Consumer experiences with crash avoidance feature repairs

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Contents

Abstract

Introduction: The popularity of crash avoidance features is growing, but so too is confusion around how to repair them, how much repairs should cost, and who should pay for those repairs. This study's purpose was to capture how these issues are affecting consumers.

Method: Vehicle owners in the United States were surveyed online and by phone about their experiences repairing the front crash prevention (n = 359), blind spot detection (n = 317), and/or driver assistance cameras (n = 348) equipped on their personal vehicles.

Results: Owners tended to have multiple reasons for repairs. Repairs due to vehicle damage (i.e., a crash or windshield damage) corresponded with the greatest likelihood of post-repair issues, especially if calibration was performed, and higher out-of-pocket costs (possibly because of deductibles or other repair work). About half of respondents who had calibrations performed on features repaired because of vehicle damage reported persisting issues with the features after repair. Post-repair issues were more common for repairs performed at independent repairers than dealership service centers, yet similar feature calibration rates were reported for both types of repairers. More people went to dealership service centers than independent repairers, and these respondents were more likely to say they would return to this type of facility for a similar repair in the future. Although most repairers explained why repairs occurred, less than half of respondents said they completely understood the reasons given.

Conclusions: There are new complications in the repair cycle that are affecting consumers. Post-repair issues are more prevalent than previously assumed, regardless of the type of crash avoidance feature repaired.

Practical applications: Post-repair issues risk undermining consumer acceptance and the safety potential of critical features. Affordable and accessible centralized databases with repair and calibration specifications and instructions from the manufacturers would be a start to addressing industry-wide challenges.

Keywords: ADAS; crash avoidance; cameras; insurance; warranty; issues

1. Introduction

Advanced driver assistance systems (ADAS) are widespread in today's new vehicle market. The technologies that have clear safety benefits are known as crash avoidance features. Some of the more well-known and popular ones, such as front crash prevention, blind spot detection, and rearview cameras (Highway Loss Data Institute [HLDI], 2022), have been shown to significantly reduce relevant crashes (Cicchino, 2017a, 2017b, 2018). As with any product, these technologies are vulnerable to wear and tear over time, yet their effectiveness has been shown to continue even as a vehicle gets older (HLDI, 2015, 2020). However, crashes and vehicle damage still occur, which means that sometimes these features need to be repaired (TÜV Rheinland Presse, 2021). When a vehicle has repairs done to areas where these features' sensors or cameras are located (e.g., bumper or windshield), they will often require calibrating as part of the repair process even if the features themselves are undamaged (AAA Automotive, n.d.; Becker, 2017; Gotsch, 2022).

These repairs are often complex and costly to the consumer, the manufacturer, repairer, and the insurer (e.g., HLDI, 2019b). There is also confusion about how to fully restore feature functionality, how much the repairs should cost, and who should pay for the repairs (TÜV Rheinland Presse, 2021). Manufacturers specify the repair process (e.g., I-CAR, n.d.; National Automotive Service Task Force, n.d.), but those processes typically cost more than the repairers or insurers are prepared for (CCC Intelligent Solutions, 2022; Gotsch, 2022). Furthermore, there is growing evidence that following specified repair procedures does not guarantee full functional restoration (e.g., AAA Automotive, n.d.; Bellon, 2019), and onboard vehicle diagnostics are sometimes unable to detect and/or report malfunctions (Becker, 2017; I-CAR, 2018; Long, 2022).

Repairers—especially independent repair businesses (i.e., not associated with a manufacturer)—have said that manufacturers do not provide adequate information about the repair process and how to restore full functionality to affected features (CRASH Network, 2021; Risk Information Inc., 2022). It can take a significant amount of time to research manufacturer repair information and specifications, which often vary among individual repairs. Some of these repair processes also require access to facilities, training resources, tools, and software that are costly for repairers to obtain (AAA Automotive, n.d.; CRASH Network, 2021; Gotsch, 2022).

