selection of Comparison Crash Types for Quasi-Induced Exposure Risk Estimation," *Traffic Injury Prevention,* pp. 23-29, 2009.

[9] A. J. Leslie, R. J. Kiefer, C. A. Flannagan, B. A. Schoettle and S. H. Owen, "Analysis of the Field Effectiveness of General Motors Model Year 2013-2020 Advanced Driver Assistance System Features," University of Michigan Transportation Research Institute, Ann Arbor, 2022.

[10] PARTS, "Real-world Effectiveness of Model Year 2015–2020 Advanced Driver Assistance Systems," The Partnership for Analytics Research in Traffic Safety, 2022.

[11] PARTS, "Advanced Driver Assistance System Crash Rate Assessment Using Vehicle-Specific Mileage Data," The Partnership for Analytics Research in Traffic Safety, 2025.

[12] National Highway Traffic Safety Administration, "MMUCC Guideline: Model Minimum Uniform Crash Criteria Fifth Edition," National Highway Traffic Safety Administration, Washington, DC, 2017.

[13] A. J. Leslie, R. J. Kiefer, M. R. Meitzner and C. A. Flannagan, "Field effectiveness of general motors advanced driver assistance and headlighting systems," *Accident Analysis & Prevention,* 2021.

[14] J. B. Cicchino, "Effects of automatic emergency braking systems on pedestrian crash risk," *Accident Analysis & Prevention,* vol. 172, December 2022.

[15] R. Spicer, A. Vahabaghale, D. Murakhovsky, S. St. Lawrence, B. Drayer and G. Bahouth, "Do driver characteristics and crash conditions modify the effectiveness of automatic emergency braking?," SAE International, 2021.

[16] SAE Standard J3016_202104, "Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles," SAE International, DOI:https://doi.org/10.4271/J3016_202104, 2021.

[17] A. E. Cox, I. J. Reagan and J. B. Cicchino, "Drivers' use of front crash prevention, lane departure warning and prevention, and speed warning systems," Insurance Institute for Highway Safety, Arlington,, VA, 2024.

[18] A. J. Leslie, R. J. Kiefer, C. A. Flannagan and S. H. Owen, "Analysis of the Field Effectiveness of General Motors Model Year 2019-2023 Advanced Driver Assistance System (ADAS) Features," University of Michigan Transportation Research Institute (UMTRI), Ann Arbor, 2025.

[19] G. Zhang, X. Jiang, X. Qiu, Y. Fan, C. Huang and M. Wei, "Validating the underlying assumption of quasi-induced exposure technique disaggregated by crash injury severity," *Journal of Safety Research,* vol. 76, pp. 197-204, 2021.

Appendix A Quasi-Induced Exposure Calculations

QIE relies on an odds ratio comparing equipped to unequipped vehicles with respect to the number of system-relevant crashes relative to the number of control crashes. The QIE ADAS odds ratio is defined as:

$$\text{ADAS odds ratio} = \frac{\text{System} - \text{Relevant Crashes for Equipped Vehicles/Control Crashes for Equipped Vehicles}}{\text{System} - \text{Relevant Crashes for Unequipped Vehicles/Control Crashes for Unequipped Vehicles}}$$

If the ADAS odds ratio is less than one, then the ADAS feature is effectively reducing the number of system-relevant crashes, assuming no other influencing factors. Therefore, the ADAS effectiveness is stated as a reduction in odds:

$$\text{ADAS Effectiveness} = 1 - \text{ ADAS odds ratio}$$

In practice, odds ratios are estimated using logistic regression. The response variable in the logistic regression indicates whether a vehicle is involved in a system-relevant crash or a control crash. A binary explanatory variable represents whether the vehicle is equipped with ADAS. The exponentiated coefficient of this binary variable from the logistic regression provides the ADAS odds ratio. This method also allows for the inclusion of additional covariates that might affect the likelihood of system-relevant crashes compared to control crashes.

$$\log(odds) = \beta_0 + \beta_{adjust} * model\ year + \beta_1 * covariate_1 + \cdots + \beta_p * covariate_p \text{log}odds = \propto_0 + \propto + \propto_{equipped,2015} + \cdots \propto_{unequipped,2018} + \propto_{equipped,2018} + \propto_{equipped,2019} + \propto_{equipped,2020} + \cdots + \propto_{equipped,2023} + \propto_1 * covariate_1 + \cdots + \propto_p * covariate\_p \propto_{equipped,2015} - \propto_{unequipped,2015} \propto_{equipped,model\ year} - \beta_{adjust} * (model\ year - 2019)$$

Appendix B Details of Adjustment for Model Years 2020+

The model year adjustment factor is calculated based on unequipped vehicles from older model years (2015–2019) when enough unequipped (approximately half of crashes vehicles were still unequipped in 2019) vehicles existed. A model year slope parameter is fit in a logistic regression containing only unequipped vehicles to ensure that the influences of ADAS features are removed. The logistic regression formula to calculate the adjustment is:

$$\log(odds) = \beta_0 + \beta_{adjust} * model\ year + \beta_1 * covariate_1 + \cdots + \beta_p * covariate_p$$

The adjustment factor is β_{adjust} in the above equation.

With the adjustment factor calculated, the next step is to fit a logistic regression to estimate the effectiveness by model year. For model years 2015–2019, both equipped and unequipped vehicles are included in the logistic regression. For model years 2020+, only equipped vehicles are included in the logistic regression. This was done to ensure that model year effects were not partially removed in the logistic regression, which would cause the adjustment factor to double penalize. The logistic regression is then fit with an ADAS variable that is mixed with model year, as defined in the following bulleted list, instead of the binary equipped and unequipped.

