



Impact of Subaru collision avoidance features on insurance losses by rated driver age

► Summary

The Insurance Institute of Highway Safety and the Highway Loss Data Institute (HLDI) have done a significant amount of research on collision avoidance systems. Prior studies (HLDI, 2018, 2019) have found insurance loss benefits for Subaru collision avoidance systems, including EyeSight, rear-vision camera, Rear Vehicle Detection, reverse automatic braking, and steering responsive headlamps. There are, however, additional questions related to these systems that need to be answered. One such question involves the extent to which the benefits of Subaru collision avoidance systems vary by rated driver age.

Subaru EyeSight was first introduced on the 2013 model year Legacy and Outback, and by the 2016 model year, every Subaru nameplate except the BRZ could be purchased with the EyeSight system. EyeSight uses a dual-camera system located behind the windshield to assess the risk of a collision with leading traffic. Prior studies (HLDI, 2018, 2019) have shown the EyeSight system to be beneficial, especially for property damage liability (PDL) and bodily injury (BI) liability coverages.

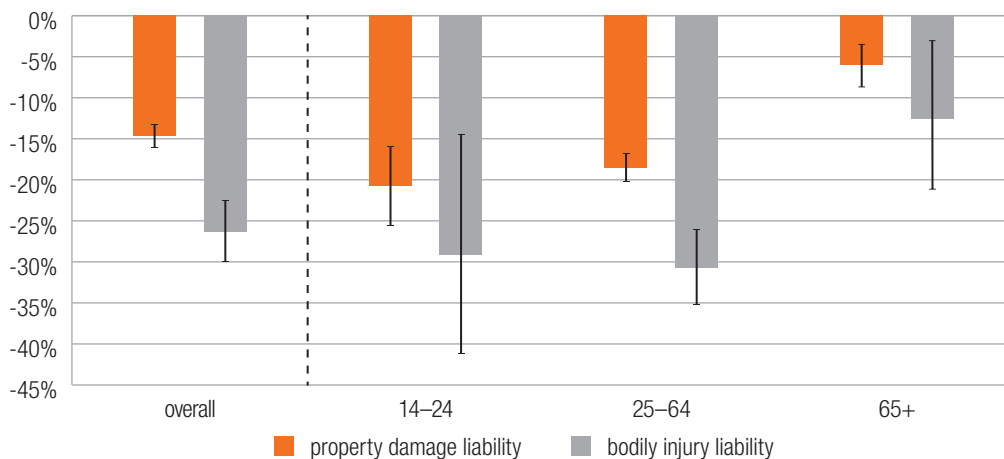
As shown in the following figure, for all age groups combined, EyeSight is associated with a 15 and 26 percent reduction to PDL and BI liability claim frequency, respectively. The results by rated driver age suggest that rated drivers in all age groups benefit from EyeSight for PDL and BI liability. However, drivers 65 and older do not seem to benefit as much from this technology as drivers under 65. Although still statistically significant, rated drivers 65 and older are associated with only a 6 and 13 percent reduction to PDL and BI claim frequency, respectively. Comparatively, rated drivers aged 14–24 are associated with a 21 and 29 percent reduction to PDL and BI claim frequency, while rated drivers aged 25–64 are associated with a reduction of 19 and 31 percent.

The effects of EyeSight on the other three coverage types (collision, medical payment, and personal injury protection) are mixed for different age groups. However, the results for the youngest group (rated drivers aged 14–24) are based on the least exposure and, consequently, have the largest confidence bounds.

The results for Subaru’s rear-vision camera and Rear Vehicle Detection also indicate reductions to both PDL and BI liability claim frequencies in all rated driver age groups, which is consistent with HLDI’s prior study (2019). These systems are associated with larger benefits for younger drivers.

In the model year 2017, three new features were introduced on Subaru vehicles including reverse automatic braking, steering responsive headlamps, and high-beam assist. These features were examined in HLDI’s 2018 and 2019 studies on Subaru collision avoidance features, where benefits were found in particular for reverse automatic braking. However, because there is limited data available for these three features in each rated driver age group, the results for these features were not included in this study.

Change in claim frequency by rated driver age for Subaru EyeSight



► Introduction

This Highway Loss Data Institute (HLDI) bulletin examines the effects of several Subaru collision avoidance systems on insurance losses by rated driver age. Prior HLDI studies (HLDI, 2018, 2019) indicated that EyeSight, rear-vision camera, Rear Vehicle Detection, reverse automatic braking, and steering responsive headlamps are having some benefits. However, as some features were first introduced in model year 2017, not all of these features have had enough claims for each rated driver age group. The features included in this analysis are described below.

EyeSight was first available on 2013–14 Legacy and Outback vehicles and on the 2014–16 Forester. In model year 2015, Subaru introduced a second generation of the EyeSight system on the Legacy and Outback. The second generation also appeared on the XV Crosstrek and Impreza four-door and five-door in 2015 and later on the WRX in model year 2016 and on the Forester in model year 2017. Both generations use a dual-camera system located behind the windshield to assess the risk of a collision with leading traffic.

The first generation utilized dual back-and-white cameras, while the second generation shifted to color cameras, along with longer and wider detection ranges, an increased ability to handle the speed differential with leading vehicles, and brake light detection. An important enhancement to the second generation of the EyeSight system is the increased speed differential. The first generation of EyeSight is operational when the speed difference between the EyeSight-equipped vehicle and another vehicle was up to 19 mph (31 km/h). On the second generation, Subaru increased the speed differential to 30 mph (48 km/h). At higher speed differentials, the EyeSight system may only be able to mitigate the crash.

Both EyeSight generations include the following four features:

Forward collision warning with automatic braking assesses the risk of a rear-end collision with an obstacle in front and warns the driver with an audible alert. If the driver does not take evasive action, the brakes are automatically applied to reduce impact damage or, if possible, prevent the collision. EyeSight is capable of avoiding a collision with a speed difference to the obstacle in front as high as 30 mph (48 km/h). However, not every situation under these conditions will result in full collision avoidance. Some of the functionality may be turned off by the driver and can be activated/deactivated via the instrument cluster controls but will reactivate at the next ignition cycle.

Adaptive cruise control with complete stop is a system that monitors traffic ahead and maintains the driver's selected speed and automatically reduces it to maintain a driver-selected following distance when the system detects a slower moving vehicle ahead. Adaptive cruise control is available at speeds up to 90 mph (145 km/h) and can bring the car to a stop in traffic. Forward collision warning remains active even when adaptive cruise control is turned off.

Lane departure warning identifies traffic lane markings. Audio and visual warnings will indicate if the vehicle path deviates from the lane and the turn signal is not on. The system is functional at speeds at or above 32 mph (51 km/h). The system may be deactivated by the driver but will reactivate at the next ignition cycle.

Lead vehicle start alert notifies the driver by means of an audible tone and the lead vehicle indicator on the multi-informational display when the driver's vehicle remains stopped after the vehicle in front has started to move forward. When the EyeSight-equipped vehicle has stopped within 32 feet of a stationary vehicle and both remain stopped for several seconds, this system will alert the driver of the EyeSight vehicle if his/her car remains stationary after the lead vehicle has moved 10 feet.

Rear-vision camera is an optical parking aid that uses a rear-facing camera mounted at the rear of the vehicle to show the area behind the vehicle on a central display screen. The image includes static distance/guidance lines to aid the driver in parking maneuvers. The display is activated when the reverse gear is engaged.

Rear Vehicle Detection uses radar sensors mounted inside the rear bumper cover to monitor the rear and side areas of a vehicle when in forward or rearward motion. The Rear Vehicle Detection system includes the following three features:

Blind spot detection alerts drivers to vehicles that are adjacent to them. If a vehicle has been detected in the monitored area behind and to either side of the vehicle, a warning light on the appropriate side mirror is illuminated and will flash if a turn signal is activated. The system is functional at speeds above 8 mph (13 km/h) and can be deactivated by the driver. At the next ignition cycle, it will be in the previous on/off setting.