With the widespread confusion around the repair processes and related information and equipment access challenges, repairers sometimes have difficulty justifying the cost of the work required to follow the repair specifications provided by the manufacturers (CCC Intelligent Solutions, 2022; CRASH Network, 2021; Risk Information Inc., 2022). Insurers may also be reluctant to pay for labor or parts that do not make a practical difference to functional performance, even if they are prescribed by the manufacturer (Risk Information Inc., 2022). If insurance or warranty coverage is insufficient, then the consumer will have to bear out-of-pocket expenses for the repair (Edmonds, 2018). What's more, if the functionality of a crash avoidance feature is not fully restored, the safety benefits that have been ascribed to it will not be realized over the life of the equipped vehicle (AAA Automotive, n.d.). Worse is the possibility that consumers may unknowingly be put at risk when these systems are not properly repaired.

To date, there is limited research on how these issues ultimately contribute to consumer experiences with crash avoidance feature repairs. The goal of this study was to capture those experiences specific to repairs of front crash prevention, blind spot detection, and driver assistance cameras (e.g., parking assistance rearview cameras). This study focused on these three features because of their popularity in the North American vehicle market. As of May 1, 2018,

NHTSA requires that all new vehicles 10,000 lbs and under must have rearview cameras as standard (Federal Motor Vehicle Safety Standards; Rear Visibility, 2014). In addition, through a voluntary commitment by 20 manufacturers that represent more than 99% of the U.S. market, front crash prevention is expected to be standard equipped on the vast majority all new vehicles as of the production year that began in September 2022 (Insurance Institute for Highway Safety, 2016). Lastly, while not standard through mandate or voluntary agreement, blind spot detection is one of the most popular and positively rated crash avoidance features among consumers (J.D. Power, 2017).

2. Method

2.1. Procedure

This study consisted of a survey that was conducted during 2021. Registered owners of model year 2011 or newer vehicles in the United States were targeted using a mixed-mode strategy (online and by phone). Vehicles older than the 2011 model year were not of interest because front crash prevention, blind spot detection, and cameras were largely unavailable on earlier models (HLDI, 2022). Respondents who were contacted online came from the Lucid Marketplace platform, which hosts panel sources of likely owners of interest. The other respondents who were contacted by phone were identified through Data Axel's access to publicly available driver and vehicle records. IntegReview IRB determined this study to be exempt from review.

Respondents were first screened to verify that they owned a vehicle within the model year range of interest and equipped with front crash prevention, blind spot detection, and/or camera features. They were then asked whether any of those features had ever needed repair. Those who said at least one of their features had been taken in for repair were asked additional

questions about their repair experience (see Survey Instrument section below). If a person reported needing more than one feature repaired, they were asked about their experience with each feature's repair separately. It took respondents approximately 10 minutes to complete the full survey online and 9 minutes by phone.

2.2 Sample

A total of 18,463 individuals were invited to participate (n = 17,674 online and n = 789 by phone), but 13,999 refused and 1,403 were ineligible to participate. Among those who were ineligible to participate, 77 were under 18 years of age or refused to provide their age, 313 did not own an eligible vehicle or refused to provide their vehicle information, 809 did not have any of the features of interest, 34 were contacted after the survey quotas had been filled, 160 did not pass quality control criteria, and 10 did not complete the survey. The remaining 3,061 individuals who had been contacted to participate (n = 2,888 online and n = 173 by phone) confirmed that they owned vehicles from model year 2011 or later and equipped with one or more of the features of interest. Four hundred and ninety-six (n = 486 online and n = 10 by phone) of those individuals reported having had at least one of their features repaired at some point. Average respondent age of the final sample was 40 years (SD = 13, min = 18, max = 87).

Many of these respondents owned vehicles that were equipped with more than one feature of interest, and not every feature on those vehicles had needed repair: 35% (n = 174) of the sample had one feature repaired, 23% (n = 116) had two features repaired, and 42% (n = 206) had three features repaired. In total, 359 respondents had their front crash prevention repaired, 317 respondents had their blind spot detection repaired, and 348 respondents had their driver assistance cameras repaired. Some vehicles equipped with driver assistance cameras offer more than one view to the driver. Respondents who had camera-specific repairs were asked to confirm

the types of cameras that their vehicles had (they could indicate more than one type if applicable): 69% (n = 239) had rearview cameras, 42% (n = 147) had front-view cameras, 31% (n = 107) had sideview cameras, and 32% (n = 110) had surround (bird's-eye-view) cameras.

