Connected and Automated Vehicles Attitudes and Perceptions

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16. Abstract

With the potential for imminent adoption of Connected and Automated Vehicle (CAV) technologies in the near future, the Wisconsin Department of Transportation (WisDOT) is invested in exploring and implementing these emerging transportation technologies to make roadways safer and more efficient. Since CAV technology is still under development, market penetration is still low and the general population's exposure has been minimal. Most knowledge about the public's attitudes on CAVs have stemmed from national surveys and small-scale pilots. Despite the variety of methods and surveys deployed in the U.S. to study CAVs, currently little is known about Wisconsin specific attitudes towards them. This work presents the results of a detailed study of the Wisconsin public's understanding of CAVs through a large-scale (N=915) survey. The results include Wisconsinites' acceptance of early testing; their perceived benefits, drawbacks, and barriers to CAV implementation; and the implications for potential WisDOT action.

Results indicate that Wisconsinites were generally willing to share the road with vehicles equipped with advanced driver-assistance systems (ADAS), were moderately comfortable with connected vehicle (CV) technologies, and not comfortable with automated vehicle (AV) systems. Results for willingness to use CAVs saw the same order of technology preference as comfort sharing the road. An exploratory factor analysis and latent class cluster analysis were conducted and yielded six factors and 5 latent clusters. These factors and clusters were used to create profiles of the Wisconsin population and document their attitudes and attributes.

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Executive Summary

While the concepts of connected and automated vehicle (CAV) technologies have been explored for decades, CAVs have had substantial improvement in recent years due to innovation, research, and private investment. Implementation of these technologies have shown great promise for yielding a variety of safety, economic, and environmental benefits. However, these technologies also come with a variety of risks including liability, privacy, cybersecurity, and inequitable benefits. With the potential for imminent adoption of CAV technologies, the Wisconsin Department of Transportation (WisDOT) is invested in exploring and implementing these emerging transportation technologies to make roadways safer and more efficient. As part of its strategic goals, WisDOT seeks to assess public attitudes and perceptions of connected and automated vehicle technology. Since CAV technology is still under development, market penetration is still low and the general population's exposure has been minimal. Most knowledge about the public's attitudes on CAVs have stemmed from national surveys and small-scale pilots. Despite the variety of methods and surveys deployed in the U.S. to study CAVs, currently little is known about Wisconsin specific attitudes towards CAVs. This work presents the results of a detailed survey of the Wisconsin public's understanding of CAVs; their acceptance of early testing; their perceived benefits, drawbacks, and barriers to CAV implementation in Wisconsin; and the implications for potential WisDOT action.

The research team first reviewed the substantial literature on public surveys of automated vehicle (AV) technologies and considerably less work focused on public attitudes of connected vehicle (CV) technologies. The literature review provided consistent definitions, methodologies for studying attitudes toward CAVs, lessons learned in past studies, and state DOT CAV interventions and communication strategies.

The primary data collection method used in this study was a 184-item survey in paper and online modes that was provided in English and Spanish. The survey was organized by the following survey sections:

- Screening Questions
- Travel Behavior
- Attitudes on CAV
- Attitudes on Interventions
- Attitudes on Technology
- Demographics

Out of the original 2,800 survey invitations sent, 672 (24%) returned a valid response. After the review of initial responses, an additional 1,500 surveys were mailed to newly recruited households to improve the power of the study. Out of the additional 1500 survey invitations sent, 243 (16.2%) returned a valid response. **Out of the total 4,300 invitations sent, 915 (21.3%) Wisconsinites returned a valid response.** This study used raking to proportionally fit the sample data to distributions found in the Wisconsin 2021 American Community Survey (ACS) 5-year estimate for two variables: age and educational attainment.

Once data cleaning and weighting was performed, the research team analyzed overall weighted population distributions and descriptive statistics. The team noted **higher than expected experience with new CAV technologies** considering that these technologies are relatively rare in the U.S. and especially Wisconsin. The CV technology discrepancy is likely due to confusion over the term "connected vehicle". It is plausible that some respondents may have assumed that vehicles with in-vehicle infotainment systems with Bluetooth or WIFI are connected vehicle technologies. While this is not necessarily incorrect, these more widely used technologies do not have the real-time communication benefits of full-fledged CV technologies this study was hoping to analyze. This misconception should be stressed when considering responses to CV-related questions within this study. Wisconsinites were generally willing to share the road with vehicles equipped with advanced driver-assistance systems (ADAS), were moderately comfortable with CV technologies, and not comfortable with AV systems, as shown in the following percentages:

- 76% - Vehicle with ADAS
- 51% - Connected Vehicle (CV)
- 15% - Highly Automated Vehicle (HAV)
- 12% - Fully Automated Vehicle (FAV)

Results for willingness to use CAVs saw the same order of technology preference as comfort sharing the road. Willingness to use AVs tracked with national surveys; however, true comparisons with other surveys are tenuous as question wording and study designs are different. The presence of an operator significantly influenced Wisconsinites' willingness to use AV. While 55% of Wisconsinites indicated no willingness to use a HAV shuttle generally, only 34% of Wisconsinites would be unwilling to use a HAV shuttle if an operator was in the driver's seat. This significant increase in willingness to use a HAV with an inclusion of an operator in the driver's seat represents an important consideration for future near-term AV pilots in Wisconsin.

Another important consideration for future pilots of CAV technologies is which data elements are Wisconsinites willing to share. When asked about their willingness to share data for a CV application that could increase their safety, Wisconsinites were generally more willing to share short-term sensor data (i.e., wiper, headlight, braking, traction, and onboard diagnostics), make/model, and mileage information than more sensitive information like vehicle ownership, trajectories, trip location, and speed. Of all respondents, 20% indicated that they would not share any information while 37% would share all nine data elements.

Respondents were asked to consider how HAVs and CVs would affect six issues areas: transportation safety, mobility for non-drivers, congestion, air quality, privacy, and greenhouse gas emissions. The issues and technologies with the highest perceived *positive* impact were HAVs effect on non-driver mobility and CVs effect on traffic safety. The issues and technologies with the highest perceived *negative* impact were HAVs effect on traffic safety and CAVs effect on privacy. There is still considerable uncertainty about the effect of these technologies on issues. For 10 of the 12 combinations, the "about the same" option was the most common selected option with five having this option chosen by a majority of respondents.