- Reference: Unequipped Model Year 2019
- Unequipped Model Year 2015
- Equipped Model Year 2015
- Unequipped Model Year 2016
- Equipped Model Year 2016
- Unequipped Model Year 2017
- Equipped Model Year 2017
- Unequipped Model Year 2018
- Equipped Model Year 2018
- Equipped Model Year 2019 (no corresponding unequipped since reference level)
- Equipped Model Year 2020
- Equipped Model Year 2021
- Equipped Model Year 2022
- Equipped Model Year 2023

Model year 2019 unequipped is used as reference since the adjustment factor starts to be applied for model year 2020+.

The logistic regression formula is as follows:

$$\log odds = \propto_0 + \propto + \propto_{equipped,2015} + \cdots \propto_{unequipped,2018} + \propto_{equipped,2018} + \propto_{equipped,2019} + \propto_{equipped,2020} + \cdots + \propto_{equipped,2023} + \propto_1 * covariate_1 + \cdots + \propto_p * covariate\_p$$

Note that in the above equation, the coefficient notation is expanded such that each coefficient corresponds to the level of a covariate rather than using more condensed notation.

To calculate the estimated ADAS effectiveness by model year for 2015–2019, the unequipped coefficient is subtracted from the equipped, as shown for model year 2015 below:

$$\propto_{equipped,2015} - \propto_{unequipped,2015}$$

The estimated effectiveness for model year 2019 is $\propto_{equipped,2019}$ since the reference level is unequipped model year 2019.

To calculate the estimated ADAS effectiveness by model year for 2020–2023, the coefficient has an adjustment factor subtracted. Since unequipped 2019 is the refence and model years 2020–2023 do not have an unequipped level, the $\propto_{equipped,model\ year}$ is the effectiveness of ADAS for that model year and also any model year effect. The adjustment factor is subtracted to remove the model year effect, which is done as follows:

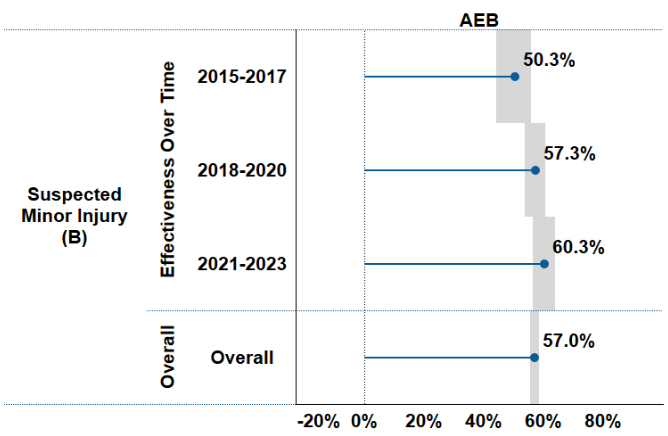
$$\propto_{equipped,model\ year} - \ \beta_{adjust} * (model\ year - 2019)$$

This method assumes the reduction in crash rates (regardless of equipage) for newer vehicles in model years 2020 forward and follows a linear trend in the log-odds space that is identical to that observed in model years 2015–2019 unequipped vehicles.

To match to previous research, the weighted average (based on proportion of equipped vehicles in each model year of the control crash) of effectiveness for each model year is calculated to arrive at an overall effectiveness. This weighting can be different from that used in previous pooled effectiveness results, potentially leading to variations between the current estimate and past pooled estimates.

Appendix C Suspected Minor Injury Crash Analysis for AEB

The overall effectiveness of AEB in reducing Suspected Minor Injury Crash (B) and the effectiveness for subsets of model years (2015–2017, 2018–2020, and 2021–2023) are shown in Figure 17 below. The results estimated a 57.0% reduction (95% CI: 55.4%, 58.5%) in suspected minor injury (B) crashes, based on 7,311 equipped and 32,983 unequipped crashes.



Group	Equipped	Unequipped
Control	364,209	617,942
System-Relevant	115,223	467,498
Control	364,203	617,942
System-Relevant	8,375	37,663
Control	361,410	617,273
System-Relevant	1,064	4,680

Figure 17. AEB Effectiveness for Suspected Minor Injury (B)

Comparing the Injury crashes (KAB) with the Fatal or Serious Injury Crashes in Table 5, it indicates that suspected minor injury crashes make up the majority of injury (KAB) crashes and are largely responsible for the higher effectiveness observed for injury crashes (KAB) compared to fatal or serious injury crashes (KA).

Table 5. Comparison of AEB Effectiveness by Injury Level

	Overall	2015-2017	2018-2020	2021-2023
All Crashes (K,A,B,C,O,Unk)	49.1% 95% CI: (48.5%, 49.7%)	45.5% 95% CI: (43.4%, 47.5%)	49.0% 95% CI: (47.7%, 50.3%)	51.6% 95% CI: (50.2%, 53.0%)
Fatal and Injury Crashes (K,A,B)	55.3% 95% CI: (53.8%, 56.8%)	49.1% 95% CI: (43.2%, 54.4%)	55.6% 95% CI: (52.1%, 58.9%)	58.5% 95% CI: (54.7%, 62.1%)
Fatal and Serious Injury Crashes (K,A)	41.8% 95% CI: (36.2%, 46.9%)	36.1% 95% CI: (14.0%, 52.5%)	42.3% 95% CI: (29.0%, 53.2%)	44.3% 95% CI: (28.4%, 56.7%)
Suspected Minor Injury Crashes (B)	57.0% 95% CI: (55.4%, 58.5%)	50.3% 95% CI: (44.2%, 55.8%)	57.3% 95% CI: (53.7%, 60.6%)	60.3% 95% CI: (56.5%, 63.9%)