2.3 Survey instrument

Every respondent who owned a vehicle equipped with at least one feature of interest was asked whether it had ever needed to be repaired. The term "repair" can imply different things to people and so respondents were specifically asked whether they had brought their vehicle into a dealership service center, an independent repair shop, or a mechanic because of a problem with one of the features of interest or for another reason that resulted in the feature being worked on. Respondents were given examples of repair causes that meet the criteria: "This could have been because, for example, the windshield had to be replaced, the feature was behaving oddly, the vehicle had been in a crash, you were notified by the vehicle itself, or you received a recall notification from the manufacturer." Only those people who said they had brought their vehicle in for feature-specific repair or whose vehicles had undergone repairs to at least one of the features of interest were then asked questions about their most recent repair experience.

Respondents were asked how likely they would be to buy another vehicle equipped with that feature using a 5-point Likert scale (extremely unlikely, somewhat unlikely, neutral, somewhat likely, and extremely likely), and how they discovered that the feature needed repairing. Everyone was asked whether they had needed that feature to be repaired more than once, whether they had issues with their feature after the repair, how well it performed after the repair compared with the way it did before the repair, and whether a calibration had been performed on their feature.

People who identified crash damage or windshield replacement were asked how much their insurance paid toward the repair, and the rest were asked whether the repair had been under warranty. Everyone was asked how much they paid out of pocket for the repair, how satisfied they were with the cost using a 5-point Likert scale (not at all, slightly, moderately, very, extremely), and how long the repair took. Respondents were asked where they took their vehicle for repair (a dealership service center or an independent mechanic, service center, or repair shop) and how likely they would be to go back to the same place for a similar repair, again using a 5-point Likert scale (extremely unlikely, somewhat unlikely, neutral, somewhat likely, and extremely likely). In addition, they were asked whether the dealership or service staff had explained why the feature had needed repairing and, separately, whether they felt they understood why it needed repairing. Responses of "I don't know" or "refused to answer" for any survey items were excluded from analysis.

3. Results

3.1 Sample characteristics

The majority of the sample was middle-aged and male (Table 1). Many of these vehicles were relatively new, and most respondents were the original owners of their vehicles. Almost half of the vehicles that needed repairs to the front crash prevention (n = 169, 47%), blind spot detection (n = 145, 46%), or camera (n = 147, 42%) were model year 2019 or newer. Many vehicle owners said that a physical repair or software update/calibration had been done to their front crash prevention (n = 287, 80%), blind spot detection (n = 241, 76%), or camera (n = 259, 74%) during their most recent repair visit. Most respondents said that they were at least somewhat likely to buy another vehicle equipped with front crash prevention (n = 317, 88%), blind spot detection (n = 281, 89%), and/or cameras (n = 306, 88%) in the future.

Table 1. Sample demographics and vehicle ownership.

	N = 496
Gender	
Male	68%
Female	32%
Age	
18 to 34 years	29%
35 to 64 years	63%
65 years and older	9%
Original vehicle owner	
Yes	85%
No	14%
Unsure	1%
Vehicle model year	
2011 to 2014	13%
2015 to 2018	46%
2019 to 2021	41%

Note. Percentages may not sum to 100 due to rounding.

3.2 Reasons for repair

When asked about their most recent feature-specific repair experience, 60% of vehicle owners said they had received a vehicle recall or service bulletin—although fewer people brought their vehicle in for repair solely for that reason (front crash prevention: 18%; blind spot detection: 19%; camera: 20%). Many respondents identified several other reasons for feature-specific repair, including windshield replacement (which typically is the result of windshield damage or flaws), crash damage, unusual vehicle behavior, vehicle notification, and/or dealership staff recommendation (Table 2). It is important to note that none of the reasons for repair were mutually exclusive. For example, some people have brought their vehicle in because of crash damage that also required a windshield replacement (front crash prevention: 9%; blind spot detection: 13%; camera: 9%), while other vehicles required feature-specific repairs because

of a windshield replacement that was unrelated to a crash (front crash prevention: 26%; blind spot detection: 25%; camera: 25%) or because of crash damage that did not require windshield replacement (front crash prevention: 11%; blind spot detection: 9%; camera: 11%).

Table 2. How respondents discovered their feature needed repairing by feature type.

