Are Drivers Becoming Over reliant and More Risk-Prone? Assessing the Impact of New Vehicle Design Features in Transportation Safety

Research Background and Problem Statement

Road traffic crashes and their consequences remain a global health concern given the extent of societal, emotional and economic impacts of these unfortunate events. According to a recent report by NHTSA (NHTSA, 2022), road traffic crashes are responsible for 39,508 fatalities in the United States and human error stands as the primary cause (94%) for these tragic occurrences (Bucsuházy et al., 2020). Irresponsible driving behaviors including speeding, distraction, aggressiveness and poor decision making, are some of the major examples of such human errors leading to a substantial number of traffic fatalities in US (Hamid and Ishak, 2023). In this context, the advancement of vehicle technologies offers a promising avenue for enhancing road safety. One of the most popular and widely available forms of this advancement is the Advanced Driver Assistance Systems (ADAS). Having features like Blind Spot Detection, Lane Keeping Assist, Adaptive Cruise Control, and Pedestrian detection, ADAS represents the initial step towards the realization of fully autonomous vehicles. These systems provide warnings and automate certain tasks, thus reducing risk of hazardous situations and increasing driving comfort. For instance, Lane Keeping Assist system provides assistance in keeping vehicles within their lanes, while Blind Spot Detection system alerts drivers of nearby lane vehicles they might miss seeing and prevents potential side collisions. Emergency braking is another key component that allows systems to detect impending accidents and apply brakes quickly or even proactively in order to reduce impact or avoid it altogether. Together, these technologies offer the potential to significantly reduce human error by providing high levels of automation or eliminating the need for human intervention in driving altogether.

Numerous studies have estimated and reported the benefits of such vehicular technologies in reducing crashes (Li et al., 2017; Masello et al., 2022; Newstead et al., 2020). But what's rarely being looked at is whether these technologies could actually encourage aggressive driving behaviors, thus causing indirect crash risk to the people who don't have these systems in their cars. This phenomenon is illustrated by the *Peltzman effect*, which postulates that enhanced safety measures can lead to compensatory behavior that cancels out the benefits. In the context of vehicles with advanced technologies, this effect suggests that drivers may become overly dependent on these systems, potentially engaging in riskier behaviors under the assumption that the technology will protect them from the consequences. Further, the variability in the usage and availability of these technoglies across different vehicles presents another significant challenge. Not all vehicles are equipped with the same level or type of ADAS technologies, leading to a diverse range of safety features on the road. As a result, the risky behavior posed by drivers in ADAS-equipped vehicles can create an indirect crash risk for those in vehicles without such systems. For example, consider a scenario where a driver operates a vehicle endowed with an emergency braking system. Trusting in the reliability of this technology, the driver might maintain a shorter following distance to the vehicle ahead, believing that the system will adequately compensate by stopping the vehicle promptly in case of a sudden halt. This behavior increases the risk of an accident, especially if the vehicle behind does not have similar safety features and cannot stop as quickly. This is not merely a hypothesis; the trend becomes evident if we look at some relevant research findings. A recent study by Insurance Institute for Highway Safety (IIHS, 2021) suggests that use of adaptive cruise control increase the speeding tendency among drivers and thus raising the risk of fatal crashes. Further, Gajera and his colleagues

(Gajera et al., 2022) found that car equipped with ADAS were more likely to collide with non-motorists as driver exhibit unsafe driving behaviors due to their over-resilience on the ADAS technologies. These findings to some extent might explain the recent surge in aggressive driving incidents observed in certain regions (13% increase in Florida). Although not all incidences can be attributed to the technology, but there is a clear indication that the proliferation of ADAS has influenced our driving behaviors to some extent. Therefore, it is critical to investigate whether there is a connection between ADAS technologies and driving behaviors, and if so, how these technologies are influencing the drivers. Understanding this dynamic is cruicla to ensure that ADAS deployment effectively enhances road safety without unintentionally encouraging riskier driving practices. To that extent, the objective of this research is twofold:

- *To analyze the trend of aggressive driving behaviors in relation to the adoption and use of Advanced Driver Assistance Systems (ADAS).*
- *To understand the behavioral patterns of drivers with ADAS technologies, particularly focusing on if and how reliance on these systems affects their driving decisions and overall safety awareness.*

Research Approach

This study will utilize a mixed-method approach combining both quantitative analysis and qualitative insights to offer a comprehensive understanding into the relationship between ADAS technology in vehicles (vehicular safety features) and the occurrence of aggressive driving behaviors. The research effort will start with a comprehensive literature review, uncovering the current state of research and recognizing areas where further understanding is needed regarding the effects of ADAS on driving behaviors. This assessment will provide a solid foundation for the subsequent research phases to build upon. Following these initial steps, our research approach is organized along two major directions (see Figure 1):