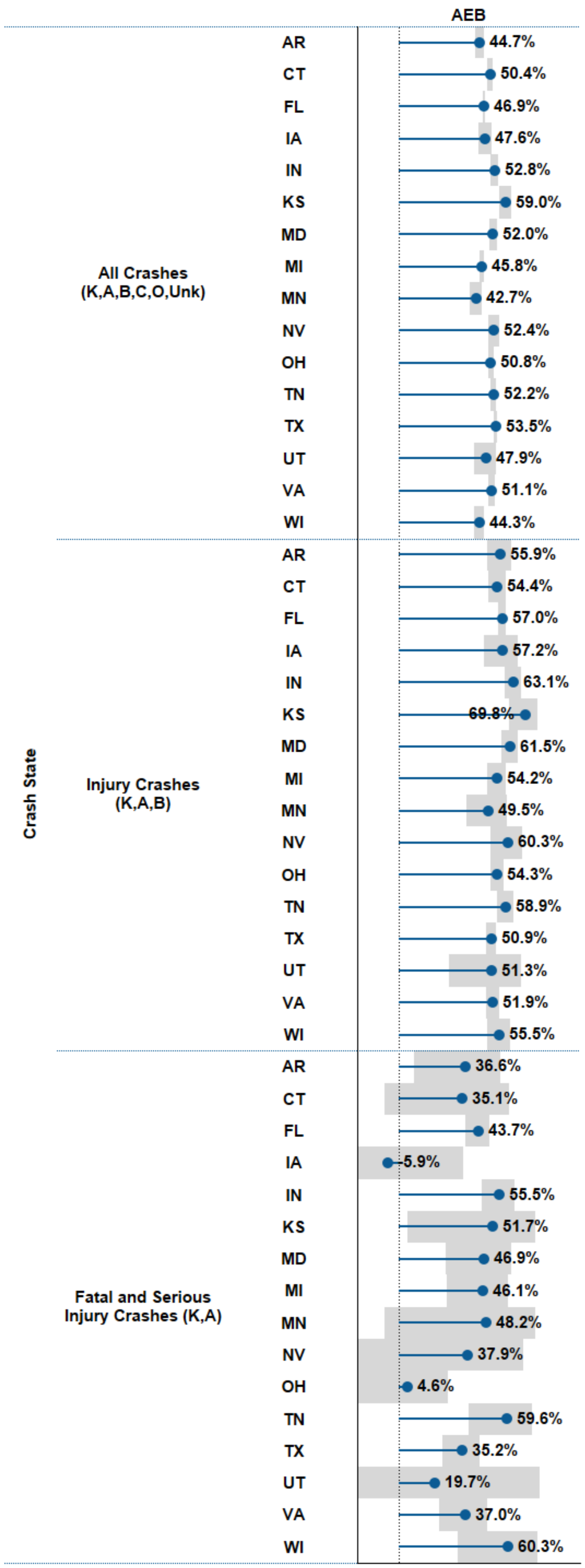
Appendix D AEB Identified Interactions

This appendix includes detailed results for all BIC identified significant interactions for AEB. Each covariate was separately included in the logistic regression as an interaction with the ADAS feature and BIC used to identify whether the interaction added meaningful information (i.e., BIC lower for logistic regression with interaction than without).

For each covariate identified by BIC, this section displays the effectiveness estimates by covariate level along with a 95% Bonferroni-corrected (based on number of levels of the covariate) CI. Additionally, the sample sizes for each level are also displayed.

No covariates were identified as statistically significant for PAEB across any injury level. Across all three lateral systems, the only covariate found to be statistically significant was Sales Type to All Crashes; none of the covariates were significant across all injury levels.