	Front crash prevention (*n* = 359)	Blind spot detection (*n* = 317)	Camera (*n* = 348)
Vehicle recall or service bulletin	60%	64%	59%
Windshield replacement	35%	38%	34%
Dealership/service staff recommended it	30%	27%	24%
Vehicle feature was behaving unusually or in ways that were unexpected	25%	32%	23%
Damaged from a crash	20%	22%	21%
Vehicle itself indicated that feature update or maintenance was required (through an error code, message, or icon lit up on the instrument cluster or center stack)	23%	18%	21%

Note. Respondents could select more than one response.

3.3 Post-repair issues

Over half of respondents said they had to have their front crash prevention (*n* = 212, 59%), blind spot detection (*n* = 196, 62%), or camera (*n* = 182, 52%) repaired more than once. When asked about their most recent repair experience, most people who had repairs due to crash damage or windshield damage or flaws said that they had issues with their features afterward (Table 3). The majority of respondents who had repairs for other reasons reported no problems afterward, although more than a third reported issues with their features after the repair.

Table 3. Percentage of respondents with feature issues after the repair by feature type.

	Front crash prevention	Blind spot detection	Camera
Among all respondents who had repairs:			
	(*n* = 359)	(*n* = 317)	(*n* = 348)
Yes	52%	57%	50%
No	47%	41%	48%
Among respondents who had repairs due to crash damage:			
	(*n* = 73)	(*n* = 70)	(*n* = 73)
Yes	73%	70%	70%
No	27%	29%	29%
Among respondents who had repairs connected with windshield replacement:			
	(*n* = 126)	(*n* = 120)	(*n* = 120)
Yes	64%	69%	71%
No	36%	29%	28%
Among respondents who had repairs not due to crash damage or connected with windshield replacement:			
	(*n* = 194)	(*n* = 167)	(*n* = 188)
Yes	40%	48%	35%
No	58%	51%	63%

Note. Percentages may not sum to 100 due to rounding. Missing values not shown.

Despite the prevalence of post-repair issues, fewer than 10% of respondents said their features performed worse after the repair (front crash prevention: *n* = 16, 4%; blind spot detection: *n* = 19, 6%; camera: *n* = 14, 4%). Most people said their features performed better after repair (front crash prevention: *n* = 255, 71%; blind spot detection: *n* = 239, 75%; camera: *n* = 245, 70%). The majority of the sample also said that their features had been calibrated during the repair (front crash prevention: *n* = 244, 68%; blind spot detection: *n* = 231, 73%; camera: *n* = 223, 64%). A greater percentage of people who had repairs due to crash damage (front crash prevention: *n* = 58, 79%; blind spot detection: *n* = 59, 84%; camera: *n* = 52, 71%) and windshield damage or flaws (front crash prevention: *n* = 96, 76%; blind spot detection: n = 94,

78%; camera: *n* = 83, 69%) said their features had been calibrated than the people who had repairs for other reasons (front crash prevention: *n* = 118, 61%; blind spot detection: *n* = 115, 69%; camera: *n* = 114, 61%).

Those individuals who said their features had been calibrated were more likely to report issues with their feature after repair than those people whose features had not been calibrated (Table 4). Among those who had calibrations performed on their features, a greater percentage of those who had repairs done because of crash damage or windshield damage or flaws reported having post-repair issues than those who needed repairs for other reasons.

Table 4. Percentage of respondents with feature issues after the repair by calibration and feature type.

	Front crash prevention		Blind spot detection		Camera	
Have you had issues with that feature after the repair?	Was calibration performed on the feature?					
	Yes	No	Yes	No	Yes	No
Among all respondents who had repairs:						
	(*n* = 244)	(*n* = 74)	(*n* = 231)	(*n* = 64)	(*n* = 223)	(*n* = 77)
Yes	61%	36%	66%	38%	68%	22%
No	39%	64%	32%	63%	31%	75%
Among respondents who had repairs due to crash damage:						
	(*n* = 58)	(*n* = 9)	(*n* = 59)	(*n* = 11)	(*n* = 52)	(*n* = 15)
Yes	81%	56%	76%	36%	85%	40%
No	19%	44%	22%	64%	15%	60%
Among respondents who had repairs connected with windshield replacement:						
	(*n* = 96)	(*n* = 26)	(*n* = 94)	(*n* = 23)	(*n* = 83)	(*n* = 33)
Yes	67%	58%	78%	39%	86%	42%
No	33%	42%	20%	61%	13%	55%
Among respondents who had repairs not due to crash damage or connected with windshield replacement:						
	(*n* = 118)	(*n* = 44)	(*n* = 115)	(*n* = 33)	(*n* = 114)	(*n* = 36)
Yes	51%	23%	57%	33%	52%	6%
No	49%	77%	43%	67%	46%	92%

Note. Percentages may not sum to 100 due to rounding. Missing values not shown.