Lane change assist alerts drivers to vehicles that are approaching in neighboring lanes. If a vehicle has been detected, a warning light on the appropriate side mirror is illuminated and will flash if a turn signal is activated. The system is functional at speeds above 8 mph (13 km/h) and can be deactivated by the driver. At the next ignition cycle, it will be in the previous on/off setting.

Rear cross traffic alert warns drivers about vehicles that are approaching from the side and may move into the path of the reversing vehicle. If a vehicle has been detected, a warning light flashes on the appropriate side mirror and an auditory warning is given. Vehicles with a rear-vision camera also receive a warning indication in the display. The system can be deactivated by the driver. At the next ignition, it will be in the previous on/off setting.

► Methods

Vehicles

The studied features—EyeSight, rear-vision camera, and Rear Vehicle Detection—are offered as optional equipment on various Subaru models. The presence or absence of these features is discernible from the information encoded in the Vehicle Identification Numbers (VINs). EyeSight is offered as optional equipment on several 2013–18 Subaru vehicles. Rear-vision camera is offered as optional equipment on some 2013–15 Subaru vehicles, and is a standard feature on 2016–18 Subaru vehicles. Rear Vehicle Detection is offered as optional equipment on several 2015–18 Subaru vehicles.

Three newer features, reverse automatic braking, steering responsive headlamps, and high-beam assist are offered as optional on some 2017–18 Subaru vehicles. As the presence or absence of the new features could also affect the insurance losses, to better understand the effectiveness of individual systems, these features are included in the regression models to separate out effects for the three studied features. Subaru vehicles without the six features served as the control vehicles in this analysis.

Rated drivers

The rated driver is the driver who is considered to represent the greatest loss potential for the insured vehicle. In a multiple-vehicle/driver household, how a driver is assigned to a vehicle can vary by insurance company and state. Information on the actual driver at the time of a loss is not available in the HLDI database. In the current study, the rated driver age groups are 24 and younger, 25–64, and 65 and older.

Table 1 lists the exposure (measured in insured vehicle years) for the age groups included in the analysis. Most of the exposure is for the 25–64 age group (70 percent), followed by 25 percent for drivers 65 and older, and 5 percent for the youngest age group (24 and younger).

| Age | Exposure |
|-------|-----------|
| 14–24 | 291,549 |
| 25–64 | 3,989,384 |
| 65+ | 1,397,068 |

Insurance data

Automobile insurance covers damages to vehicles and property in crashes plus injuries to people involved in the crashes. Different insurance coverages pay for vehicle damage versus injuries, and different coverages may apply depending on who is at fault. The current study is based on collision, property damage liability (PDL), bodily injury (BI) liability, personal injury protection (PIP), and medical payment (MedPay) coverages. Exposure is measured in insured vehicle years. An insured vehicle year is one vehicle insured for 1 year, two vehicles insured for six months, etc.

Because different crash avoidance features may affect different types of insurance coverage, it is important to understand how coverages vary among the states and how this affects inclusion in the analyses. Collision coverage insures against vehicle damage to an at-fault driver's vehicle sustained in a crash with an object or other vehicle; this coverage is common to all 50 states. PDL coverage insures against vehicle damage that at-fault drivers cause to other people's vehicle and property in crashes; this coverage exists in all states except Michigan, where vehicle damage is covered on a no-fault basis (each insured vehicle owner pays for their own damage in a crash, regardless of who is at fault).

Coverage of injuries is more complex. BI coverage insures against medical, hospital, and other expenses for injuries that at-fault drivers inflict on occupants of other vehicles or others on the road; although motorists in most states may have BI coverage, this information is analyzed only in states where the at-fault driver has first obligation to pay for injuries (33 states with traditional tort insurance systems). MedPay coverage, also sold in the 33 states with traditional tort insurance systems, covers injuries to insured drivers and the passengers in their vehicles, but not injuries to people in other vehicles involved in the crash. Seventeen other states employ no-fault injury systems (personal injury protection coverage, or PIP) that pay up to a specified amount for injuries to occupants of involved-insured vehicles, regardless of who is at fault in a collision. The District of Columbia has a hybrid insurance system for injuries and is excluded from the injury results.

Statistical methods

Regression analysis was used to quantify the effect of each vehicle feature by rated driver age while controlling for the other features and covariates. The covariates included calendar year, model year, garaging state, vehicle density (number of registered vehicles per square mile in the garaging zip code area), rated driver gender, rated driver marital status, deductible range (collision coverage only), and risk. For each safety feature studied, a binary variable was included.

Claim frequency was modeled using a Poisson distribution, whereas claim severity (average loss payment per claim) was modeled using a Gamma distribution. Both models used a logarithmic link function. Estimates for overall losses were derived from the claim frequency and claim severity models. Estimates for claim frequency, claim severity, and overall losses are presented for collision and PDL coverages. For PIP, BI, and MedPay coverages, three frequency estimates are presented. The first frequency is the frequency for all claims, including those that already have been paid and those for which money has been set aside for possible payment in the future, known as claims with reserves. The other two claim frequencies include only paid claims separated into low- and high-severity ranges. Note that the percentage of all injury claims that were paid by the date of analysis varies by coverage: 74.6 percent for PIP, 64.2 percent for BI, and 63.5 percent for MedPay. The low-severity range was less than \$1,000 for PIP and MedPay, less than \$5,000 for BI; high-severity covered all loss payments greater than that.

For space reasons, only the estimates for the individual crash avoidance features are shown on the following pages. To illustrate the analyses, however, the **Appendix** contains full model results for collision claim frequencies in age group 25–64. To further simplify the presentation here, the exponent of the parameter estimate was calculated, 1 was subtracted, and the resultant multiplied by 100. The resulting number corresponds to the effect of the feature on that loss measure. For example, the estimate of EyeSight effect on collision claim frequency for age group 25–64 was -0.0210 ; thus, for rated drivers 25–64, vehicles with EyeSight had 2.1 percent fewer collision claims than vehicles without EyeSight ($\exp(-0.0210) - 1 * 100 = -2.1$).

► Results

Full results for Subaru’s collision avoidance systems by rated driver age group are presented in **Tables 2–10**. For each system, there are three tables of results—one for each rated driver age group (14–24, 25–64, 65+). Results by rated driver age group for EyeSight are contained in **Tables 2–4**; rear-vision camera results are in **Tables 5–7**; and Rear Vehicle Detection results are in **Tables 8–10**. The lower and upper bounds represent the 95 percent confidence limits for the estimates. Estimates that are statistically significant at the 95 percent confidence level are bolded.

EyeSight system

Results for Subaru’s EyeSight system for rated drivers younger than 25 are summarized in **Table 2**. For vehicle damage losses, claim frequency was down for collision and PDL coverages by 5 and 21 percent, respectively. Both decreases were statistically significant.

For injury losses, EyeSight was associated with a significant 29 percent reduction to overall BI claim frequency among rated drivers under 25. MedPay showed essentially no change in claim frequency while PIP frequency increased by 16 percent but was not significant. Among low- and high-severity claims, the results were mixed, but BI liability claim frequencies continued to show reductions. However, the low-severity claim frequency for PIP showed a statistically significant increase.