AEB by Crash State

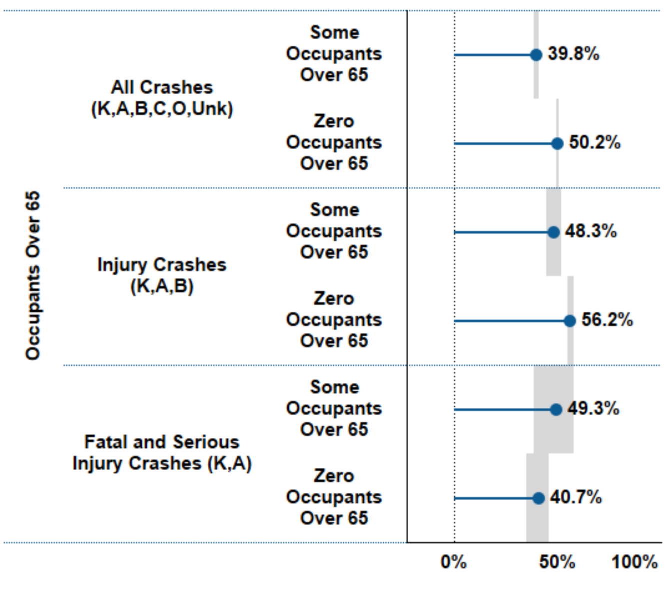


Group	Equipped	Unequipped
Control	9,177	17,147
System-Relevant	3,008	13,124
Control	16,952	27,940
System-Relevant	5,323	20,964
Control	137,403	198,491
System-Relevant	48,420	157,848
Control	4,345	8,619
System-Relevant	1,168	5,973
Control	9,889	31,394
System-Relevant	2,424	19,789
Control	3,614	8,186
System-Relevant	979	5,667
Control	10,268	17,747
System-Relevant	3,215	13,880
Control	28,055	83,096
System-Relevant	8,290	53,873
Control	5,748	5,697
System-Relevant	1,859	4,631
Control	5,231	7,259
System-Relevant	1,584	5,663
Control	24,415	37,853
System-Relevant	6,704	28,854
Control	18,212	27,340
System-Relevant	5,319	21,314
Control	63,743	98,925
System-Relevant	19,007	80,699
Control	1,462	4,578
System-Relevant	353	2,754
Control	15,966	26,572
System-Relevant	4,692	20,358
Control	9,729	17,098
System-Relevant	2,878	12,107
Control	9,177	17,147
System-Relevant	169	929
Control	16,952	27,940
System-Relevant	391	1,623
Control	137,402	198,491
System-Relevant	2,550	10,062
Control	4,345	8,619
System-Relevant	78	477
Control	9,889	31,394
System-Relevant	232	2,345
Control	3,613	8,186
System-Relevant	63	447
Control	10,268	17,747
System-Relevant	337	1,655
Control	28,055	83,096
System-Relevant	302	2,296
Control	5,747	5,697
System-Relevant	94	269
Control	5,231	7,259
System-Relevant	80	343
Control	24,415	37,853
System-Relevant	694	3,120
Control	18,212	27,340
System-Relevant	345	1,467
Control	63,740	98,925
System-Relevant	1,785	7,187
Control	1,462	4,578
System-Relevant	22	186
Control	15,966	26,572
System-Relevant	1,034	4,230
Control	9,729	17,098
System-Relevant	199	1,027
Control	9,131	17,139
System-Relevant	28	128
Control	16,836	27,898
System-Relevant	14	48
Control	136,329	198,317
System-Relevant	419	1,459
Control	4,318	8,612
System-Relevant	17	47
Control	9,848	31,352
System-Relevant	98	995
Control	3,592	8,176
System-Relevant	10	55
Control	10,200	17,726
System-Relevant	37	157
Control	27,628	82,908
System-Relevant	36	276
Control	5,697	5,687
System-Relevant	7	24
Control	5,186	7,255
System-Relevant	8	29
Control	24,265	37,812
System-Relevant	65	171
Control	18,100	27,314
System-Relevant	20	108
Control	63,274	98,879
System-Relevant	187	701
Control	1,455	4,575
System-Relevant	2	12
Control	15,882	26,546
System-Relevant	103	387
Control	9,669	17,077
System-Relevant	13	83

Figure 18. Estimated AEB Effectiveness by Crash States

AEB for Occupants Over 65

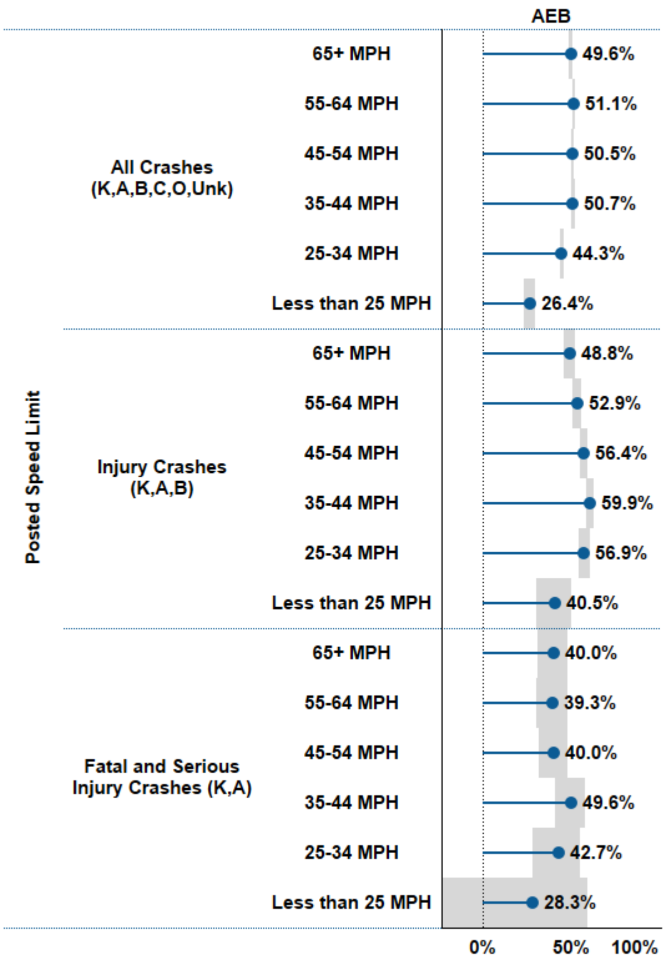
Estimated AEB effectiveness was found to be lower for injury crashes when elderly occupants were present compared to all other injury crashes. Other factors, such as driver demographics when an elderly occupant is present may have confounded this finding.