3.4 Coverage, out-of-pocket cost, and duration of repair

Over two thirds of respondents who had a repair due to a windshield replacement or crash damage said their insurer covered the repair costs completely (Table 5). A similar pattern was observed for vehicle warranty coverage among respondents who had repairs for reasons other than windshield replacement or crash damage; however, a greater percentage of respondents who had camera repairs said they were not covered at all under the vehicle's warranty, compared with respondents who had the other two features repaired (Table 6). More people who had repairs due to windshield replacement or crash damage reported high out-of-pocket costs than the rest of the sample (Table 7). Nevertheless, most people were very or extremely satisfied with the out-of-pocket cost for their repairs, regardless of repair cause (Table 8).

Table 5. Degree to which repair was covered by insurance among respondents who identified crash damage or windshield damage/flaw as causes for their repair by feature type.

	Front crash prevention	Blind spot detection	Camera
Among respondents who had repairs due to crash damage:			
	(*n* = 73)	(*n* = 70)	(*n* = 73)
Not at all	3%	3%	4%
Partially	21%	19%	18%
Completely	74%	79%	74%
Among respondents who had repairs connected with windshield replacement:			
	(*n* = 126)	(*n* = 120)	(*n* = 120)
Not at all	< 1%	4%	8%
Partially	22%	22%	19%
Completely	76%	73%	73%

Note. Percentages may not sum to 100 due to rounding. Missing values not shown.

Table 6. Degree to which repair was covered by warranty among respondents who did not identify crash damage or windshield damage/flaw as causes for their feature repair by feature type.

	Front crash prevention (n = 194)	Blind spot detection (n = 167)	Camera (n = 188)
Not at all	6%	5%	14%
Partially	23%	20%	21%
Completely	71%	74%	62%

Note. Percentages may not sum to 100 due to rounding. Missing values not shown.

Table 7. Out-of-pocket cost for the repair.

	Front crash prevention	Blind spot detection	Camera
Among all respondents who had repairs:			
	(*n* = 359)	(*n* = 317)	(*n* = 348)
< $100	16%	15%	20%
$100 to < $200	10%	9%	14%
$200 to < $300	13%	13%	10%
$300 to < $400	19%	17%	16%
$400 to < $500	17%	20%	17%
$500 to < $1,000	18%	17%	17%
$1,000 or more	5%	8%	4%
Among respondents who had repairs due to crash damage:			
	(*n* = 73)	(*n* = 70)	(*n* = 73)
< $100	8%	11%	7%
$100 to < $200	8%	1%	8%
$200 to < $300	11%	10%	11%
$300 to < $400	25%	16%	26%
$400 to < $500	15%	21%	21%
$500 to < $1,000	25%	29%	23%
$1,000 or more	6%	11%	4%
Among respondents who had repairs due to windshield replacement:			
	(*n* = 126)	(*n* = 120)	(*n* = 120)
< $100	4%	8%	9%
$100 to < $200	11%	7%	8%
$200 to < $300	13%	11%	13%
$300 to < $400	22%	20%	20%
$400 to < $500	21%	25%	21%
$500 to < $1,000	23%	22%	25%
$1,000 or more	6%	8%	4%
Among respondents who had repairs not due to crash damage or windshield damage/flaw:			
	(*n* = 194)	(*n* = 167)	(*n* = 188)
< $100	25%	20%	29%
$100 to < $200	10%	11%	18%
$200 to < $300	12%	14%	8%
$300 to < $400	18%	15%	11%
$400 to < $500	15%	16%	14%
$500 to < $1,000	12%	13%	11%
$1,000 or more	4%	7%	3%

Note. Percentages may not sum to 100 due to rounding. Missing values not shown.

Table 8. Satisfaction with out-of-pocket repair cost by feature type.