An exploratory factor analysis was conducted to develop discrete factors of variables that describe the variation observed in respondents' attitudes. These factors represent interdependencies across the variables within each factor, but are generally unrelated to other factors and the variables that make them. The six factors uncovered were:

- Factor 1 (*AV Acceptance*) – willingness to use AVs
- Factor 2 (*CAV Benefits*) – perceptions of benefits from CAVs on issue areas
- Factor 3 (*State CAV Action*) – perceptions of Wisconsin State government actions
- Factor 4 (*CAV Concerns*) – concern over potential issues with CAVs
- Factor 5 (*CAV Education*) – willingness to learn more about CAVs
- Factor 6 (CV/ADAS Acceptance) – comfort using and sharing the road with CVs and ADAS equipped vehicles

A latent class cluster analysis (LCCA) was performed on the survey data to provide a grouping of Wisconsin residents by unique views across a range of CAV topics. This clustering incorporated the factors and other attitudinal, travel, and sociodemographic variables to define a 5 cluster and 3 cluster model. The results show that, overall, the clusters from the 5-class model nest very well in the 3-class model with four of the clusters nearly entirely matching one of the 3-class model clusters. Some of the insights gained from these clusters are provided below:

- Cluster 1 (27%)
    - Primarily urban women living in 1-2-person households
    - Accepting of ADAS, moderately accepting of CVs and not very accepting of AVs
    - Most interested of any cluster in learning more about CAVs
    - Saw little benefits or concerns with CAV technologies
- Cluster 2 (24%)
    - Primarily white, older than age 39, without a college degree, living in 1-2-person households in small cities or rural areas
    - Accepting of ADAS, moderately accepting of CVs and not very accepting of AVs
    - Most interested of any cluster in learning more about CAVs
    - Saw high benefits and concerns with CAV technologies
- Cluster 3 (27%)
    - Primarily white, older than age 39, without a college degree, living in 1-2-person households in small cities or rural areas
    - Not interested in any of the vehicle technologies
    - Least interested of any cluster in learning more about CAVs
    - Saw lowest benefits and highest concerns with CAV technologies
- Cluster 4 (20%)
    - Generally, live in larger households who tend to be younger than age 40
    - Accepting of ADAS and moderately accepting of CVs and AVs
- Cluster 5 (8%)
    - Primarily young urban men
    - Accepting of ADAS, CVs, and AVs
    - Second least interest of any cluster in learning more about CAVs, though YouTube videos appeal to them
    - Saw highest benefits and lowest concerns with CAV technologies

The study concluded with implications of the results on WisDOT actions. Respondents were asked about the importance of nine separate Wisconsin state government CAV-related actions. Clarifying liability in a crash, addressing cybersecurity, overseeing safe technology development, and addressing data privacy were deemed the most important actions. These items can generally be categorized as regulatory/information technology actions. The distributions of importance across these top items did not vary strongly across clusters. This is an interesting finding as attitudes about CAV technology varied strongly between clusters, but support for state government action was generally uniformly strong. Maintaining equal access to CAV technology was a regulatory action that did not have as strong support across the population. Respondents indicated that actions specifically related to government funding were least important, although there was still relatively strong support for all actions.

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1. Introduction

While the concepts of connected and automated vehicle (CAV) technologies have been explored for decades, CAVs have had substantial improvement in recent years due to innovation, research, and private investment. Implementation of these technologies have shown a great promise for yielding a variety of safety, economic, and environmental benefits. However, these technologies also come with a variety of risks including liability, privacy, cybersecurity, and inequitable benefits (Gkartzonika and Gkritza, 2019). With the potential for imminent adoption of CAV technologies, Wisconsin Department of Transportation (WisDOT) is invested in exploring and implementing these emerging transportation technologies to make roadways safer and more efficient. As part of its strategic goals, WisDOT seeks to assess public attitudes and perceptions of CAV technology. Since CAV technology is still under development, market penetration is still low and the general population's exposure has been minimal. Most information on CAVs the public has been exposed to has originated from conventional media. Most knowledge about the public's attitudes on CAVs have stemmed from national surveys and small-scale pilots. Despite the variety of methods and surveys deployed in the U.S. to study (CAVs), currently little is known about Wisconsin-specific attitudes towards them. This work presents the results of a detailed study of the Wisconsin public's understanding of CAVs; their acceptance of early testing; their perceived benefits, drawbacks, and barriers to CAV implementation in Wisconsin; and the implications for potential WisDOT action.

2. Literature Review

This project surveyed a representative sample of Wisconsinites to determine their attitudes and perceptions of CAVs. This literature review covers definitions, important dimensions of CAVs, and surveys of public attitudes on CAVs. This review provides a foundation for key elements of the project survey and analysis including:

1. Definitions
2. Aspects of CAV attitudes that are generally consistent across studies
3. CAV attitude study analysis techniques
4. Survey distribution methods
5. Survey response analysis methodologies
6. Checks for survey response validity
7. Methods to account for general attitudes towards technology
8. Survey question wording and choice options for multiple choice questions
9. Interventions and State DOTs' CAV communication strategies
10. Gaps identified in the literature and implications for future research

Definitions

To avoid confusion this study will primarily use the terms automated vehicles (AVs), connected vehicles (CVs), and connected and automated vehicles (CAVs). The five varying levels of automation have been defined in the Society of Automotive Engineers (SAE) standard J3016. When necessary to disambiguate between levels of automation, the study will refer to AV levels 1-2 as ADAS systems, levels 3-4 as highly automated vehicles, and level 5 as fully automated vehicles. Below are a few definitions that will help the reader understand the following literature:

Attitudes reflect latent variables corresponding to the characteristics of the decision-maker and reflect individuals' needs, values, tastes, and capabilities (Daly et al. 2011). Attitudes are formed over time and are affected by experience and external factors, including socio-economic characteristics (Ben-Akiva et al., 2002).

Connected vehicles (CVs) are vehicles equipped with at least one wireless communications device that can communicate with other travelers and roadway infrastructure (Park et al., 2018).

Automated vehicles (AVs) are vehicles in which some aspects of safety-critical control function occur without driver input. They typically use onboard sensors, high-definition maps, GPS, and software to control the vehicle (Park et al., 2018). **SAE Level 1-5**

Advanced driver assistance systems (ADAS) use hardware and software to support the driver in performing part of the dynamic driving task. If the ADAS system controls vehicle functions (as opposed to providing warnings) it is an example of an automated vehicle. **SAE Level 1-2**

Automated driving system (ADS) use hardware and software to fully perform the entire dynamic driving task on a sustained basis. **SAE Level 3-5**

Highly automated vehicles (HAVs) or self-driving vehicles are automated vehicles that still require a human backup operator, but can drive by themselves without the intervention of a human driver (Park et al., 2018). **SAE Level 4**

Fully automated vehicles (FAVs) or driverless vehicles are automated vehicles that are able to drive fully autonomously without the need for a backup human driver (Park et al., 2018). **SAE Level 5**

Perceptions are the process by which individuals experience their environment (Lindsay and Norman, 1972) and are exclusively related to the way certain alternatives are perceived (Bahamonde-Birke et al., 2017).