Table 2: Change in insurance losses for EyeSight, for rated drivers younger than 25

| Vehicle damage coverage type | Lower bound | FREQUENCY | Upper bound | Lower bound | SEVERITY | Upper bound | Lower bound | OVERALL LOSSES | Upper bound |
|------------------------------|-------------|---------------|-------------|-------------|------------------------|-------------|-------------|-------------------------|-------------|
| Collision | -8.9% | -4.9% | -0.8% | -4.4% | 0.1% | 4.8% | -10.6% | -4.8% | 1.3% |
| Property damage liability | -25.6% | -20.7% | -15.6% | 0.4% | 6.7% | 13.4% | -22.5% | -15.5% | -7.7% |
| Injury coverage type | Lower bound | FREQUENCY | Upper bound | Lower bound | LOW-SEVERITY FREQUENCY | Upper bound | Lower bound | HIGH-SEVERITY FREQUENCY | Upper bound |
| Bodily injury liability | -41.1% | -29.1% | -14.7% | -40.1% | -16.8% | 15.5% | -54.9% | -38.1% | -15.0% |
| Medical payment | -17.5% | 0.2% | 21.6% | -58.1% | -31.5% | 12.2% | -22.7% | 3.1% | 37.4% |
| Personal injury protection | -1.1% | 15.5% | 35.0% | 1.4% | 38.7% | 89.7% | -7.1% | 16.5% | 46.0% |

Table 3 displays the results for Subaru’s EyeSight for rated drivers 25–64. Statistically significant reductions in claim frequency were estimated for vehicle damage coverages (2 percent for collision coverage and 19 percent for PDL coverage), while the claim severities were up slightly but insignificantly, resulting in a significant 17 percent decrease in overall losses for PDL and an insignificant 1 percent decrease for collision.

For injury losses, only BI liability showed statistically significant decreases for overall, low-, and high-severity claim frequencies. The overall BI claim frequency was down by 31 percent, while the low- and high-severity claim frequencies were down by 30 and 35 percent, respectively.

Table 3: Change in insurance losses for EyeSight, for rated drivers 25–64

| Vehicle damage coverage type | Lower bound | FREQUENCY | Upper bound | Lower bound | SEVERITY | Upper bound | Lower bound | OVERALL LOSSES | Upper bound |
|------------------------------|-------------|---------------|-------------|-------------|------------------------|-------------|-------------|-------------------------|-------------|
| Collision | -3.3% | -2.1% | -0.8% | -0.1% | 1.4% | 2.9% | -2.6% | -0.7% | 1.2% |
| Property damage liability | -20.3% | -18.5% | -16.8% | -0.4% | 1.6% | 3.8% | -19.6% | -17.2% | -14.7% |
| Injury coverage type | Lower bound | FREQUENCY | Upper bound | Lower bound | LOW-SEVERITY FREQUENCY | Upper bound | Lower bound | HIGH-SEVERITY FREQUENCY | Upper bound |
| Bodily injury liability | -35.1% | -30.7% | -25.9% | -38.0% | -30.0% | -20.9% | -42.3% | -35.3% | -27.4% |
| Medical payment | -2.4% | 3.1% | 8.8% | -6.1% | 8.2% | 24.7% | -1.3% | 6.8% | 15.6% |
| Personal injury protection | 0.3% | 5.0% | 9.9% | -4.8% | 5.0% | 15.8% | -2.0% | 4.4% | 11.3% |

Table 4 summarizes the results for Subaru’s EyeSight system for rated drivers 65 and older. PDL coverage showed statistically significant reductions to claim frequency (6 percent) and overall losses (5 percent). For collision coverage, claim frequency increased slightly whereas claim severity and overall losses were reduced. Only the result for claim severity was statistically significant.

For injury losses, overall BI claim frequency was associated with a significant 13 percent reduction. The low-severity BI claim frequency was down significantly by 18 percent while the high-severity claim frequency decreased by 13 percent but was not significant.

Table 4: Change in insurance losses for EyeSight, for rated drivers 65+

| Vehicle damage coverage type | Lower bound | FREQUENCY | Upper bound | Lower bound | SEVERITY | Upper bound | Lower bound | OVERALL LOSSES | Upper bound |
|------------------------------|-------------|--------------|-------------|-------------|----------|--------------|-------------|----------------|-------------|
| | Collision | -0.6% | 1.4% | 3.5% | -4.6% | -2.4% | -0.2% | -3.9% | -1.0% |
| Property damage liability | -8.8% | -6.0% | -3.1% | -1.8% | 1.2% | 4.2% | -8.8% | -4.9% | -0.8% |

| Injury coverage type | Lower bound | FREQUENCY | Upper bound | Lower bound | LOW-SEVERITY FREQUENCY | Upper bound | Lower bound | HIGH-SEVERITY FREQUENCY | Upper bound |
|----------------------------|-------------------------|-----------|---------------|-------------|------------------------|---------------|-------------|-------------------------|-------------|
| | Bodily injury liability | -21.4% | -12.6% | -2.9% | -32.7% | -18.3% | -1.0% | -27.0% | -12.8% |
| Medical payment | -7.7% | 1.6% | 11.8% | -27.5% | -5.3% | 23.6% | -6.7% | 6.3% | 21.1% |
| Personal injury protection | -12.4% | -5.0% | 3.0% | -19.3% | -2.8% | 17.2% | -18.7% | -9.5% | 0.8% |

Rear-vision camera

Results for Subaru’s rear-vision camera for rated drivers younger than 25 are shown in **Table 5**. For vehicle damage losses, claim frequencies were down for PDL by a statistically significant 12 percent and down slightly but insignificantly for collision by 2 percent.

For injury losses, claim frequency was lower for BI but not for PIP or MedPay, and none of the differences were statistically significant except for low-severity BI claims. The overall claim frequency for BI was down by 20 percent, and the low- and high-severity claim frequencies were down by 36 and 14 percent, respectively.

Table 5: Change in insurance losses for rear-vision camera, for rated drivers younger than 25

| Vehicle damage coverage type | Lower bound | FREQUENCY | Upper bound | Lower bound | SEVERITY | Upper bound | Lower bound | OVERALL LOSSES | Upper bound |
|------------------------------|-------------|---------------|-------------|-------------|----------|-------------|-------------|----------------|-------------|
| | Collision | -7.9% | -2.2% | 4.0% | -3.6% | 3.0% | 10.0% | -7.8% | 0.8% |
| Property damage liability | -18.8% | -12.0% | -4.7% | -5.3% | 2.2% | 10.3% | -19.5% | -10.1% | 0.4% |

| Injury coverage type | Lower bound | FREQUENCY | Upper bound | Lower bound | LOW-SEVERITY FREQUENCY | Upper bound | Lower bound | HIGH-SEVERITY FREQUENCY | Upper bound |
|----------------------------|-------------------------|-----------|-------------|-------------|------------------------|---------------|-------------|-------------------------|-------------|
| | Bodily injury liability | -36.5% | -20.2% | 0.4% | -57.9% | -35.9% | -2.5% | -41.2% | -14.2% |
| Medical payment | -18.5% | 6.7% | 39.9% | -51.0% | 0.7% | 106.9% | -25.6% | 9.2% | 60.1% |
| Personal injury protection | -9.4% | 14.0% | 43.5% | -21.9% | 24.3% | 97.8% | -14.2% | 19.1% | 65.3% |

Table 6 summarizes the results for Subaru’s rear-vision camera for rated drivers 25–64. For vehicle damage losses, claim frequencies showed a significant 2 percent increase for collision and a significant 8 percent decrease for PDL. Claim severities were up 2 and 3 percent for collision and PDL, respectively, but only the result for PDL was statistically significant, resulting in a significant 3 percent increase in overall losses for collision and a significant 5 percent decrease for PDL.

For injury losses, overall claim frequency was slightly lower for BI (2 percent) and essentially unchanged for PIP, while it was slightly up for MedPay (4 percent). None of the differences were statistically significant.