	Front crash prevention	Blind spot detection	Camera
Among all respondents who had repairs:			
	(*n* = 359)	(*n* = 317)	(*n* = 348)
Not at all	2%	< 1%	2%
Slightly	4%	3%	8%
Moderately	13%	12%	14%
Very	29%	33%	26%
Extremely	52%	50%	48%
Among respondents who had repairs due to crash damage:			
	(*n* = 73)	(*n* = 70)	(*n* = 73)
Not at all	0%	1%	1%
Slightly	4%	4%	8%
Moderately	21%	9%	12%
Very	23%	26%	26%
Extremely	52%	60%	52%
Among respondents who had repairs due to windshield replacement:			
	(*n* = 126)	(*n* = 120)	(*n* = 120)
Not at all	1%	0%	0%
Slightly	5%	3%	6%
Moderately	11%	13%	8%
Very	30%	28%	29%
Extremely	53%	57%	58%
Among respondents who had repairs not due to crash damage or windshield replacement:			
	(*n* = 194)	(*n* = 167)	(*n* = 188)
Not at all	3%	1%	3%
Slightly	4%	3%	9%
Moderately	13%	12%	17%
Very	27%	37%	25%
Extremely	52%	45%	45%

Note. Percentages may not sum to 100 due to rounding. Missing values not shown.

On average, over two thirds of repairs took up to a day (front crash prevention: *n* = 257, 72%; blind spot detection: *n* = 214, 68%; camera: *n* = 255, 73%), less than a fifth took up to a week (front crash prevention: *n* = 51, 14%; blind spot detection: *n* = 53, 17%; camera: *n* = 41, 12%), less than 10% took up to a month (front crash prevention: *n* = 27, 8%; blind spot

detection: *n* = 22, 7%; camera: *n* = 21, 6%), and approximately 5% took over a month to be completed (front crash prevention: *n* = 18, 5%; blind spot detection: *n* = 18, 6%; camera: *n* = 17, 5%).

3.5 Repairers

More respondents went to a dealership service center than an independent mechanic, service center, or repair shop (Table 9). A greater percentage of those who went to an independent repairer reported that they had issues with their features after the repair compared with those who went to a dealership service center. Similar percentages of respondents said that the dealership and independent repairers had calibrated their features.

Table 9. Percentage of respondents who had post-repair issues and calibrations performed on their features by repairer and feature type.

	Front crash prevention		Blind spot detection		Camera	
	Whom did you go to for the repair?					
	Dealership	Independent	Dealership	Independent	Dealership	Independent
	(*n* = 242)	(*n* = 108)	(*n* = 210)	(*n* = 93)	(*n* = 221)	(*n* = 114)
Have you had issues with that feature after the repair?						
Yes	46%	70%	51%	74%	48%	57%
No	53%	30%	48%	25%	51%	42%
Was calibration performed on that feature?						
Yes	68%	73%	77%	72%	67%	64%
No	20%	20%	17%	24%	20%	26%

Note. Percentages may not sum to 100 due to rounding. Missing values not shown.

A slightly higher percentage of people who went to the dealership service center said they would be extremely likely to go back to the same facility for a similar repair to their front crash prevention (*n* = 150, 62%), blind spot detection (*n* = 137, 65%), or camera (*n* = 148, 67%)

compared with those who went to an independent mechanic, service center, or repair shop (front crash prevention: *n* = 56, 52%; blind spot detection: *n* = 43, 46%; camera: *n* = 58, 51%). While a staff member had explained to most people why their feature needed to be repaired (front crash prevention: *n* = 274, 76%; blind spot detection: *n* = 247, 78%; camera: *n* = 258, 74%), less than half of respondents said that they completely understood the reason (front crash prevention: *n* = 175, 49%; blind spot detection: *n* = 149, 47%; camera: *n* = 161, 46%).

4. Discussion

This study captured consumer experiences with crash avoidance feature repairs. The findings highlight many of the issues that the industry is facing around the repair processes for these increasingly popular technologies. Vehicle warranties often state that repairs should be performed with manufacturer parts and by manufacturer-certified technicians—to the frustration of some independent repairers (LaChance, 2021a, 2022). It is therefore not surprising that more people go to dealership service centers for feature-specific repairs and that those who go to independent repairers are more likely to report issues after repair. Although most repairers try to explain why features need repairing, many customers say that they do not fully understand the reasons given, which underscores the lack of transparency around these repair processes and the poor understanding that the public has about these technologies (McDonald et al., 2016; McDonald, Carney, & McGehee, 2018).