Aspects of CAV attitudes that are generally consistent across studies

This review first explores the aspects of CAV attitudes studied in past research. As methodologies, quality, geographies, and populations vary for each study, research results and conclusions vary considerably across the literature. This review primarily focuses on conclusions that are generally consistent across studies. This section first introduces research related to AVs, follows with CV research, and concludes with combined CAV research.

Automated Vehicles

Gkartzonika and Gkritza (2019) provided a comprehensive review of 43 stated preference and choice studies on AVs published in the U.S., Europe, Asia, and Australia from 2012 to 2018. The authors concluded that there is a consensus on the following outcomes associated with the widespread adoption of AVs:

- fewer crashes
- lower vehicle emissions
- better fuel economy
- improved productivity while riding in AVs

The researchers also noted broad consensus on the potential barriers to AV adoption:

- legal liability
- ethical issues
- privacy concerns (i.e., about the disclosure of trip data)
- cybersecurity
- hacking issues

Golbabaei et al. (2020) performed a comprehensive literature review of individual predictors of public acceptance and intention to use automated vehicles. The research team first identified 1,966 studies on automated vehicles published from 2012-2020. The researchers screened studies on a number of factors and included 80 relevant full-text articles written in English in their final review. The table below shows the generalized results of their synthesis across 22 variables. It is important to note that these general trends are not consistent across studies and do not reflect complicated interdependency between variables.

Table 1: Factors Influencing Willingness to Use Automated Vehicles (developed from Golbabaei et. al 2020)

Attribute	General Finding
Demographics	
Gender	Men are more interested in AVs
Age	Varied, but most research finds young people more open to AVs
Education Level	Higher education correlated with willingness to use AVs
Employment	Lower comfort with AVs those working in manual labor, unemployed, retired, and farmers
Household income	Higher income correlated with willingness to use AVs
Household structure	High interest in households with children
Residential context	People in urban, higher density locations are more willing to use AVs
Psychological	
Tech savviness	Technology enthusiasts are more likely to use AVs
Awareness	Type of information received can affect willingness to use
Environmental	Concern about global warming positively correlated with AV use
Facilitating conditions	Individuals with internal locus of control less willing to use AVs
Social influence	Social trust and influence positively correlated with use of AVs
Hedonic motivation	Individuals who enjoy driving and drive alone are less likely to use AVs
Perceived usefulness	Positively correlated with AV use
Perceived ease of use	Positively correlated with AV use
Mobility Behavior	
Vehicle ownership	Ownership and use affect desire to own private AV or used shared AV
Driver's license	Individuals with license less likely to adopt shared AVs
Exposure to in-vehicle tech	Individuals who own and use existing tech more likely to use AVs
Driving frequency	Individuals who drive more are more positive toward AVs
Daily travel time	Individuals who travel longer are more positive toward AVs
Crash history	Individuals involved in crashes perceive AVs as safer
Mobility impairments	Individuals with disabilities are more likely to accept AVs

Harp et al. (2021) provided a comprehensive review of 78 papers and reports on behavioral effects of AVs published in 2011-2020 to address the following five behavior research questions:

- **What is the willingness to adopt AV technology?**
  - People in the U.S. still have reservations about AVs, albeit, ones that seem to be fading over time, stemming mainly from
    - lack of trust in AVs operating properly
    - fear of security breaches
  - The share of the population who are unwilling to adopt AVs ranges from 19% to 68% (depending on population and geography)
- **What are the impacts of CAV technology on in-vehicle behavior?**
  - Some people believe they will multitask while riding AVs while others (up to 46%) believe they will not due to
    - Lack of trust in the technology
    - Motion sickness
- **What are the impacts of the technology on value of time?**
  - The ability to multi-task or relax during one's commute is found by most studies to reduce the AV riders' value of time by 5 to 55%
- **What are the impacts of the technology on travel-related behaviors (activity pattern, mode, destination, residential location)?**
  - Activity Pattern
    - The number of trips will increase by 2.5% to 58%
    - The average trip length will increase by 14% to 20%
      - A policy of increasing the operating costs of private AVs, however, can reduce the average trip length by up to 16%
  - Mode choice
    - People generally prefer owning AVs over sharing them, with pooled SAVs being the least favored AV
    - Most studies report that AV technology will reduce transit ridership by amounts ranging from 9% to 70%
      - A policy of increasing operating costs of AVs has the potential to substantially increase transit share by as much as 140%
  - Residential Location
    - Survey studies indicated a majority of people (80% to 85%) do not believe their residential location will be impacted by the adoption of AVs
    - Simulation studies indicate that lower travel costs will drive people further away from their work location
- **What are the impacts of the technology on vehicle miles traveled?**
  - Most studies predict an increase in vehicle miles traveled from 1% to 90%

The American Automobile Association (AAA) has been conducting national surveys on CAV attitudes since 2016 (Moye, 2023), although the research methodology changed in 2020 (Edmonds, 2020) which limits a full longitudinal analysis. According to Moye (2023) roughly 85% of respondents reported being fearful or unsure of self-driving technology in 2020-2022 with that level increasing to 91% in 2023 due to an increasing number of respondents being afraid of the technology.

Song et al. (2021) used 266 responses from an online survey administered to two small cities in Wisconsin: Eau Claire and Janesville. A technology-savviness factor score from five technology attitude survey items saw relationships to excitement about transit integrations brought by vehicle automation, but also was associated with concerns about problems that may be brought by vehicle automation.

Connected Vehicles

There has been considerably less work focused on public attitudes of connected vehicle (CV) technologies. Based on the authors' perspectives and a literature review, Acharya and Mekker (2021) identified four major issues with connected vehicle technologies:

- Data
  - privacy
    - unauthorized access, loss, misuse, modification, and disclosure of personal information
  - security
    - how data is stored and protected
  - ownership
    - who owns different data
  - use
    - how different data is used
- Equity
  - literacy, physical capability, sociodemographic attributes, and attitudes may influence whether and how CV applications are used
- Cost
- Driver's distraction

Acharya and Mekker (2021) conducted a 2,400-respondent online survey evaluating public perception on data sharing intention for CV applications. Using factor analysis, the researchers found that:

- users consider their data sharing interest based on the uses of data rather than on the types of data
- there are four groupings of data sharing intention by purposeful use of CV data
  - driver information, congestion assessment and reduction, pavement and infrastructure assessment and improvement (ICP)
  - enforcement of traffic rules and fees based on usage (EF)
  - roadside assistance and crash investigation (RC)
  - research purpose (RP)
- the use of CV data for enforcement purposes lowers the overall data sharing intention and could reduce the overall intention to use CVs
- the data sharing intention was found to be higher for those having higher familiarity with connected features but having low or no driving experience

Connected and Automated Vehicles

There has also been considerably less research devoted to the relatively rare deployment of CAVs. Much of the research that includes mention of CAVs is focused more specifically on AVs. For example, Dennis et al. (2021) surveyed the general public and riders of a traffic signal integrated CAV in downtown Las Vegas. The general public survey (N=236) was distributed to community centers and to common university channels and included four sections:

- demographic information
- current transportation behavior
- potential to use of CAVs
- perceptions and opinions of CAVs

The rider survey (N=153) was distributed to riders of a CAV shuttle and consisted of the three sections:

- demographic information
- perceptions and opinions of CAVs
- how the shuttle affected their perceptions or opinions

Despite including a connected and automated vehicle in the pilot, it is not clear if any questions were specifically targeted to CV technologies. Thus, the study's results are likely more appropriate for AVs.