Table 6: Change in insurance losses for rear-vision camera, for rated drivers 25–64

| Vehicle damage coverage type | Lower bound | FREQUENCY | Upper bound | Lower bound | SEVERITY | Upper bound | Lower bound | OVERALL LOSSES | Upper bound |
|------------------------------|-------------|--------------|-------------|-------------|-------------|-------------|-------------|----------------|-------------|
| Collision | 0.1% | 1.7% | 3.4% | -0.4% | 1.5% | 3.4% | 0.7% | 3.3% | 5.9% |
| Property damage liability | -10.4% | -8.2% | -5.9% | 1.0% | 3.4% | 5.8% | -8.2% | -5.1% | -1.9% |

| Injury coverage type | Lower bound | FREQUENCY | Upper bound | Lower bound | LOW-SEVERITY FREQUENCY | Upper bound | Lower bound | HIGH-SEVERITY FREQUENCY | Upper bound |
|----------------------------|-------------|-----------|-------------|-------------|------------------------|-------------|-------------|-------------------------|-------------|
| Bodily injury liability | -8.9% | -2.0% | 5.3% | -19.2% | -8.2% | 4.3% | -11.3% | 0.1% | 13.0% |
| Medical payment | -3.2% | 3.7% | 11.0% | -14.3% | 2.1% | 21.6% | -1.7% | 8.7% | 20.2% |
| Personal injury protection | -6.0% | -0.4% | 5.6% | -11.6% | 0.2% | 13.6% | -5.8% | 2.1% | 10.7% |

Results for Subaru’s rear-vision camera for rated drivers 65 and older are summarized in **Table 7**. A significant 9 percent reduction in claim frequency was estimated for PDL coverage, while the claim severity was estimated to significantly increase by 8 percent, resulting in an insignificant reduction of 1 percent for overall losses. The collision claim frequency, severity, and overall losses were up slightly with the overall loss increase being significant.

For injury losses, the results were mixed, and none of them were statistically significant.

Table 7: Change in insurance losses for rear-vision camera, for rated drivers 65+

| Vehicle damage coverage type | Lower bound | FREQUENCY | Upper bound | Lower bound | SEVERITY | Upper bound | Lower bound | OVERALL LOSSES | Upper bound |
|------------------------------|-------------|--------------|-------------|-------------|-------------|-------------|-------------|----------------|-------------|
| Collision | -0.7% | 2.0% | 4.9% | -0.9% | 2.3% | 5.6% | 0.1% | 4.4% | 8.9% |
| Property damage liability | -12.2% | -8.7% | -5.0% | 4.0% | 8.0% | 12.3% | -6.6% | -1.3% | 4.2% |

| Injury coverage type | Lower bound | FREQUENCY | Upper bound | Lower bound | LOW-SEVERITY FREQUENCY | Upper bound | Lower bound | HIGH-SEVERITY FREQUENCY | Upper bound |
|----------------------------|-------------|-----------|-------------|-------------|------------------------|-------------|-------------|-------------------------|-------------|
| Bodily injury liability | -18.1% | -6.7% | 6.2% | -19.4% | 1.4% | 27.4% | -19.2% | 0.4% | 24.7% |
| Medical payment | -11.1% | 1.1% | 14.9% | -19.6% | 16.5% | 68.9% | -19.6% | -4.7% | 13.0% |
| Personal injury protection | -2.9% | 8.6% | 21.5% | -19.1% | 4.3% | 34.4% | -0.4% | 15.8% | 34.5% |

Rear Vehicle Detection

Table 8 displays the results for Subaru's Rear Vehicle Detection for rated drivers younger than 25. For vehicle damage losses, claim frequency for PDL decreased by 12 percent and the claim severity decreased by 3 percent, resulting in a 15 percent decrease for overall losses. The results for claim frequency and overall losses were statistically significant. Collision claim frequency and overall losses showed small insignificant decreases (5 and 2 percent, respectively), while the claim severity showed an insignificant 3 percent increase.

For injury losses, overall claim frequencies were lower than expected for all three injury coverage types, but none of them were statistically significant. Low-severity claim frequency for PIP showed a statistically significant 35 percent reduction.

Table 8: Change in insurance losses for Rear Vehicle Detection, for rated drivers younger than 25

| Vehicle damage coverage type | Lower bound | FREQUENCY | Upper bound | Lower bound | SEVERITY | Upper bound | Lower bound | OVERALL LOSSES | Upper bound |
|------------------------------|-------------|---------------|-------------|-------------|----------|-------------|-------------|----------------|-------------|
| | Collision | -9.4% | -4.8% | 0.0% | -2.2% | 3.2% | 8.9% | -8.6% | -1.7% |
| Property damage liability | -18.3% | -11.9% | -5.1% | -10.1% | -3.2% | 4.1% | -23.3% | -14.8% | -5.4% |

| Injury coverage type | Lower bound | FREQUENCY | Upper bound | Lower bound | LOW-SEVERITY FREQUENCY | Upper bound | Lower bound | HIGH-SEVERITY FREQUENCY | Upper bound |
|----------------------------|-------------------------|-----------|-------------|-------------|------------------------|-------------|-------------|-------------------------|-------------|
| | Bodily injury liability | -24.2% | -5.1% | 18.8% | -37.5% | -6.0% | 41.5% | -34.2% | -3.2% |
| Medical payment | -25.1% | -3.7% | 23.9% | -26.8% | 33.7% | 144.0% | -33.2% | -3.5% | 39.4% |
| Personal injury protection | -32.0% | -17.5% | 0.1% | -57.0% | -35.4% | -2.9% | -38.8% | -18.8% | 7.6% |

Table 9 summarizes the results for Subaru's Rear Vehicle Detection for rated drivers 25–64. For PDL, claim frequency was associated with a significant 7 percent reduction, and claim severity was essentially unchanged, resulting in a significant 7 percent reduction in overall losses. Collision claim frequency showed a small insignificant increase, while claim severity and overall losses showed small insignificant decreases.

Similarly, for injury losses, overall claim frequencies were lower than expected for all three injury coverage types, but none of them were statistically significant. Low-severity claim frequency for MedPay showed a statistically significant reduction of 25 percent.

Table 9: Change in insurance losses for Rear Vehicle Detection, for rated drivers 25–64

| Vehicle damage coverage type | Lower bound | FREQUENCY | Upper bound | Lower bound | SEVERITY | Upper bound | Lower bound | OVERALL LOSSES | Upper bound |
|------------------------------|-------------|--------------|-------------|-------------|----------|-------------|-------------|----------------|-------------|
| | Collision | -0.6% | 1.0% | 2.7% | -3.1% | -1.3% | 0.5% | -2.7% | -0.3% |
| Property damage liability | -9.2% | -6.8% | -4.3% | -2.8% | -0.3% | 2.3% | -10.4% | -7.0% | -3.5% |

| Injury coverage type | Lower bound | FREQUENCY | Upper bound | Lower bound | LOW-SEVERITY FREQUENCY | Upper bound | Lower bound | HIGH-SEVERITY FREQUENCY | Upper bound |
|----------------------------|-------------------------|-----------|-------------|-------------|------------------------|-------------|-------------|-------------------------|-------------|
| | Bodily injury liability | -13.1% | -5.7% | 2.3% | -23.2% | -10.6% | 3.9% | -12.0% | 1.4% |
| Medical payment | -11.0% | -4.2% | 3.1% | -38.4% | -24.8% | -8.2% | -19.1% | -9.9% | 0.2% |
| Personal injury protection | -7.5% | -1.8% | 4.3% | -7.7% | 4.9% | 19.2% | -11.2% | -3.4% | 5.2% |

Results for Subaru’s Rear Vehicle Detection for rated drivers 65 and older are summarized in **Table 10**. For PDL coverage, claim frequency was down by a statistically significant 6 percent, and claim severity was down slightly but insignificantly by 2 percent, resulting in a statistically significant 7 percent reduction in overall losses. For collision coverage, claim frequency, severity, and overall losses were slightly but insignificantly up.