Group	Equipped	Unequipped
Control	49,251	66,366
System-Relevant	13,890	35,699
Control	314,958	551,576
System-Relevant	101,333	431,799
Control	49,250	66,366
System-Relevant	1,131	3,327
Control	314,953	551,576
System-Relevant	7,244	34,336
Control	48,809	66,273
System-Relevant	125	476
Control	312,601	551,000
System-Relevant	939	4,204

Figure 19. Estimated AEB Effectiveness for Occupants Over 65

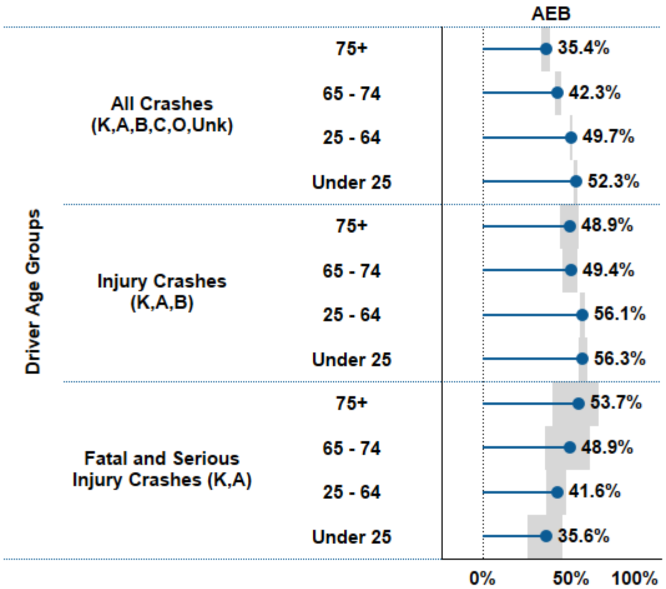
AEB by Posted Speed Limit



Group	Equipped	Unequipped
Control	40,469	66,377
System-Relevant	13,409	53,271
Control	50,483	85,778
System-Relevant	15,411	65,667
Control	108,818	182,675
System-Relevant	33,770	137,932
Control	106,577	184,219
System-Relevant	31,929	136,809
Control	48,861	85,857
System-Relevant	16,293	63,339
Control	9,001	13,036
System-Relevant	4,411	10,480
Control	40,468	66,377
System-Relevant	1,505	5,692
Control	50,482	85,778
System-Relevant	1,664	7,214
Control	108,815	182,675
System-Relevant	2,435	10,943
Control	106,576	184,219
System-Relevant	1,858	9,585
Control	48,861	85,857
System-Relevant	759	3,754
Control	9,001	13,036
System-Relevant	154	475
Control	40,153	66,304
System-Relevant	264	1,024
Control	50,128	85,681
System-Relevant	253	1,130
Control	107,936	182,446
System-Relevant	295	1,189
Control	105,770	184,052
System-Relevant	167	919
Control	48,492	85,767
System-Relevant	73	376
Control	8,931	13,023
System-Relevant	12	42

Figure 20. Estimated AEB Effectiveness by Posted Speed Limit

AEB by Driver Age Group

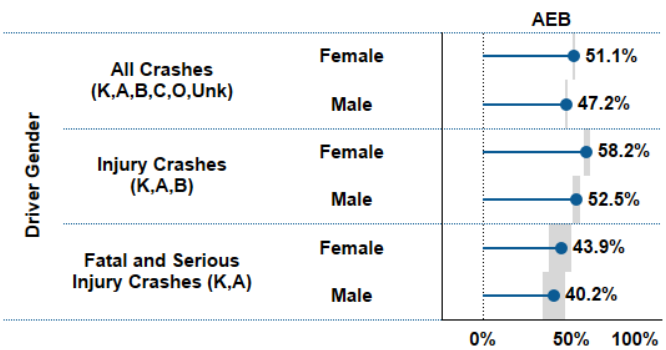


Group	Equipped	Unequipped
Control	13,165	17,004
System-Relevant	5,654	12,912
Control	34,390	48,207
System-Relevant	8,628	24,395
Control	278,919	473,730
System-Relevant	77,435	309,936
Control	37,735	79,001
System-Relevant	23,506	120,255
Control	13,165	17,004
System-Relevant	488	1,352
Control	34,389	48,207
System-Relevant	646	2,048
Control	278,915	473,730
System-Relevant	5,539	25,056
Control	37,734	79,001
System-Relevant	1,702	9,207
Control	13,040	16,971
System-Relevant	53	210
Control	34,064	48,142
System-Relevant	69	274
Control	276,735	473,208
System-Relevant	725	3,178
Control	37,571	78,952
System-Relevant	217	1,018

Figure 21. Estimated AEB Effectiveness by Driver Age Group

AEB by Driver Gender

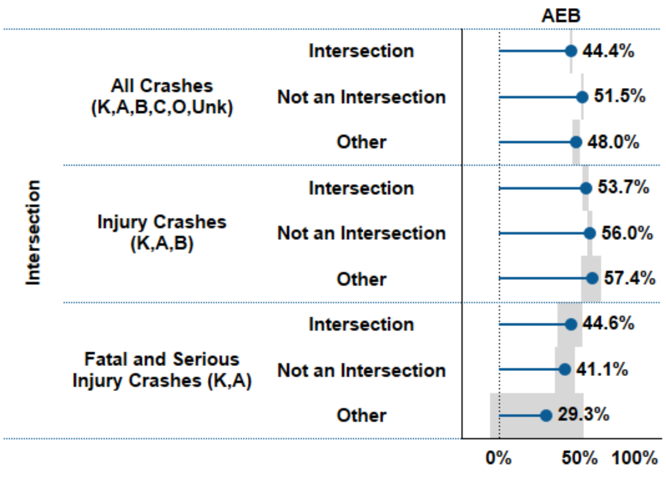
Estimated AEB effectiveness was found to be lower for male drivers in injury crashes compared to all other injury crashes. This finding may be confounded by other factors such as driving behavior.