Schoettle and Sivak (2014a and 2014b) used online surveys of adults living in the U.S., U.K. and Australia to measure public opinion of AVs and CVs, respectively. A comparison of the results of the two studies reveals a majority (66%) of respondents had heard of AVs while a minority (21.9%) had heard of CVs. However, a higher percentage of respondents were willing to own vehicles with CV technologies, (85.6%) compared to (65.9%) for AV technologies, but of those who were willing to own an AV, they were also willing to pay more than those interested in CVs.

Bansal and Kockelman (2016) found similar results in their online panel survey of 1088 Texans about their opinions of AVs and interest in CVs among other topics. The authors found that willingness to pay for automated technologies varied with the level of automation (i.e. $2,910 for Level 2 up to $7,589 for Level 4). Only 19% of the respondents had heard of CVs before the survey, and respondents were willing to pay a one-time amount of $127, on average, for CV technologies.

Lui et al. (2020) analyzed the expert opinions (N=36) of the factors affecting CAV acceptance with an emphasis on cyber security and privacy issues. They argued that experts are in the best position to identify and contextualize these factors in this early stage of development. The research team defined six themes from the interviews:

- Awareness
- User and vendor education
- Safety
- Responsibility
- Legislation
- Trust

CAV attitude study analysis techniques

Although a survey is specifically called for in this study, it is important to understand what different techniques have been used to study attitudes toward CAVs and what conclusions those varying techniques offer to inform this project.

Harp et al. (2021) provided a comprehensive review of 78 papers and reports on behavioral effects of AVs published in 2011-2020 to address five behavior research questions. Notably, they included research that used a variety of techniques:

- **Controlled testbeds** - testing in areas with limited number of intersections, pedestrians, traffic, etc.
    - Useful for studying human factors and safety
    - Not useful for behavioral insights

- **Driving simulators** – vehicle-like setting with a screen to simulate a road network and often accompanied with a survey to obtain information about the subject's experience
    - Useful for studying human factors and safety
    - Limited when subjects fail to perceive the true risks or conditions in the real-world
- **Virtual reality (VR**) – immersive simulations using VR equipment and often accompanied by a survey to obtain information about the subject's experience
    - Useful for increasing sense of reality when studying human factors and safety
    - Currently limited understanding of the degree VR can lead to realistic behavioral results
- **Agent-based and travel-demand models** – disaggregate agent-based models based upon historical choice models
    - Useful for extrapolating individual decisions onto large scale effects
    - Limited in predictive power as they require researcher assumptions on changes to inputs
- **Surveys** – either direct questions about attitudes or scenario-based discrete choice experiments
    - Useful to gain insights on travel behaviors that do not currently exist
    - Limited in three ways
        - Hypothetical scenarios and questions may not reflect respondents' real preferences
        - Techniques such as video or text descriptions to provide context may be interpreted differently by different people
        - The current context and responses from current generations may not be representative of future behaviors
- **Field experiments** – real-world experiences that either use an AV in a bounded geographic space or simulate AV features using a chauffeur
    - Useful in allowing subjects to obtain firsthand experience with AV features
    - Limited by geographic context, can be influenced by having a human driver or attendant, and generally short experiences

Survey distribution methods

Survey distribution methods vary significantly across studies and domains. Some survey distribution methods include:

- Open online
- Online panel
- Phone
- Mail
- Focus groups
- Interviews
- Mixed mode
- Alongside deployments

Gkartzonikas and Gkritza (2019) provided a comprehensive review of 43 stated preference and choice studies on AVs published in the U.S., Europe, Asia, and Australia in 2012-2018. The authors included a table documenting study area, target population, sampling strategy, distribution method, and number of responses among other information. Almost all (86%) of studies exclusively used online surveys, while others used interviews, focus groups, paper-based, or mixed-modes. Although the average number of responses was around 3,000, 21% of studies had fewer than 385 responses and 49% had fewer than 1,000 responses. 53% of studies only reported descriptive statistics from their survey.

Based on a literature review of studies focused on public acceptance attitudes of AVs since 2010, Chen et al. (2022) noted that online surveys and face to face interviews were the most common methods used.

Survey response analysis methodologies

It is first important to understand that studies vary widely on which outcome variables they choose to focus, and that has implications on their claims. These outcome variables generally vary among the following options:

- Willingness to try (i.e. short-term) CAVs
- Willingness to use (i.e. long-term) CAVs
- Willingness to buy CAVs
- Willingness to share the road with CAVs

Rahimi et al. (2020) grouped the surveyed attitudes measurement methodologies into three main approaches including Direct Estimation, Factor Analysis, and Structural Equations Modeling. In addition to these techniques, the generation of summary statistics and pairwise correlations were other techniques that were almost exclusively applied to CAV attitudinal research prior to 2014 (Bansal and Kockelman, 2016). Cluster analysis is an additional technique used by several researchers to develop distinct segments of the population that vary by their AV adoption interest (Nielsen and Haustein, 2018; Kim et al., 2020; Acharya and Humagain, 2022). These combined methodologies are described below.

- Descriptive Statistics
    - Respondents are asked direct attitudinal questions and responses are compared as attitudes across various sub-populations
    - Useful to describe one-dimensional associations with outcome variables
    - Limited as these methods cannot account for complex interactions of predictive variables
- Direct Estimation
    - Respondents are asked direct attitudinal questions and responses are taken directly as indicators of attitudes in models to estimate willingness to pay, willingness to use, or other behavioral dependent variables
    - Useful for establishing relationships between demographic and attitudinal indicators with a dependent variable
    - Limited in its ability to handle a large number of indicator variables or correlations between indicators
- Factor Analysis
    - Reduces several correlated variables into more manageable set of factors
    - Useful to allow for many correlated variables to be studied at once
    - Limited as it does not establish causal inferences from the correlations provided
- Structural Equations Modeling
    - Reduces measurement error by explicitly including measurement error variables
    - Allows testing of multiple hypotheses simultaneously
    - Limited by overcomplexity of methods and possibility for multiple equivalent models
- Market Segmentation or Cluster Analysis
    - Can be used to extend factor analysis to cluster groups of people by shared attitudinal and other factors

  - Post hoc segmentations clusters respondents based on the data collected which might not be repeatable in future studies of the same population or in different populations
  - A priori segmentation defines specific target groups which may not be representative of the target population

Checks for survey response validity

Maintaining the quality of the project's data increases the confidence in the study's results. One way to maintain data quality is to establish survey response validity checks that discard respondent data when those surveys are determined to be lower quality and not reflective of a respondent's true attitudes and preferences. In addition to historic issues with human respondents rushing through the survey, autonomous programs, also known as web bots, are increasingly used to answer survey forms that do not reflect the attitudes and perceptions of any specific living person.