Even so, people tend to have multiple reasons for bringing their vehicle in for feature-specific repair. While the most common reason observed in this study was a vehicle recall or service bulletin, other reasons, such as windshield replacement, crash damage, and unusual feature behavior, were frequently mentioned too. In many instances, multiple crash avoidance features could have been repaired at once. This helps to explain why windshield replacement—

which typically affects the front crash prevention's windshield-mounted camera—was often cited as a reason for repair for blind spot detection and driver assistance cameras, as many of those people also identified crash damage as an associated reason for repair. Furthermore, many of the people who had gone in for repair because of crash damage (front crash prevention: 33%; blind spot detection: 27%; camera: 21%) and/or windshield replacement (front crash prevention: 40%; blind spot detection: 33%; camera: 38%) had been advised by dealership or service staff to have their features repaired. Whether that advice meant their features had to be physically repaired or just calibrated is unknown; however, calibration is becoming common practice for repairs when vehicle parts that house feature-specific hardware are removed, adjusted, or replaced (LaChance, 2021b). It is also unclear what the underlying causes were behind the unusual feature behavior that some people reported, but many vehicle owners who sought repair for that reason said that their features had been repaired more than once (front crash prevention: 71%; blind spot detection: 64%; cameras: 53%), which raises concerns about the quality and efficacy of those previous repairs.

Almost half of the vehicles in this survey were 2019 or newer, which would be expected as the number of new vehicles on the market with crash avoidance features, either as optional or standard equipment, has been growing substantially over the last few years (HLDI, 2022). Although vehicle age itself is unlikely to reduce the efficacy of these features (HLDI, 2015, 2020), repair rates will likely increase as more vehicles on the road have these technologies. What was not anticipated, though, was the frequency of issues that persist or develop after repair. Even though most people said that their features performed better after their most recent repair than before, many reported issues with their features afterward.

The persistence of issues after repair is worrying as most vehicle owners said that their features had been calibrated during their most recent repair. In fact, people who had repairs because of crash damage or windshield replacement were more likely to report post-repair issues, and more of their repairs involved calibration than people who had repairs for other reasons. Unfortunately, malfunctioning crash avoidance features are usually not as easily detectable as visible damage to the vehicle itself and perhaps calibrations are not being performed to specification, especially among independent repairers. As possible explanations for this, it has been reported that some repairers are failing to keep their calibration tools up to date with the latest software, verify vehicle alignment prior to calibration, address pre-existing codes from the vehicle scan prior to calibration, keep calibration equipment fully charged and clean, or keep the vehicle and its sensors clean (Becker, 2017; I-CAR, 2018; Long, 2022; Oakes, 2022).

Although technical support solutions exist to help repairers address calibration issues, they tend to be expensive and updated frequently, making it difficult for repairers to stay on top of relevant information in a financially viable manner. Sensor manufacturers often have comprehensive support for certain automakers that have implemented their technology, which is why many repairers have committed resources to specialize in servicing vehicles from specific automakers (Steckler, 2022). However, the required investment in equipment and frequent training on changing procedures remains prohibitive for many repairers, especially independent businesses. There is also an education component to this issue, as some repairers do not understand why the instructions for these processes are important (Whitney, 2021) or why the instructions sometimes subtly vary among models and model years from a single automaker (Croker, 2022). Another factor contributing to the issue is the fact that the scanning and calibration procedures are tedious and rigid in application. These observations help to explain

why repairers sometimes fail to follow the processes as specified by the manufacturers and why this study found that a greater percentage of people who went to independent repairers reported issues with their features after they were repaired. They also help explain repairer complaints that manufacturers are not making appropriate information and equipment accessible and inexpensive enough to facilitate comprehensive feature repair and calibration.

Although some vehicle owners who had repairs because of crash damage or windshield replacement reported higher out-of-pocket repair costs than the rest of the sample, most people reported being satisfied with their repair costs. Given that many of these individuals also said that their insurance had completely covered the repair, these out-of-pocket costs may have been deductibles under their automobile collision or comprehensive insurance coverage (HLDI, 2019a). Another possible reason for out-of-pocket costs could be that other vehicle repair work unrelated to the crash avoidance feature was performed at the same time.