Group	Equipped	Unequipped
Control	197,468	317,792
System-Relevant	55,459	221,143
Control	166,741	300,150
System-Relevant	59,764	246,355
Control	197,464	317,792
System-Relevant	3,904	17,847
Control	166,739	300,150
System-Relevant	4,471	19,816
Control	196,161	317,528
System-Relevant	458	1,983
Control	165,249	299,745
System-Relevant	606	2,697

Figure 22. Estimated AEB Effectiveness by Driver Gender

AEB by Intersection

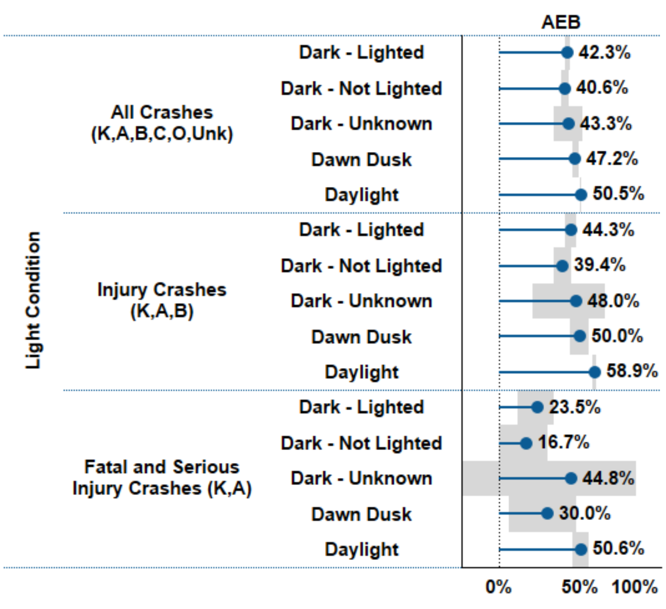


Group	Equipped	Unequipped
Control	119,349	208,733
System-Relevant	40,168	154,960
Control	234,758	391,621
System-Relevant	71,704	299,264
Control	10,102	17,588
System-Relevant	3,351	13,274
Control	119,346	208,733
System-Relevant	2,686	11,949
Control	234,756	391,621
System-Relevant	5,505	24,820
Control	10,101	17,588
System-Relevant	184	894
Control	118,466	208,488
System-Relevant	274	1,308
Control	232,928	391,219
System-Relevant	765	3,262
Control	10,016	17,566
System-Relevant	25	110

Figure 23. Estimated AEB Effectiveness by Intersection

AEB by Light Condition

Estimated AEB effectiveness was found to be lower for All Crashes and Injury Crashes in known dark or dawn/dusk conditions compared to daylight. Effectiveness was also found to be lower for known dark conditions compared to daylight for Fatal and Serious Injury Crashes.

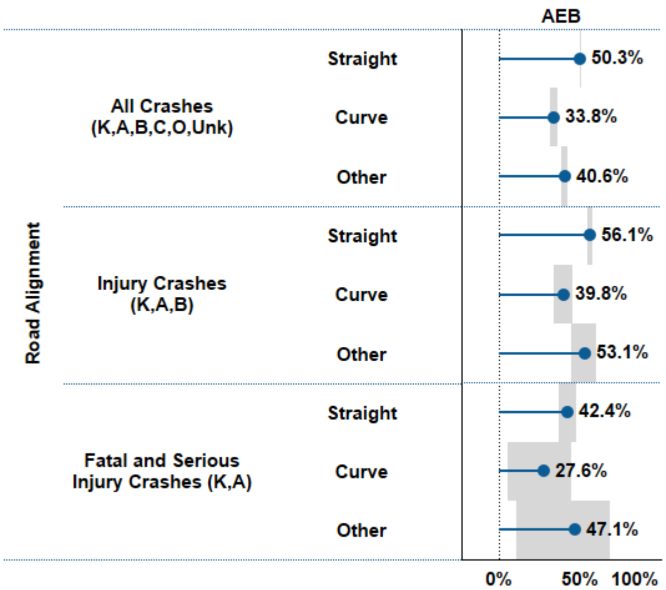


Group	Equipped	Unequipped
Control	43,798	76,829
System-Relevant	16,685	60,000
Control	10,484	21,136
System-Relevant	4,434	18,217
Control	679	1,252
System-Relevant	259	995
Control	13,117	24,467
System-Relevant	4,339	18,191
Control	296,131	494,258
System-Relevant	89,506	370,095
Control	43,798	76,829
System-Relevant	1,655	6,009
Control	10,484	21,136
System-Relevant	761	2,877
Control	679	1,252
System-Relevant	28	106
Control	13,117	24,467
System-Relevant	339	1,493
Control	296,125	494,258
System-Relevant	5,592	27,178
Control	43,521	76,752
System-Relevant	251	844
Control	10,397	21,105
System-Relevant	171	621
Control	678	1,251
System-Relevant	3	12
Control	13,017	24,444
System-Relevant	47	192
Control	293,797	493,721
System-Relevant	592	3,011

Figure 24. Estimated AEB Effectiveness by Light Condition

AEB by Road Alignment

Estimated AEB effectiveness was found to be lower for injury crashes that occurred on curved roadway segments compared to all other injury crashes.

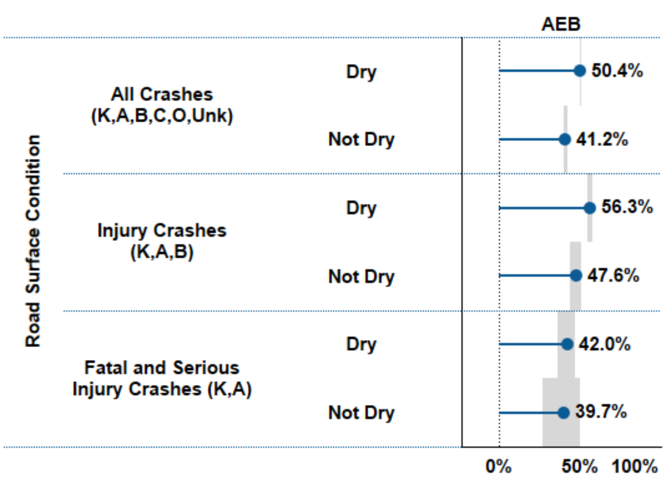


Group	Equipped	Unequipped
Control	333,746	551,106
System-Relevant	103,101	418,992
Control	17,323	28,362
System-Relevant	7,787	23,168
Control	13,140	38,474
System-Relevant	4,335	25,338
Control	333,740	551,106
System-Relevant	7,720	35,047
Control	17,323	28,362
System-Relevant	528	1,725
Control	13,140	38,474
System-Relevant	127	891
Control	331,257	550,562
System-Relevant	995	4,377
Control	17,226	28,333
System-Relevant	57	214
Control	12,927	38,378
System-Relevant	12	89