On a 93-question survey, Bansal and Kockelman (2016) used several checks for survey response validity to discard responses:

- Surveys completed in less than 15 minutes
- Respondents who did not understand the NHTSA's automation level after reading a description of the levels
- Minors younger than 18 years of age
- Reporting more workers or children in household than the household size
- Reporting the same distance of their home to various destinations
- Other conflicting answers

Baker and Downes-LeGuin (2007) define eight characteristics of suspicious surveys:

- Unusually short completion times compared with the median interview length
- Selection of all items in a multiple response or other obvious cheating behavior in qualifying questions
- Selection of bogus or low probability answers
- Internal inconsistencies
- Low differentiation or "straight lining" in grids
- High levels of item nonresponse
- Failure of verification items in grids
- Gibberish or duplicated responses in text entry boxes

Methods to account for general attitudes towards technology

Respondents' attitudes toward CAVs may be influenced by larger attitudes toward technology in general. It is valuable to disentangle these attitudes when developing messages to members of the public. Many approaches have been developed to capture how technologies are perceived by the public. Porter and Donthu (2006) noted that two research paradigms have emerged on technology adoption and acceptance:

- Focusing on trait variables to explain propensity to use new technology ***generally***
  - Example – Technology Readiness Index (TRI)
- Focusing on how a ***particular*** technology's attributes affect perceptions and use of that technology
  - Example – Technology Acceptance Model (TAM)

Pangriya and Singh (2019) provided a study of 112 papers on these paradigms published between 2000 and 2019. The researchers summarized the first as it, "relates to the perceptions, beliefs, and feelings an individual hold concerning high-tech products and services" pg. 3. While examples of the latter category employ varying structures to predict attitudes and behavior related to specific technologies (including Theory of Reasonable Action (TRA), Theory of Planned Behavior (TPB), Unified Theory of Acceptance and Use of Technology (UTAUT), and others). A thorough review of these models can be found in Lai (2017). The TAM specifically focuses on users' perception of the usefulness and perceived ease of use of a particular technology. There are also hybrid models such as the Technology Readiness Acceptance Model (TRAM) that integrate the TRI into the overall TAM structural model to study the effect on perceptions and use of specific technologies.

Survey Question Wording and Choice Options for Multiple Choice Questions

"Improving question design is one of the easiest, most cost-effective steps that can be taken to improve the quality of survey data" (Fowler 1995, vii). Iarossi (2006) defined two basic rules to make a good question:

- Relevance – is the information generated appropriate for the purpose of the study
- Accuracy – is the information generated reliable and valid

Technology descriptions and question wording is important not only to avoid influencing respondents, but also to avoid differentially influencing responses across subpopulations. For example, certain phrases may be interpreted differently across subpopulation which may affect respondents' choices differently than the construct the study is trying to measure. Classen et al. (2021) focused on three types of validity in the development of their survey:

- Face – testing what is supposed to be tested and items are plausible
- Content – testing the extent empirical measures reflect a specific domain of content
- Construct – testing the level of agreement between responses and theory

For face validity specifically Classen et al. (2021) solicited feedback from a focus group on questions and measured the Flesch Reading Ease Score and Flesch-Kincaid Grade Level Score of the survey. These scores are readily available in Microsoft word, and target score ranges of 60-70 and 7-8, respectively, should be used for standard documents.

Full survey instruments were obtained from 11 studies reviewed in the literature. These surveys were combined to generate a list of survey items to choose from for the purposes of the current study. The use of exact wording potentially allows for comparison of results across this study and other studies found in the literature.

Choice options are also critically important as they frame the choice architecture of multiple-choice questions for respondents. Again, choices were collected from historic surveys as they were available. Also, research summaries in Section 1 of the literature review can be used to provide choice options for some questions. For example, based on the results from focus groups conducted by Schmidt et al. (2016), key advantages and disadvantages of CV technologies can be obtained:

- Advantages
    - Safety
    - Comfort
    - Efficiency
    - Costs

- Disadvantages
    - Privacy
    - Control
    - Illegal Access
    - Position
    - Identifiability

Another example comes from an online study of 101 Flinders University's staff and students. Kaur and Rampersad (2018) found that the context matters to respondents when asked whether the respondents were willing to accept AV testing and use. In regards to context, the research team found respondents preferences to testing generally consisted of the following:

- Locations of most willingness to adopt
    - Closed environments
    - Finding a carpark
    - Highways where drivers can take full control
    - Public transportation with a chaperone
- Locations of most unwillingness to adopt
    - Driving a vehicle with no driver controls
    - Areas with high pedestrian traffic
    - Drop-offs and pick-ups of children
    - Public transportation with no chaperone

This result implies that context matters when it comes to accepting AV testing and general acceptance questions should be avoided.

Nair and Bhat (2021) surveyed 5341 respondents as part of the American Trends Panel survey in 2014, 2015, and 2017. The researchers identified three outcome variables with associated questions and answer choices:

1. AV awareness
    - How much have you seen or heard about the effort to develop driverless vehicles – that is, cars and trucks that can operate on their own without a human driver?"
        - Nothing at all
        - A little
        - A lot
2. AV interest
    - Would you, personally, want to ride in a driverless vehicle if you had the opportunity?
        - No
        - Yes
3. Perceived safety of sharing the road with AVs
    - How safe would you feel sharing the road with a driverless passenger vehicle?
        - Not safe at all
        - Not too safe
        - Somewhat safe
        - Very Safe

Interventions and State DOTs' CAV Communication Strategies

Understanding the range of interventions and communication strategies employed by other state DOTs and others that could be used will help the research team to link attitudes to possible treatments.