For injury losses, overall claim frequencies were lower than expected for BI and MedPay, and higher for PIP, with none of the results being significant. Among paid claims, results were mixed and only the frequency for high-severity BI claims was significantly lower by 33 percent.

Table 10: Change in insurance losses for Rear Vehicle Detection, for rated drivers 65+

| Vehicle damage coverage type | Lower bound | FREQUENCY | Upper bound | Lower bound | SEVERITY | Upper bound | Lower bound | OVERALL LOSSES | Upper bound |
|------------------------------|-------------|--------------|-------------|-------------|----------|-------------|-------------|----------------|-------------|
| Collision | -1.1% | 1.8% | 4.8% | -1.7% | 1.6% | 5.1% | -1.0% | 3.4% | 8.1% |
| Property damage liability | -9.8% | -5.7% | -1.3% | -6.1% | -1.8% | 2.7% | -13.1% | -7.4% | -1.3% |

| Injury coverage type | Lower bound | FREQUENCY | Upper bound | Lower bound | LOW-SEVERITY FREQUENCY | Upper bound | Lower bound | HIGH-SEVERITY FREQUENCY | Upper bound |
|----------------------------|-------------|-----------|-------------|-------------|------------------------|-------------|-------------|-------------------------|-------------|
| Bodily injury liability | -25.5% | -12.3% | 3.3% | -13.7% | 19.0% | 64.0% | -48.7% | -32.7% | -11.7% |
| Medical payment | -20.5% | -7.6% | 7.4% | -30.6% | 6.6% | 63.8% | -26.5% | -9.7% | 11.0% |
| Personal injury protection | -4.6% | 7.9% | 22.0% | -19.3% | 6.6% | 40.6% | -1.8% | 15.4% | 35.7% |

Figures 1–3 display the changes in claim frequencies for Subaru collision avoidance systems across the rated driver age groups. The overall results in each figure are from the prior study (HLDI, 2019), and only the coverages with overall results being statistically significant are included.

Figure 1 shows the changes in collision, PDL, and BI liability claim frequencies for Subaru’s EyeSight by rated driver age. In general, the claim frequency for BI had the largest reduction in all age groups, followed by PDL. For collision, the youngest drivers benefited the most from the EyeSight system, with a significant 5 percent reduction in claim frequency. Prime age drivers (25–64) also benefited with a significant 2 percent reduction to collision claim frequency. Drivers 65 and older were associated with a slight, but not significant, increase in collision claim frequency. For PDL, reductions ranged from 6 percent for drivers 65 and older to 21 percent for drivers 24 and younger. Significant reductions were seen for all drivers regardless of age. For BI liability, the largest effect of EyeSight was observed for the rated drivers 25–64, with a significant 31 percent reduction in claim frequency, while the reduction in claim frequency for the youngest drivers followed (29 percent). For rated drivers 65 and older, the claim frequency for BI liability was 13 percent lower than expected. All reductions were statistically significant.

Figure 1: Change in claim frequency by rated driver age for EyeSight

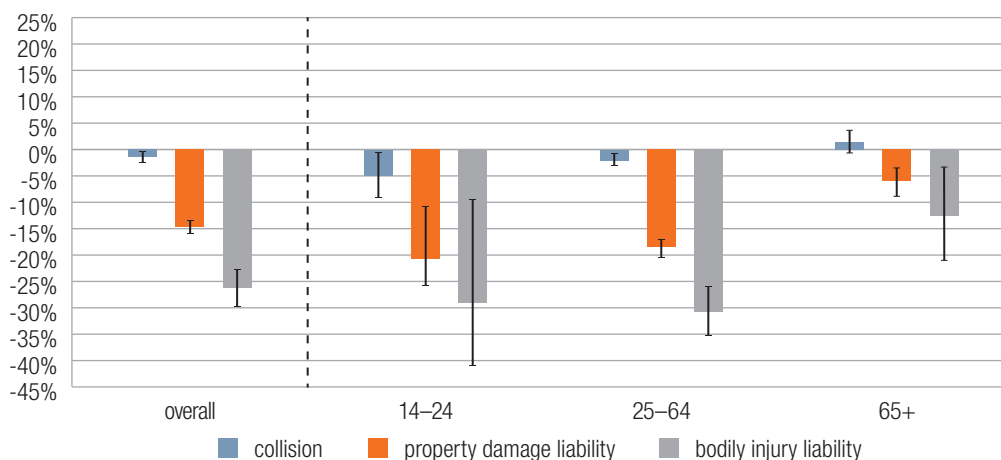


Figure 2 summarizes the changes in collision and PDL claim frequencies for Subaru’s rear-vision camera by rated driver age. For collision, the results suggested increases in claim frequency for all rated driver age groups except for rated drivers 24 and younger. Among the three age groups, only the result for the rated drivers 25–64 was statistically significant. For PDL, the rear-vision camera showed statistically significant benefits for all rated driver age groups. The youngest drivers were associated with the largest reduction (12 percent), while the frequencies for the older rated driver age groups (25–64, and 65 and older) showed similar reductions (8 and 9 percent, respectively).

Figure 2: Change in claim frequency by rated driver age for rear-vision camera

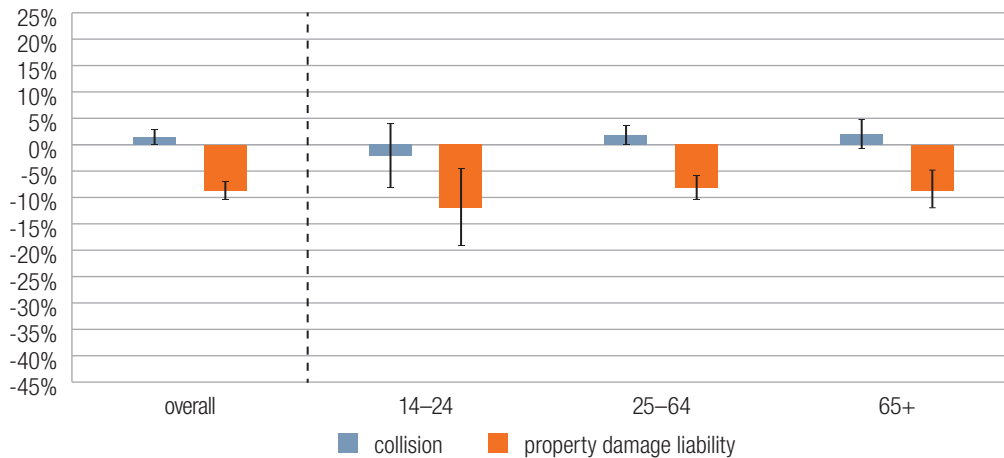
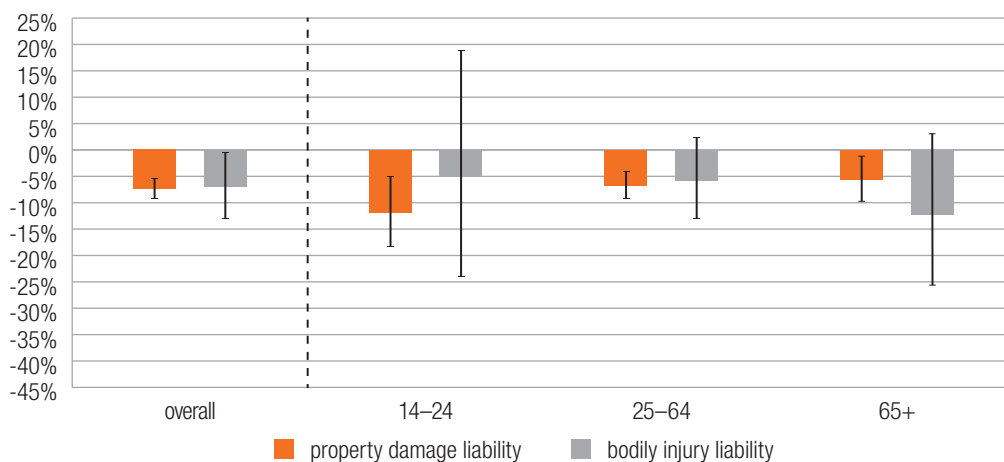


Figure 3 shows the changes in PDL and BI liability claim frequencies for Subaru Rear Vehicle Detection by rated driver age. For PDL, the benefits of Rear Vehicle Detection decreased with rated driver age. The reductions ranged from 12 percent for drivers 24 and younger to 6 percent for drivers 65 and older. All reductions were statistically significant. For BI, the benefits of Rear Vehicle Detection were similar for rated drivers under 65 (5–6 percent), while the claim frequency for rated drivers 65 and older showed a 12 percent reduction. None of the reductions were statistically significant.