Figure 25. Estimated AEB Effectiveness by Road Alignment

AEB by Road Surface Condition

Estimated AEB effectiveness was found to be lower for injury crashes occurring when the road was not dry compared to all injury crashes.

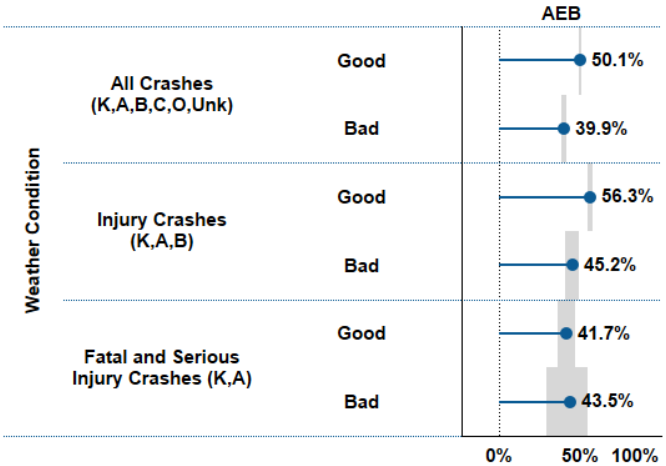


Group	Equipped	Unequipped
Control	308,479	511,724
System-Relevant	98,247	400,910
Control	55,730	106,218
System-Relevant	16,976	66,588
Control	308,473	511,724
System-Relevant	7,278	33,051
Control	55,730	106,218
System-Relevant	1,097	4,612
Control	306,069	511,164
System-Relevant	953	4,145
Control	55,341	106,109
System-Relevant	111	535

Figure 26. Estimated AEB Effectiveness by Road Surface Condition

AEB by Weather Condition

Estimated AEB effectiveness was found to be lower for injury crashes occurring during adverse weather conditions than all other injury crashes.

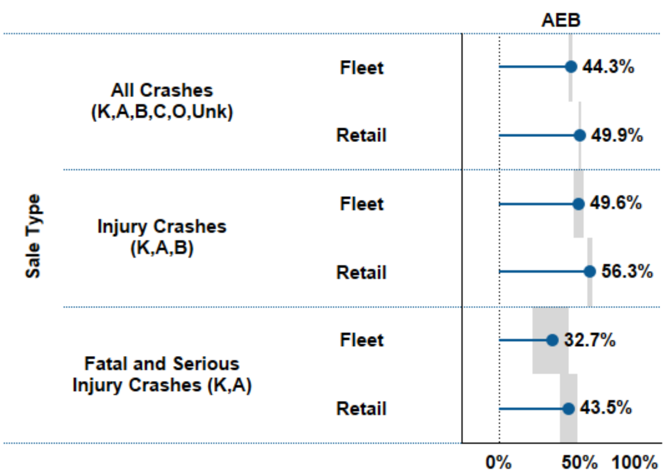


Group	Equipped	Unequipped
Control	325,073	543,191
System-Relevant	103,269	421,260
Control	39,136	74,751
System-Relevant	11,954	46,238
Control	325,068	543,191
System-Relevant	7,550	34,338
Control	39,135	74,751
System-Relevant	825	3,325
Control	322,541	542,593
System-Relevant	988	4,292
Control	38,869	74,680
System-Relevant	76	388