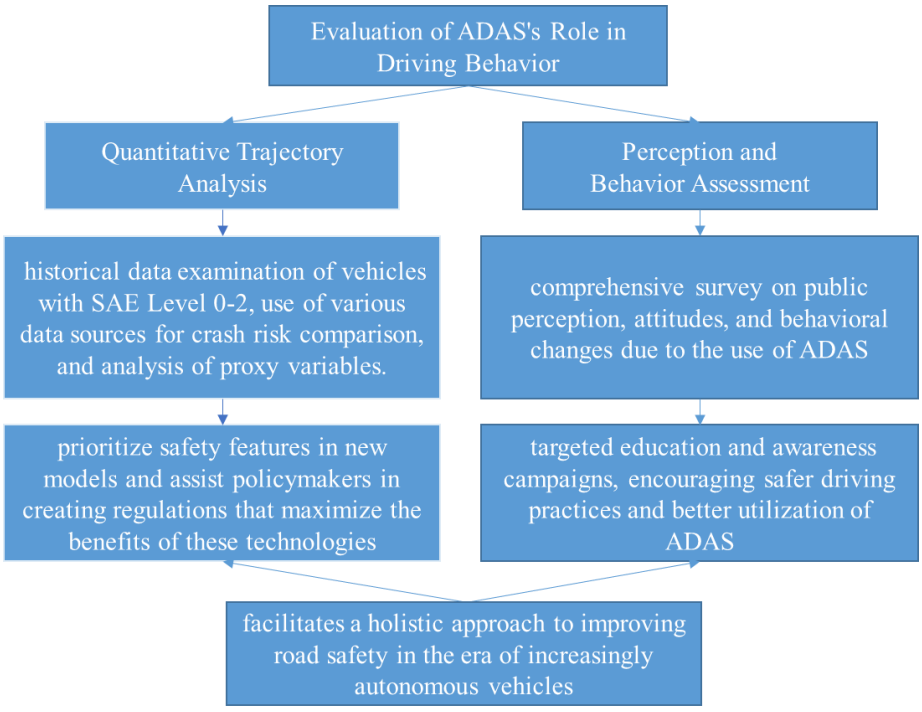


Figure 1: Overview of the Research Vision

The first direction of research will focus on a data-driven quantitative analysis through a historical examination of vehicles equipped with SAE (Society of Automotive Engineers) Level 0-2 features, such as lane assist and blind spot indicators. The analysis aims to compare the crash risk as well as the corresponding injuries associated with these early autonomous technologies against traditional vehicles without such features. By examining these trends, we intend to understand how the integration of initial vehicular technologies influences crash risk, providing insights into the evolving safety landscape as we progress towards a more automated driving environment. Moving forward, our analysis will focus on different proxy variables to supplement driving behavior data. This involves a detailed examination of the impact of ADAS on braking patterns, vehicle speed variations, and the frequency of emergency braking incidents. Furthermore, we will examine the temporal and spatial dynamics of the relationship between ADAS and driving behavior trends. With regard to temporal analysis, we will evaluate data spanning multiple years, enabling us to understand how the adoption and evolution of ADAS may have influenced driving behaviors and safety outcomes over time. Regarding spatial analysis, we will assess data from various locations to determine if there are differences in how ADAS affects driving behavior in different regions. Specifically, we aim to discover if areas with a higher incidence of aggressive driving linked to ADAS and, conversely, if there are regions where such behaviors are less prevalent. Should we identify variations, we will explore the factors contributing to these differences. This could provide insights into why some locations might experience more benefits from ADAS technologies than others. This preliminary analysis will not only offer insights into the influence of ADAS on driving behavior, but also serve as a foundation for forecasting future trends and devising strategies for the transition towards greater integration of CAVs in a mixed environment. In terms of data, we will explore a variety of databases, such as the Crash Report Sampling System (CRSS), Fatality Analysis Reporting System (FARS), and National Highway Traffic Safety Administration (NHTSA). Each of these data sources provides information on the Vehicle Identification Number (VIN), a crucial element in identifying vehicles equipped with modern smart features. Based on this, we will create a fused database combining information from multiple data sources for our analysis. Further, we will look into Highway Safety Information System (HSIS) database which is a multistate database that provides linkable data on crashes, roadway inventory and traffic volumes. Within HSIS, the state of OHIO provides VIN information (up to 2018) which could be an additional data source for our analysis. Additionally, the research team will also explore other data sources like Insurance Institute for Highway Safety (IIHS) and Naturalistic Driving Study (NDS) data to enhance the investigation further.