Figure 3: Change in claim frequency by rated driver age for Rear Vehicle Detection



► Discussion

This is the first HLDI study evaluating the benefits of Subaru collision avoidance systems by rated driver age. The features analyzed in this study are EyeSight, rear-vision camera, and Rear Vehicle Detection. Subaru added three new optional features to 2017–18 model year vehicles (reverse automatic braking, steering responsive headlamps, and high-beam assist). However, as there is limited data available for these new features in each rated driver age group, especially for the youngest drivers, the analysis controlled for the effects of these systems, but the results were excluded from this report.

Subaru's EyeSight system was designed to assess the risk of a collision with leading traffic. The system includes four features: forward collision warning with autonomous braking, adaptive cruise control with complete stop, lane departure warning, and lead vehicle start alert. These features could prevent or mitigate front-to-rear crashes, which typically result in PDL and BI claims if an injury occurs in the struck vehicle. In prior HLDI studies of the Subaru EyeSight system (HLDI, 2018, 2019), large significant claim frequency benefits were observed for PDL and BI coverages.

The current study found benefits of the EyeSight system for all rated driver age groups, which is consistent with the 2019 HLDI study. However, the benefit was diminished for rated drivers over 65 compared with those under 65. The finding that the benefits of the EyeSight system diminished with driver age is consistent with prior HLDI research. A study on the Honda Accord forward collision warning and lane departure warning systems (HLDI, 2017) also found reduced PDL claim frequency benefits for older drivers. Earlier studies (HLDI, 2014) have also shown that younger drivers have higher claim frequencies, and they have more frontal crashes than drivers of other ages, which support the findings in this research that the younger drivers may benefit more from front crash prevention systems like EyeSight. However, the effects of EyeSight on the other three coverage types (collision, MedPay, and PIP) were mixed by rated driver age. In addition, the youngest rated driver age group (24 and younger) has the least exposure and the estimates have large confidence bounds.

Subaru rear-vision camera is a parking aid that can be activated when the reverse gear is engaged. Benefits were observed for all age groups for PDL claims, which is consistent with the prior study (HLDI, 2019). The PDL benefit for the youngest group (12 percent) was higher than the other two groups (8–9 percent). For collision claims, only the frequency for the youngest age group was estimated to decrease, while the frequency for the other two groups was estimated to increase.

Subaru's Rear Vehicle Detection is a combination of features that includes blind spot warning, lane change assist, and rear cross traffic alert. It could prevent incursion into an occupied adjacent lane that would be expected to result in a two-vehicle crash leading to a PDL claim against the encroaching driver. Benefits were observed for all age groups. The PDL benefits decreased with driver age, with all results being statistically significant. The BI benefit for the oldest age group (12 percent) was higher than the other two age groups (5–6 percent), but none of the results were statistically significant.

Overall, these results seem to imply that while advanced driver assistance systems benefit all drivers, it is the youngest and perhaps the riskiest drivers that benefit the most from these technologies.

► Limitations

There are limitations to the data used in this analysis. At the time of a crash, the status of a feature is not known. The features in this study can be deactivated by the driver, and there is no way to know how many, if any, of the drivers in these vehicles had manually turned off the system prior to the crash. However, surveys conducted by the Insurance Institute for Highway Safety indicate that large majorities of drivers with these types of systems leave them on (Reagan, Cicchino, Kerfoot, & Weast, 2018). If a significant number of drivers do turn these features off, any reported reductions may actually be underestimates of the true effectiveness of these systems.

Additionally, the data supplied to HLDI does not include detailed crash information. The specific crash types addressed by the different technologies cannot be isolated in these analyses. For example, it is not known how many of the crashes in the rear-vision camera analysis involved backing up, which is the only maneuver during which this camera is active. All collisions, regardless of the ability of a feature to mitigate or prevent the crash, are included in the analysis.

All of these features are optional and associated with increased costs. The type of person who selects these options may be different from the person who declines. While the analysis controls for several driver characteristics, there may be other uncontrolled attributes associated with people who select these features.

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► Appendix

| Appendix: Illustrative regression results — collision claim frequency in age group 25–64 | | | | | | | | | |
|--|--------------------------------|--------------------|----------|--------|----------------|----------------------------|---------|------------|---------|
| Parameter | | Degrees of freedom | Estimate | Effect | Standard error | Wald 95% confidence limits | | Chi-square | P-value |
| Intercept | | 1 | -9.1026 | | 0.0353 | -9.1719 | -9.0333 | 66328.90 | <0.0001 |
| Calendar year | 2012 | 1 | -0.0035 | -0.3% | 0.0490 | -0.0995 | 0.0925 | 0.01 | 0.9426 |
| | 2013 | 1 | 0.0998 | 10.5% | 0.0151 | 0.0702 | 0.1293 | 43.74 | <0.0001 |
| | 2014 | 1 | 0.1326 | 14.2% | 0.0100 | 0.1129 | 0.1523 | 174.45 | <0.0001 |
| | 2015 | 1 | 0.1282 | 13.7% | 0.0075 | 0.1135 | 0.1429 | 291.89 | <0.0001 |
| | 2016 | 1 | 0.1027 | 10.8% | 0.0062 | 0.0905 | 0.1149 | 273.09 | <0.0001 |
| | 2017 | 1 | 0.0604 | 6.2% | 0.0055 | 0.0496 | 0.0712 | 119.40 | <0.0001 |
| | 2018 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| Vehicle model year and series | 2014 Forester 4dr 4WD | 1 | -0.0404 | -4.0% | 0.0194 | -0.0784 | -0.0024 | 4.35 | 0.0370 |
| | 2015 Forester 4dr 4WD | 1 | -0.0293 | -2.9% | 0.0190 | -0.0666 | 0.0080 | 2.37 | 0.1234 |
| | 2016 Forester 4dr 4WD | 1 | 0.0119 | 1.2% | 0.0199 | -0.0271 | 0.0510 | 0.36 | 0.5491 |
| | 2017 Forester 4dr 4WD | 1 | 0.0116 | 1.2% | 0.0197 | -0.0271 | 0.0503 | 0.35 | 0.5562 |
| | 2018 Forester 4dr 4WD | 1 | 0.0002 | 0.0% | 0.0235 | -0.0459 | 0.0462 | 0.00 | 0.9945 |
| | 2015 Impreza 4dr 4WD | 1 | 0.3790 | 46.1% | 0.0249 | 0.3302 | 0.4278 | 231.53 | <0.0001 |
| | 2016 Impreza 4dr 4WD | 1 | 0.3776 | 45.9% | 0.0278 | 0.3232 | 0.4320 | 184.94 | <0.0001 |
| | 2017 Impreza 4dr 4WD | 1 | 0.3108 | 36.5% | 0.0309 | 0.2503 | 0.3713 | 101.48 | <0.0001 |
| | 2018 Impreza 4dr 4WD | 1 | 0.4032 | 49.7% | 0.0429 | 0.3191 | 0.4872 | 88.35 | <0.0001 |
| | 2015 Impreza station wagon 4WD | 1 | 0.2831 | 32.7% | 0.0215 | 0.2409 | 0.3253 | 172.69 | <0.0001 |
| | 2016 Impreza station wagon 4WD | 1 | 0.2947 | 34.3% | 0.0233 | 0.2490 | 0.3404 | 159.58 | <0.0001 |
| | 2017 Impreza station wagon 4WD | 1 | 0.3060 | 35.8% | 0.0247 | 0.2575 | 0.3544 | 153.20 | <0.0001 |
| | 2018 Impreza station wagon 4WD | 1 | 0.3126 | 36.7% | 0.0322 | 0.2494 | 0.3758 | 94.03 | <0.0001 |
| | 2013 Legacy 4dr 4WD | 1 | 0.1942 | 21.4% | 0.0221 | 0.1509 | 0.2375 | 77.16 | <0.0001 |
| | 2014 Legacy 4dr 4WD | 1 | 0.2003 | 22.2% | 0.0227 | 0.1559 | 0.2448 | 77.97 | <0.0001 |
| 2015 Legacy 4dr 4WD | 1 | 0.1804 | 19.8% | 0.0205 | 0.1402 | 0.2206 | 77.41 | <0.0001 | |
| 2016 Legacy 4dr 4WD | 1 | 0.2145 | 23.9% | 0.0222 | 0.1711 | 0.2579 | 93.75 | <0.0001 | |
| 2017 Legacy 4dr 4WD | 1 | 0.2774 | 32.0% | 0.0255 | 0.2275 | 0.3273 | 118.69 | <0.0001 | |
| 2018 Legacy 4dr 4WD | 1 | 0.2837 | 32.8% | 0.0369 | 0.2113 | 0.3561 | 59.00 | <0.0001 | |