Nair and Bhat (2021) found that the influence of socio-demographics characteristics on AV interest and safety perception is primarily mediated through enthusiasm. The researchers conclude that if the goal is to increase interest in AVs among those subpopulations less interested in AVs (e.g. older people, women, and those with less education) there should be a focus on promoting benefits and usefulness to those subpopulations including the following examples:

- Older people
  - Target a means to avoid difficulties of driving and serve the purpose of expensive recreational vehicles. A renewed sense of adventure can be emphasized to mitigate concerns of disruptions to established habits.
- Women
  - Target the time use productivity without the need for a driver and associated potential security concerns, leaving more time for social-recreational activities.
  - Target the safety benefits of AVs.
- People with less education
  - Target policies that promote affordable retraining programs to dissuade concerns of the elimination of low-skilled jobs

MnDOT's CAV program commissioned a 2,200 respondent online survey and roughly 60 interview follow-ups in 2020. The research team adopted a marketing approach borrowed from Denver's Mobility Choice Blueprint that focuses on discrete personas to provide tangible representations of subpopulations. Provided in the *Minnesota CAV Messaging and Engagement Guidance Document* (Minnesota Department of Transportation, 2022) from this survey and framework, the MnDOT team developed four discrete, but not mutually exclusive perspectives:

- CAV Cautious – The Information Seekers
  - Baseline perspective
  - Generally cautious
  - Interested in how the technology works
- CAV Confident – The Spirit Squad
  - Positive outlook
  - More common in urban areas
  - CAV ambassadors in their communities
- CAV Caregiver – The Community Allies
  - Concerned about social issues associated with CAV
  - Distrust of government and/or private industry
- CAV Critical – The Historically Underprioritized
  - Don't believe CAV will be accessible or benefit them
  - Demographic groups likely to hold this perspective include people:
    - of Color
    - with Low income
    - with Disabilities
    - who are older
    - who are women
    - who live in rural communities

The research team also generated 29 engagement options:

- Form Community Advisory Councils to implement and review engagement work
- Data tracking on engagement, demographics and success metrics
- Advertise & market your work
- Publish work and partnerships
- Use storying telling
- Create a brand
- Send regular newsletters
- Fact sheets and pamphlets
- Have more presence on social media
- 1:1 meetings
- Develop earned media
- Pitch stories to media
- Make websites more user/public friendly
- Create CAV “ambassadors”
- CAV speaker's bureau
- CAV 101 presentations – “Train the trainer” model with standard presentations
- Develop thought leaders
- Create “canned” articles to share
- Highlight relevant blog posts from industry
- Host regular webinars.
- Host lunch hour presentations
- Host an annual CAV conference
- Organize regular tech showcases
- Hold public demonstrations
- Coordinate work across organizations
- K-12/Higher ed outreach
- Create list of orgs to send updates and articles
- Speak at annual conferences
- Develop systematic approach to engaging with private and nonprofit sector

Murphy et al. (2021) have created an index comprised of 16 survey items to classify respondents' level of transportation insecurity. The Transportation Security Index the researchers have created allows researchers to determine what relationship transportation insecurity has with demographics, attitudes, behaviors, and travel outcomes. The researchers have developed a preliminary shortened 6 item index that is still being validated, but could be used as part of this research to assess the effects of transportation insecurity of attitudes toward CAVs.

Gaps Identified in the Literature and Implications for Future Research

This study seeks to understand the public's attitudes and perceptions towards CAVs in Wisconsin. In some ways, this project will verify whether insights gained in the literature apply to Wisconsinites as well. However, it is vital to understand what gaps have been identified in the literature, in order for this study to correct for those deficiencies and contribute to the larger and continually changing understanding of public attitudes towards CAVs.
Some of the summarized findings of the gaps in the literature include:

- A lack of consistent descriptions of AVs (Hassol et al., 2019; Harp et al., 2021)
- A lack of inclusion of a comprehensive set of personal and family attributes (Hassol et al., 2019; Nair and Bhat, 2021)

- A lack of research related to people with disabilities (Dicianno et al. 2021)

The following sources offer specific examples of these gaps and recommendations in the existing literature:

- Hassol et al. (2019)
    - AV descriptions in surveys vary widely and can affect the respondents
    - Cited several studies that show that preferences about "really new products" are unstable over time and highly dependent upon survey framing effects
    - Few studies have included all key attributes of users, including:
        - Performance expectancy
        - Effort expectancy
        - Social influence
        - Income
        - Family Composition
        - Driver/commuting behaviors
        - Driving enjoyment
        - Tech savviness
- Nair and Bhat (2021)
    - Few studies have included
        - The influence of technology use effects (e.g. Tesla's autopilot)
        - The influence of household-level demographic variables
- Dicianno et al. (2021)
    - 31 gaps in AV research identified related to people with disabilities including
        - How can people with disabilities gain realistic experience with current and likely future AV capabilities and limitations, allowing them to make better-informed decisions about the safety and suitability of AV for their specific sets of disabilities?
        - What topics of education about AV are needed for specific disability groups?
        - What format of education about AVs is most effective in improving the acceptance of AVs for people with disabilities?
        - How can the need for monitoring and communicating with users of an AV be balanced with privacy concerns?
- Harp et al. (2021)
    - Need to monitor the evolution of responses over time, for different groups, as a function of social or formal information sources, and across cultures (pg. 28).
    - Found inconsistency in how AVs and mobility are described in survey studies and identified important questions to consider:
        - A definition of an automated vehicle, its characteristics, and whether it permits manual driving or not could help achieve more consistent results from survey studies (pg. 31).
        - A clear definition of adoption and which service models (ownership, sharing, or mobility as a service) is needed.
- Chen et al. (2022)
    - Few studies analyzed the impact of AVs on the community, such as the repurposing and redesigning of the urban setting

Conclusion

This literature review provided context on 10 dimensions of CAVs and survey studies. The research team used this review to develop research objectives, a survey plan, and the survey instrument. These products consider the lessons learned in prior research and identify a plan to fill the gaps identified as they apply to this study of CAV attitudes and perceptions in Wisconsin.

2. Methodology

The research team initially intended to administer a 15-minute survey, administered online and paper-based, and translated to Spanish and Hmong. These languages were chosen based on data of limited English proficient populations in Wisconsin. These represented the two highest proportions of languages spoken for people who spoke English less than "very well" with 1.7% of the Wisconsin population speaking Spanish and 0.25% speaking Hmong. Due to cost and the potential to delay the administration of the survey by one month, the survey was only translated into Spanish.