Figure 27. Estimated AEB Effectiveness by Weather Condition

AEB by Sale Type

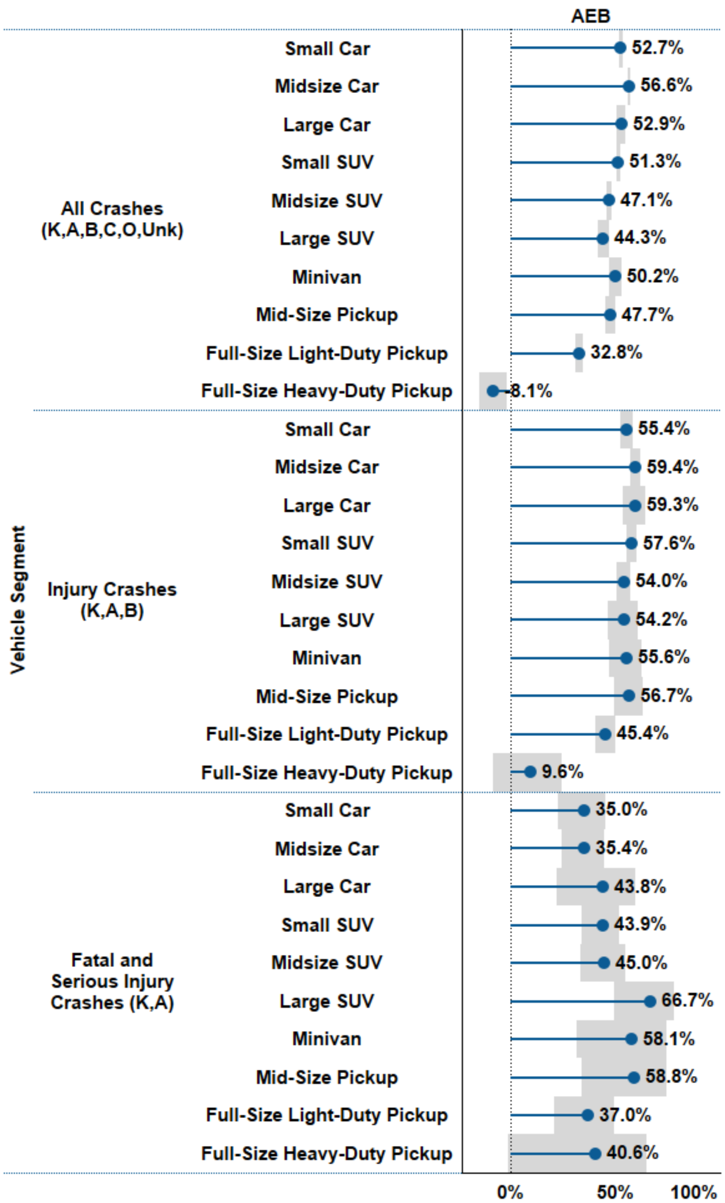
Estimated AEB effectiveness was found to be lower for injury crashes involving fleet vehicles compared to all other injury crashes.



Group	Equipped	Unequipped
Control	43,649	116,430
System-Relevant	16,653	96,177
Control	320,560	501,512
System-Relevant	98,570	371,321
Control	43,649	116,430
System-Relevant	1,257	7,868
Control	320,554	501,512
System-Relevant	7,118	29,795
Control	43,426	116,347
System-Relevant	170	1,028
Control	317,984	500,926
System-Relevant	894	3,652

Figure 28. Estimated AEB Effectiveness by Sale Type

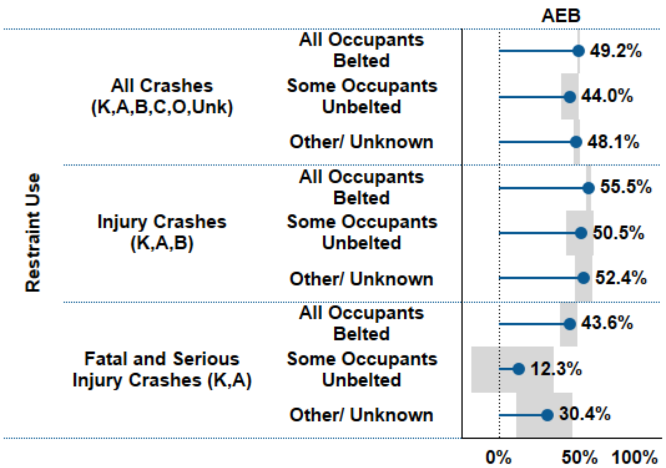
AEB by Vehicle Segment



Group	Equipped	Unequipped
Control	50,483	91,892
System-Relevant	21,488	92,902
Control	62,750	113,376
System-Relevant	18,449	91,011
Control	11,076	42,282
System-Relevant	4,021	38,489
Control	100,208	134,922
System-Relevant	27,597	86,936
Control	73,722	115,403
System-Relevant	19,024	70,993
Control	21,288	7,156
System-Relevant	7,565	4,559
Control	9,238	10,746
System-Relevant	2,165	5,922
Control	11,054	17,554
System-Relevant	3,514	11,338
Control	22,263	63,981
System-Relevant	9,554	46,114
Control	2,127	20,630
System-Relevant	1,846	19,234
Control	50,483	91,892
System-Relevant	1,618	7,854
Control	62,750	113,376
System-Relevant	1,509	7,530
Control	11,076	42,282
System-Relevant	326	3,327
Control	100,208	134,922
System-Relevant	2,045	7,061
Control	73,716	115,403
System-Relevant	1,328	5,310
Control	21,288	7,156
System-Relevant	423	294
Control	9,238	10,746
System-Relevant	163	474
Control	11,054	17,554
System-Relevant	211	803
Control	22,263	63,981
System-Relevant	634	3,518
Control	2,127	20,630
System-Relevant	118	1,492
Control	49,916	91,401
System-Relevant	215	933
Control	62,750	113,376
System-Relevant	231	904
Control	10,940	42,130
System-Relevant	46	460
Control	99,860	134,922
System-Relevant	254	859
Control	72,374	115,377
System-Relevant	141	595
Control	21,288	7,156
System-Relevant	42	57
Control	9,238	10,746
System-Relevant	18	59
Control	10,677	17,554
System-Relevant	22	100
Control	22,240	63,981
System-Relevant	83	466
Control	2,127	20,630
System-Relevant	12	247

Figure 29. Estimated AEB Effectiveness by Vehicle Segment

AEB Restraint Use



Group	Equipped	Unequipped
Control	352,521	597,012
System-Relevant	110,567	447,740
Control	1,426	2,740
System-Relevant	662	3,016
Control	10,262	18,190
System-Relevant	3,994	16,742
Control	352,515	597,012
System-Relevant	7,813	35,043
Control	1,426	2,740
System-Relevant	190	980
Control	10,262	18,190
System-Relevant	372	1,640
Control	349,810	596,365
System-Relevant	920	4,060
Control	1,419	2,738
System-Relevant	70	290
Control	10,181	18,170
System-Relevant	74	330

Figure 30. Estimated AEB Effectiveness by Restraint Use