Appendix: Illustrative regression results — collision claim frequency in age group 25–64

| Parameter | Degrees of freedom | Estimate | Effect | Standard error | Wald 95% confidence limits | Chi-square | P-value |
|-------------------------------------|--------------------|----------|--------|----------------|----------------------------|------------|---------|
| 2013 Outback station wagon 4WD | 1 | -0.0066 | -0.7% | 0.0198 | -0.0455 0.0323 | 0.11 | 0.7412 |
| 2014 Outback station wagon 4WD | 1 | -0.0083 | -0.8% | 0.0200 | -0.0475 0.0308 | 0.17 | 0.6767 |
| 2015 Outback station wagon 4WD | 1 | 0.0039 | 0.4% | 0.0194 | -0.0342 0.0419 | 0.04 | 0.8427 |
| 2016 Outback station wagon 4WD | 1 | 0.0499 | 5.1% | 0.0200 | 0.0108 0.0891 | 6.24 | 0.0125 |
| 2017 Outback station wagon 4WD | 1 | 0.0609 | 6.3% | 0.0228 | 0.0161 0.1056 | 7.11 | 0.0077 |
| 2018 Outback station wagon 4WD | 1 | 0.0697 | 7.2% | 0.0251 | 0.0205 0.1189 | 7.72 | 0.0055 |
| 2016 WRX 4dr 4WD | 1 | 0.3169 | 37.3% | 0.0225 | 0.2727 0.3611 | 197.58 | <0.0001 |
| 2017 WRX 4dr 4WD | 1 | 0.3947 | 48.4% | 0.0235 | 0.3487 0.4407 | 282.90 | <0.0001 |
| 2018 WRX 4dr 4WD | 1 | 0.4369 | 54.8% | 0.0300 | 0.3780 0.4957 | 211.67 | <0.0001 |
| 2015 XV Crosstrek station wagon 4WD | 1 | 0.0294 | 3.0% | 0.0208 | -0.0114 0.0702 | 1.99 | 0.1580 |
| 2016 XV Crosstrek station wagon 4WD | 1 | 0.0645 | 6.7% | 0.0205 | 0.0243 0.1048 | 9.88 | 0.0017 |
| 2017 XV Crosstrek station wagon 4WD | 1 | 0.0526 | 5.4% | 0.0285 | -0.0032 0.1084 | 3.42 | 0.0646 |
| 2018 XV Crosstrek station wagon 4WD | 0 | 0 | 0 | 0 | 0 0 | | |
| Rated driver age group | | | | | | | |
| 25–29 | 1 | 0.1876 | 20.6% | 0.0080 | 0.1719 0.2034 | 543.52 | <0.0001 |
| 30–39 | 1 | 0.0775 | 8.1% | 0.0068 | 0.0642 0.0909 | 129.08 | <0.0001 |
| 40–49 | 1 | 0.0673 | 7.0% | 0.0071 | 0.0535 0.0812 | 90.77 | <0.0001 |
| 50–59 | 1 | 0.0142 | 1.4% | 0.0068 | 0.0010 0.0275 | 4.42 | 0.0356 |
| 60–64 | 0 | 0 | 0 | 0 | 0 0 | | |
| Rated driver gender | | | | | | | |
| Male | 1 | -0.0362 | -3.6% | 0.0043 | -0.0445 -0.0278 | 71.26 | <0.0001 |
| Unknown | 1 | -0.1499 | -13.9% | 0.0229 | -0.1948 -0.1051 | 42.90 | <0.0001 |
| Female | 0 | 0 | 0 | 0 | 0 0 | | |
| Rated driver marital status | | | | | | | |
| Married | 1 | -0.1627 | -15.0% | 0.0046 | -0.1716 -0.1537 | 1273.96 | <0.0001 |
| Unknown | 1 | -0.0252 | -2.5% | 0.0209 | -0.0662 0.0158 | 1.45 | 0.2286 |
| Single | 0 | 0 | 0 | 0 | 0 0 | | |
| Risk | | | | | | | |
| Nonstandard | 1 | 0.2300 | 25.9% | 0.0116 | 0.2073 0.2526 | 396.43 | <0.0001 |
| Standard | 0 | 0 | 0 | 0 | 0 0 | | |
| State | | | | | | | |
| Alabama | 1 | 0.0021 | 0.2% | 0.0351 | -0.0668 0.0709 | 0.00 | 0.9532 |
| Alaska | 1 | 0.1260 | 13.4% | 0.0284 | 0.0704 0.1817 | 19.70 | <0.0001 |
| Arizona | 1 | 0.1062 | 11.2% | 0.0216 | 0.0638 0.1486 | 24.07 | <0.0001 |
| Arkansas | 1 | -0.0401 | -3.9% | 0.0349 | -0.1085 0.0283 | 1.32 | 0.2503 |
| California | 1 | 0.2660 | 30.5% | 0.0118 | 0.2429 0.2891 | 508.21 | <0.0001 |
| Colorado | 1 | 0.1204 | 12.8% | 0.0134 | 0.0942 0.1466 | 81.03 | <0.0001 |
| Connecticut | 1 | -0.0393 | -3.9% | 0.0159 | -0.0706 -0.0081 | 6.09 | 0.0136 |
| Delaware | 1 | -0.0113 | -1.1% | 0.0366 | -0.0830 0.0605 | 0.09 | 0.7583 |
| Dist of Columbia | 1 | 0.2411 | 27.3% | 0.0385 | 0.1658 0.3165 | 39.31 | <0.0001 |
| Florida | 1 | -0.0890 | -8.5% | 0.0164 | -0.1211 -0.0568 | 29.42 | <0.0001 |
| Georgia | 1 | -0.0715 | -6.9% | 0.0211 | -0.1128 -0.0301 | 11.47 | 0.0007 |
| Hawaii | 1 | 0.1288 | 13.7% | 0.0376 | 0.0550 0.2025 | 11.71 | 0.0006 |
| Idaho | 1 | -0.0680 | -6.6% | 0.0277 | -0.1222 -0.0137 | 6.03 | 0.0140 |
| Illinois | 1 | 0.0108 | 1.1% | 0.0148 | -0.0182 0.0398 | 0.53 | 0.4651 |