Survey Instrument

The process of creating the survey instrument started by pooling survey items from 11 other surveys on CAVs and transportation issues. Items most relevant to this study were included in an online survey template hosted on *Qualtrics*, a cloud-based survey software platform. This draft version of the questionnaire was reviewed and revised by TOPS staff and sent to the WisDOT POC for review on March 29, 2023. TOPS staff incorporated final comments into the draft survey questionnaire and sent to the University of Wisconsin Survey Center on April 10, 2023 for review. The Survey Center provided crucial feedback on the format of many survey items and substantial edits were made to the questionnaire. This effort produced an updated sixteen-page 184-item paper survey that was copied back into the online mode and translated to Spanish in both modes. The full English version of the paper survey can be found in **Appendix 1**. The survey was organized by the following survey sections:

- Screening Questions
- Travel Behavior
    - Mode use frequency
    - Transportation Security Index
    - Transportation challenges
    - Impairments affecting transportation
    - Involvement in traffic crash
    - Number of working vehicles
- Attitudes on CAV
    - CAV technology definitions
    - CAV technology familiarity
    - CAV technology experience
    - Willingness to use CAV technology
    - Conditions for use of HAV of 65-mph highway
    - Conditions for use of HAV of neighborhood street
    - Willingness to share data items related to CV safety application
    - Comfort sharing 65 mph road with CAV technologies
    - Comfort sharing neighborhood with CAV technologies
    - Need for testing requirements for HAVs

    - Impact of HAVs on issue areas
    - Impacts of CVs on issues areas
    - CAV concerns
- Attitudes on Interventions
    - Importance of actions taken by Wisconsin State government
    - Helpfulness of ways to learn more about CAVs
- Attitudes on Technology
    - Technology Readiness Index
- Demographics

Random Sample Data Set

The adult population of Wisconsin was randomly sampled based on addresses, with recruitment letters sent to a random sample of Wisconsin households. This group is called the random sample data set. The research team contracted with Marketing Systems Group (MSG) to provide a probability-based sample of addresses within Wisconsin. The sample uses the Postal Service address database and is restricted to residential addresses excluding traditional PO boxes and vacant addresses. The research team verified that the sample provided is consistent with population shares by county. The initial sample targeted 2,800 Wisconsin households. On May 16, 2023, the team printed and sent a presurvey to 50 addresses to verify the online survey process was working correctly. No significant changes were needed between the pretest and full distribution. The team printed 2,750 envelopes and recruitment letters, inserted one-dollar bill in each, and mailed the survey to these addresses on June 13, 2023. The team received 334 online responses before July 1, 2023, which the team used to determine the quality of responses and representation of the state's demographics. Based on the results of the initial data analysis, the team decided to send an additional 1,500 surveys to new participants based on a random sample of the entire state. At the end of July, the team sent the 3,960 paper-based versions of the survey to the 2,460 recruited participants who hadn't responded to the initial mailing and the 1,500 who were new to the study.

All respondents in the random sample data set who provided a valid complete survey received a $10 post-incentive. Only one complete survey would be accepted for each address within the random sample data set.

Convenience Sample Data Set

The survey was also administered online via WisDOT social media and the Department of Motor Vehicles (DMV) monitors. This group is called the convenience sample data set. A post that included a link to the survey was sent on WisDOT's LinkedIn and Twitter accounts on July 29, 2023. This post is included in **Figure 1**. The post was also sent on WisDOT's Facebook account on August 12, 2023. No responses were recorded from the DMV monitor recruitment and 134 responses were recorded from the social media recruitment. Due to the relatively small sample and convenience-based sampling approach, this data was recorded but not analyzed further at this time.

Figure 1: Convenience Sample Twitter Recruitment Message

3. Data Cleaning

Non-Response and Data Preparation

The following data cleaning and analysis was performed exclusively on the random sample data set presented in the last section. Unit non-response refers to the occurrence of sampled units (i.e. households) that failed to respond to the survey recruitment. The non-response could be due to a variety of circumstances including: refusal to participate, language barriers, or extended vacation. Unit non-response is typically divided into three types:

- Non-contact
- Inability to respond
- Refusal

The first two types result in no response received from the survey team. In this survey, 3,340 of the 4,300 recruited, or 77.7% of survey invitations, received no response. The last type includes those who sent back the survey material with a message indicating they do not want to participate. Seven (0.16%) households recruitment for the study returned surveys indicated they do not wish to participate.

The next step the research team considered is whether responses received were valid. The research team received 961 responses via the online survey (N=497) and the paper-based versions (N=466). Ten mailed paper surveys were returned after the August 16 deadline and deemed invalid. The 951 remaining responses received were reviewed for missing and invalid data. Case flags were determined based on the standard deviation of responses across question sections. For example, in Q22, "How much better or worse do you think highly automated "self-driving" vehicles will make each of the following issues?" there are six issue areas listed for respondents to provide feedback (i.e. transportation safety, mobility for non-drivers, congestion, air quality, privacy, and greenhouse gas emissions.) If a respondent provided the same response for each item within Q22, they received a flag for that question section. Thresholds were determined for each question section based upon the overall distribution of responses. Question sections that saw high levels of uniform responses across all responses did not have flags. Responses provided online were reviewed for additional flags based on duration to complete the online form. These two duration flags were set at 13 minutes and 8 minutes. 13 minutes was chosen as it represented one-standard deviation less than the average time of 22 minutes and included roughly 16% of the respondent population. This flag had a weight of 1. 8 minutes was chosen as a secondary threshold as there existed a significant drop off in the distribution of respondents below that time. This flag had a weight of 7. All other flags had a weight of 1. Weighted flags were summed for each respondent and 9 respondents with sums higher than 8 were removed from further analysis. Additionally, high rates of missing data were reviewed for response validity. Several respondents left whole pages of the printed survey blank, seemingly from pages sticking together. The highest number of items included on two consecutive pages of the printed survey was 44. If a respondent left more than 44 items blank, their response was deemed invalid. 29 respondents left more than 44 items blank and were removed from further analysis. These thresholds and the number of respondents meeting them are provided in **Appendix 1**.

Out of the original 2,800 survey invitations sent, 672 (24%) returned a valid response. Out of the additional 1,500 survey invitations sent, 243 (16.2%) returned a valid response. Out of the total 4,300 invitations sent, 915 (21.3%) Wisconsinites returned a valid response.

To preserve location privacy, data validation and cleaning of location data was performed before further data cleaning in the statistical software SPSS. Responses to Question 39. “In which Wisconsin county do you live most often?” were compared to the addresses where surveys were sent. 46 (5%) valid responses did not specify their household county. If the respondent’s response was blank, the data was entered from the address of the survey. 18 (2%) responses had differences between county responses and respondent addresses. In most cases (14 or 1.5%) counties were adjacent and it is possible respondents were trying to mask their household locations or surveys were sent to a nearby second house or vacation property. These responses were retained. In some cases, 4 (0.5%) county responses were southern counties while the address the survey was sent to was a northern county. These could be attributed to residents with vacation properties, so responses were retained.