4.1 Limitations and future considerations

Although this study was a survey of consumer experiences, these data do not represent a census of how prevalent feature repairs are among the registered fleet nor of how many repaired vehicles are operating with unrestored functionality. It is also unknown how many participants ultimately had their feature issues resolved. In addition, these results do not reflect a comprehensive list of all possible reasons for repairs or the nature and scope of post-repair issues. Even though the data suggest that feature calibration during the repair process seems to correspond with post-repair issues, this study was unable to verify whether calibrations were actually performed during the repairs, which limits the conclusions that can be drawn about the nature of calibration-specific issues. While this survey connects consumer experiences to the

complaints that manufacturers, repairers, and insurers have, many of the underlying causes behind those issues remain unclear.

It also is an open question how post-repair issues influence feature use and what the safety consequences are when people use features that have not been fully restored. Even though this study found that most people who had a feature repaired are still willing to buy another vehicle with similar technology, enthusiasm was not universally high among respondents. Some said they were unlikely to buy a vehicle with these features again (front crash prevention: 7%, blind spot detection: 5%; camera: 7%). Rearview cameras and front crash prevention are now standard on the vast majority of new vehicles, but blind spot detection is not, and the limited interest among people who have had these features repaired it is worrying. A driver who does not value a technology will not use it, even if it is equipped on their vehicle (Reagan, Cicchino, Kerfoot, & Weast, 2018). Refusal to purchase vehicles equipped with crash avoidance features and/or use them will eliminate the safety benefits that the technology has. On the other hand, faulty performance can elevate the driver's crash risk, such as with phantom braking by front crash prevention on high-speed roadways (see NHTSA, 2019). Consumer skepticism is understandable if people have had negative experiences of the technology not working properly.

4.2 Conclusions

This study confirms that there are new complications in the general repair process that are affecting consumers and their vehicles once they return to the road. Many consumers say that they have had to have these features repaired more than once. Complaints persist, regardless of whether the feature repaired was front crash prevention, blind spot detection, or a driver assistance camera. Feature repairs because of vehicle damage seem to have the highest likelihood of post-repair issues, especially if a calibration was performed, and higher out-of-pocket costs;

however, those repairs are also likely to be covered by insurance, and people are generally satisfied with the out-of-pocket cost. Nevertheless, if post-repair issues become more frequent as more vehicles on the road have the features equipped, the inconvenience and potential safety implications will undoubtedly undermine consumer confidence in the technology. Waning consumer acceptance of these established vehicle safety features will have adverse consequences for the industry and for traffic safety.

5. Practical applications

Vehicle repairs are now more complex than ever. Repairers, insurers, and manufacturers face significant hurdles when it comes to repairing crash avoidance features. Crash avoidance feature equipment size and location vary widely based on vehicle model, model year, and class, which means that having repair processes standardized across the market (or even within an automaker) is an unrealistic goal for the near term (Long, 2022). One of the challenges repairers face is the need to subscribe to numerous information services to gain access to repair instructions for various manufacturers. There are solutions that would help to improve the repair, warranty, and insurance processes tremendously, such as manufacturers simplifying scanning and calibration procedures and the establishment of a centralized database with repair and calibration specifications and instructions from the manufacturers for individual crash avoidance features by vehicle model and model year. Regrettably, as of right now, accessible and inexpensive databases with comprehensive repair information for the modern vehicle fleet are out of reach for most technicians.

Another part of the solution to aid repairers may involve more comprehensive self-diagnostic communication strategies. Similar strategies already exist for various vehicle systems. Some participants in this study even said that they had discovered the need for their crash

avoidance features to be repaired because their vehicles had alerted them. Our recommendation would be for comprehensive self-diagnostic strategies for these technologies that could function similarly to the way a tire pressure monitoring system gives a notification when it detects that one or more of the vehicle's tires has low pressure. Such mechanisms could help repairers verify whether their repairs were successful.

Unfortunately, it is unknown how many of our respondents ultimately obtained a resolution to their reported post-repair issues. It is also unclear whether their issues reflected safety concerns or just annoyances. What this study has shown is that there is an immediate need to measure how significant the problem is around reduced feature efficacy among repaired vehicles compared with those that have never needed repair. If a significant proportion of the registered vehicle fleet has nonworking crash avoidance features, then the full expected safety benefits of the technology may never materialize and consumers may be unknowingly at risk.

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