Appendix: Illustrative regression results — collision claim frequency in age group 25–64

| Parameter | Degrees of freedom | Estimate | Effect | Standard error | Wald 95% confidence limits | | Chi-square | P-value |
|-----------------------------------|--------------------|----------|--------|----------------|----------------------------|---------|------------|---------|
| Indiana | 1 | -0.0041 | -0.4% | 0.0212 | -0.0455 | 0.0374 | 0.04 | 0.8473 |
| Iowa | 1 | -0.1435 | -13.4% | 0.0301 | -0.2025 | -0.0846 | 22.76 | <0.0001 |
| Kansas | 1 | -0.0943 | -9.0% | 0.0308 | -0.1547 | -0.0340 | 9.38 | 0.0022 |
| Kentucky | 1 | -0.1915 | -17.4% | 0.0324 | -0.2551 | -0.1280 | 34.93 | <0.0001 |
| Louisiana | 1 | 0.0613 | 6.3% | 0.0361 | -0.0095 | 0.1320 | 2.88 | 0.0898 |
| Maine | 1 | 0.0274 | 2.8% | 0.0248 | -0.0212 | 0.0760 | 1.22 | 0.2686 |
| Maryland | 1 | 0.0375 | 3.8% | 0.0162 | 0.0056 | 0.0693 | 5.32 | 0.0210 |
| Michigan | 1 | 0.3424 | 40.8% | 0.0183 | 0.3065 | 0.3783 | 349.32 | <0.0001 |
| Minnesota | 1 | -0.0592 | -5.7% | 0.0172 | -0.0929 | -0.0256 | 11.89 | 0.0006 |
| Mississippi | 1 | 0.1025 | 10.8% | 0.0659 | -0.0266 | 0.2316 | 2.42 | 0.1197 |
| Missouri | 1 | -0.0817 | -7.8% | 0.0234 | -0.1275 | -0.0359 | 12.22 | 0.0005 |
| Montana | 1 | 0.0556 | 5.7% | 0.0323 | -0.0077 | 0.1189 | 2.96 | 0.0853 |
| Nebraska | 1 | -0.1369 | -12.8% | 0.0287 | -0.1932 | -0.0806 | 22.74 | <0.0001 |
| Nevada | 1 | 0.1139 | 12.1% | 0.0239 | 0.0670 | 0.1609 | 22.63 | <0.0001 |
| New Hampshire | 1 | 0.1568 | 17.0% | 0.0214 | 0.1150 | 0.1987 | 53.86 | <0.0001 |
| New Jersey | 1 | -0.0356 | -3.5% | 0.0144 | -0.0638 | -0.0074 | 6.12 | 0.0134 |
| New Mexico | 1 | 0.0428 | 4.4% | 0.0296 | -0.0152 | 0.1009 | 2.09 | 0.1483 |
| New York | 1 | 0.0909 | 9.5% | 0.0123 | 0.0668 | 0.1151 | 54.52 | <0.0001 |
| North Carolina | 1 | -0.2134 | -19.2% | 0.0184 | -0.2495 | -0.1773 | 134.42 | <0.0001 |
| North Dakota | 1 | 0.1652 | 18.0% | 0.0401 | 0.0866 | 0.2437 | 16.99 | <0.0001 |
| Ohio | 1 | -0.1845 | -16.8% | 0.0159 | -0.2157 | -0.1533 | 134.35 | <0.0001 |
| Oklahoma | 1 | -0.0480 | -4.7% | 0.0315 | -0.1098 | 0.0138 | 2.32 | 0.1276 |
| Oregon | 1 | 0.0110 | 1.1% | 0.0160 | -0.0203 | 0.0423 | 0.48 | 0.4902 |
| Pennsylvania | 1 | 0.0704 | 7.3% | 0.0126 | 0.0458 | 0.0950 | 31.41 | <0.0001 |
| Rhode Island | 1 | 0.1405 | 15.1% | 0.0280 | 0.0856 | 0.1954 | 25.14 | <0.0001 |
| South Carolina | 1 | -0.1693 | -15.6% | 0.0301 | -0.2283 | -0.1103 | 31.63 | <0.0001 |
| South Dakota | 1 | 0.0385 | 3.9% | 0.0434 | -0.0465 | 0.1235 | 0.79 | 0.3753 |
| Tennessee | 1 | -0.0241 | -2.4% | 0.0223 | -0.0679 | 0.0196 | 1.17 | 0.2788 |
| Utah | 1 | -0.0820 | -7.9% | 0.0201 | -0.1214 | -0.0427 | 16.70 | <0.0001 |
| Vermont | 1 | 0.0788 | 8.2% | 0.0272 | 0.0255 | 0.1321 | 8.41 | 0.0037 |
| Virginia | 1 | 0.0235 | 2.4% | 0.0148 | -0.0055 | 0.0525 | 2.52 | 0.1122 |
| Washington | 1 | 0.0456 | 4.7% | 0.0135 | 0.0191 | 0.0721 | 11.41 | 0.0007 |
| West Virginia | 1 | -0.1340 | -12.5% | 0.0249 | -0.1829 | -0.0851 | 28.86 | <0.0001 |
| Wisconsin | 1 | -0.0930 | -8.9% | 0.0180 | -0.1283 | -0.0577 | 26.65 | <0.0001 |
| Wyoming | 1 | -0.0230 | -2.3% | 0.0423 | -0.1059 | 0.0599 | 0.29 | 0.5874 |
| Texas | 0 | 0 | 0 | 0 | 0 | 0 | | |
| Texas | 0 | 0 | 0 | 0 | 0 | 0 | | |
| Deductible range | | | | | | | | |
| 0–250 | 1 | 0.1505 | 16.2% | 0.0053 | 0.1400 | 0.1609 | 797.71 | <0.0001 |
| 501–1000 | 1 | -0.3283 | -28.0% | 0.0065 | -0.3411 | -0.3154 | 2516.45 | <0.0001 |
| 1001+ | 1 | -0.7249 | -51.6% | 0.0330 | -0.7896 | -0.6601 | 481.52 | <0.0001 |
| 251–500 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| Registered vehicle density | | | | | | | | |
| 0–99 | 1 | -0.1029 | -9.8% | 0.0070 | -0.1166 | -0.0892 | 217.42 | <0.0001 |
| 100–499 | 1 | 0.1463 | 15.8% | 0.0050 | 0.1365 | 0.1562 | 848.46 | <0.0001 |
| 500+ | 0 | 0 | 0 | 0 | 0 | 0 | | |

Appendix: Illustrative regression results — collision claim frequency in age group 25–64

| Parameter | Degrees of freedom | Estimate | Effect | Standard error | Wald 95% confidence limits | | Chi-square | P-value |
|-------------------------------|--------------------|----------|--------|----------------|----------------------------|---------|------------|---------|
| Rear-vision camera | 1 | 0.0173 | 1.7% | 0.0084 | 0.0008 | 0.0338 | 4.21 | 0.0402 |
| EyeSight | 1 | -0.0210 | -2.1% | 0.0066 | -0.034 | -0.0081 | 10.11 | 0.0015 |
| Rear Vehicle Detection | 1 | 0.0101 | 1.0% | 0.0083 | -0.0061 | 0.0263 | 1.49 | 0.2221 |
| Reverse automatic braking | 1 | -0.0738 | -7.1% | 0.0220 | -0.1169 | -0.0308 | 11.30 | 0.0008 |
| Steering responsive headlamps | 1 | -0.0105 | -1.0% | 0.0186 | -0.0469 | 0.0259 | 0.32 | 0.5724 |
| High-beam assist | 1 | -0.0207 | -2.0% | 0.0231 | -0.0659 | 0.0246 | 0.80 | 0.3705 |



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