In the second direction of the study, we will develop and administer a comprehensive survey to gain a more in-depth understanding of public perceptions, attitudes, and behavioral shifts concerning Advanced Driver Assistance Systems. Key components of the survey will include questionnaires related to: a) Driver’s Understanding, Perceptions, and Trust in ADAS b) Behavior Shift Due to ADAS and c) Demographic information. The first section of the survey is intended to explore individuals' comprehension and perceptions of ADAS technology. Questions will focus on drivers' awareness, engagement with, and attitudes toward a variety of ADAS technologies. Participants will be asked about the ADAS features they regularly use, their level of trust in these systems under different driving conditions, and whether or not they consistently enable/disable specific functions. The aim is to investigate drivers' knowledge and trust levels regarding ADAS technologies, as these variables significantly impact their willingness to depend

on these features while driving. The next section of this survey (Behavior Shift Due to ADAS) will explore the influence of ADAS on driving behavior. Here, participants will be asked about their experiences with ADAS systems in various driving contexts, like whether Adaptive Cruise

Drivers' Understanding, Perceptions and Trust in ADAS	Behavioral Shift Due to ADAS
• Which ADAS features are you aware of and have used in your vehicle? (e.g., Lane Keeping Assist, Automatic Emergency Braking, Adaptive Cruise Control) • On a scale of 1 to 10, how much do you trust ADAS technologies to work correctly under various driving conditions? • Do you usually keep all available ADAS features activated in your vehicle? If not, please specify which ones you prefer to deactivate and why.	• With Adaptive Cruise Control activated, do you find yourself driving at higher speeds than you normally would? • Has the Blind Spot Detection system influenced how you perform lane changes in heavy traffic? • How does the presence of ADAS technologies like Automatic Emergency Braking affect your following distance on highways?

Control encourages them to drive at higher speeds and/or Blind Spot Detection alters their lane-changing practices. The objective is to determine if and how the presence and use of ADAS influence drivers towards more aggressive driving behaviors and to understand the underlying reasons for this trend (overreliance or perceived increased safety benefits). The final part of the survey will include questions about demographics details of the participants like age, gender, employment, education, vehicle type and location to understand how different population segments perceive and interact with such vehicular features. For example, we might find younger drivers having more trust in ADAS technologies compared to older drivers, or individuals with higher educational levels might have a different understanding of these systems. Understanding this variation of ADAS use and misuse across different groups will allow us to tailor our educational and safety initiatives more effectively. The survey will be deployed through various platforms, including social media and email campaigns, to ensure a diverse and representative sample of drivers across different demographics.

Research Impact

In summary, this study seeks to bridge a significant gap in existing literature by examining the potential link between ADAS and aggressive driving behavior, and if present, to delve into the nature of this relationship. By identifying the specific aspects of ADAS that may inadvertently encourage riskier driving practices, the research could serve as a critical resource for the Department of Transportation (DOT) in evaluating current regulations and guidelines regarding ADAS-equipped vehicles. For example, the quantitative trajectory analysis might reveal a decrease in frontal collisions for vehicles equipped with Forward Collision Warning (FCW) systems, highlighting the system's potential to improve road safety. On the other hand, through perception and behavior assessment, we might discover that drivers become overly confident when using FCW, leading them to increased tailgating habits. By merging insights from both research directions, the current study aims to identify and mitigate potential negative impacts of ADAS. This could involve creating targeted interventions that adjust user perceptions to a more accurate understanding of what ADAS can and cannot do, alongside technological enhancements designed to ensure that ADAS features truly improve road safety rather than detracting from it.

Therefore, the findings of this study have the potential to significantly contribute to road safety, aligning with the DOT's goal of reducing, and ideally eliminating, traffic-related fatalities and injuries.

Research Team

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Dr. Bhowmik will serve as the principal investigator of the project, working closely with his graduate student, Mr. Pabitra Kumar Roy. Together, they will oversee the research's direction, ensuring that the team adheres to the project's objectives and timelines.

Dr. Bhowmik has extensively worked on developing data-driven quantitative approaches including econometric models and optimization techniques to uncover causal relationships within the transportation safety and address different transportation safety related issues. The road safety issues that he have addressed can broadly be categorized as: (1) crash severity analysis, (2) crash frequency analysis, (3) real-time crash risk analysis and (4) road user behavior from safety perspective. Throughout his academic journey, he worked on several funded projects from the National Cooperative Highway Research Program (NCHRP), National Science Foundation (NSF), Florida Department of Transportation (FDOT), Federal Highway Administration (FHWA), and the Smart City Research Program. His scholarly endeavors have resulted in the authorship or co-authorship of over 65 scientific articles, published in premier transportation safety journals (33) and conference proceedings (34).

Conflict of Interest

There is no financial or other conflict of interests to declare.

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