Thirty-three (3.6%) blank responses to question 40, “Which one of the following best describes the location where you live?” were imputed from the address to which the survey was sent. Census defined urban areas were used to differentiate between city and rural areas. Small cities were defined as having populations less than 39,000 as defined by state statute as third- and fourth-class cities. Some additional data cleaning was performed for responses to question 40 and coded in the variable Q40_cleaned. This was mainly performed based on visual inspection from neighboring responses. For example, **Figure 2** below shows the approximate addresses of six respondents from Marshfield. Five respondents indicated their residence was in a small city while one respondent indicated large city. This data was updated to reflect the most common response.

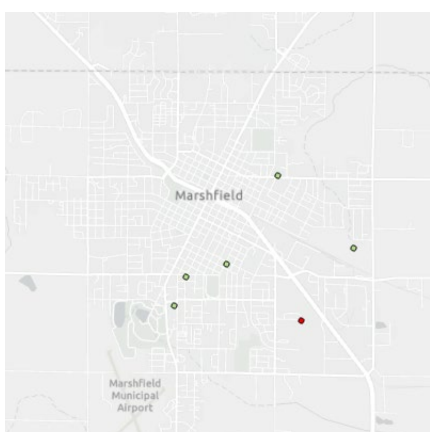


Figure 2: Example of Residential Context Data Cleaning

Missing data was analyzed for all survey questions across the 915 valid survey responses. There were several questions that asked for "other" responses, for example: other challenges, other impairments, other conditions, other requirements, other genders, or other races. These questions were optional and offered respondents the ability to capture response differences that the survey administrators did not anticipate or could not fit in the instrument. Of the 184 total survey items, 17 (9%) were this type of question. For the remaining 167 survey items, missing responses were analyzed. The vast majority of items (150, or 90%) saw less than 2% missing rates. 15 items (9%) saw missing rates between 2% and 4%. Two questions (1%) saw missing rates over 8%. These two questions were:

- Q36: "In 2022, including all sources, what was your total annual household income before taxes?"
- Q41: "If you are or have been employed, what is your main job?"

Q36 is a sensitive question. Some respondents on paper surveys indicated that question was not applicable or appropriate for this survey. Q41 is also more personal and respondents may have avoided a response either because they were currently retired and felt is wasn't applicable or thought the item was too personal. Responses to Q41 were highly heterogeneous, as respondents' answers to this question varied from industries to specific jobs. While additional analysis could define clusters of answers and impute cluster assignment for missing responses, this was not pursued at this time. General guidance on missing rates in survey data (Mirzaei, 2021) suggest that missing data rates of less than 5% are negligible and can be treated with either deletion methods or imputation methods. Missing data rates between 5% and 10% should be tested for the type of missingness using Little's test. If the test is insignificant, meaning a p-value greater than the test statistics (usually 0.05), the data can be treated with either deletion or imputation methods as they are likely missing completely at random. If the test is significant, meaning a p-value greater than the test statistics (usually 0.05), further study is needed. Nine variables (Q29, Q30, Q31, Q32, Q33, Q34, Q35, Q36, Q37) were analyzed in Little's test and the result was a p-value of 0.016, indicating a significant result. This means the null hypothesis that the data is missing completely at random is rejected and additional tests are needed. Q36 was studied further for which variables are related to its missingness. A binary logistic regression was conducted to estimate the missingness of Q36 with 8 predictor variables (Q3, Q10, Q29, Q30, Q33, Q34, Q35, Q40). The research team found that older respondents (Q29) and those respondents who chose "Not listed, please tell us:" in Q30 were significantly and positively associated with missing income data in Q36. The response to Q30 makes sense as only three respondents chose that response and one of those did not complete the income data. The respondent age variable displays a more interesting pattern. For every 1-year increase in age, the probability of not completing the income data increased by 5%. The predictive value of the logistic regression was still low, as it only accounted for 0.1% of the variation in missing income responses. For that reason, one can conclude that values in income are missing at random and depend on other study variables, but are not able to be imputed accurately.

Two external indexes were included in the survey questionnaire:

- Question 6 (6 items) – Transportation Security Index
- Question 27 and 28 (16 items) – Technology Readiness Index

To calculate the Transportation Security Index a sum of responses to all six questions is performed. Higher numbers represent higher levels of transportation insecurity and the index's authors have defined thresholds representing discrete levels of insecurity:

- 0-1 – No insecurity
- 2-5 – Marginal/Low insecurity
- 6-12 – Moderate/High insecurity

To obtain a wholistic index for each respondent with at least some data, missing values were imputed. 14 respondents had missing values for all six questions and their data was not imputed. Four respondents had missing values imputed for a total of 6 imputations. As the option choice "never" was, by far, the most common response, each missing value was imputed with never coded as 0.

The authors of the Technology Readiness Index have a recommended procedure for handling missing data, whereby when there are less than 4 missing items, those missing items should be imputed as neutral and coded as 3. When missing items exceed 3, no index should be calculated for that respondent. 15 respondents provided no responses and 13 respondents had less than 4 missing responses for total of 15 imputed values.

To produce factors during the latent class cluster analysis discussed later, data was imputed using maximum likelihood for several attitudinal variables:

- Willingness to Use CV and AV (Q14) (8 items)
- Willingness to share highway with CV and AV (Q18) (6 items)
- Effect on issues from AVs and CVs (Q22 and Q23) (12 items)
- Concerns with CAVs (Q24) (9 items)
- Actions by Wisconsin State government (Q25) (10 items)
- Helpfulness of methods to learn more about CAV (Q26) (7 items)

This was a necessary step as factor scores would not be available for the latent cluster analysis if missing data was not imputed. The imputed values were only used during the factor analysis and latent class cluster analysis and are reported as missing in other results provided.

Weighting

Despite targeting a random sample of addresses within Wisconsin, valid responses do not match observed population in a number of ways. This is primarily due to differential non-response bias where some groups of the population are less likely to respond to survey, and therefore the survey sample is effectively missing their responses. To correct for these missing groups, response weighting was performed. The three primary techniques for survey data weighting are:

- Raking
    - Iterative proportional fitting to fit weights to multiple distributions using marginal proportions.
- Matching
    - Matching uses a sample distribution that is representative of a population and matches cases from the study distribution until all cases in the sample distribution are matched.
- Propensity weighting
    - Propensity weighting uses the inverse of the probability of selection to account for bias in the study distribution

This study uses raking to proportionally fit the sample data to distributions found in the Wisconsin 2021 American Community Survey (ACS) 5-year estimate data. Household income was not used in the weighting process due to three reasons:

- Household income is, by definition, a household statistic and not a personal one
- The variable had a relatively large portion of missing responses, as noted earlier
- The variable's unweighted distribution was relatively similar to the ACS distribution

The following figures show the unweighted, weighted, and ACS distributions for key variables. Age and educational attainment displayed significant deviations from the ACS data and were included in the weighting process. Age was divided into four groups of roughly 20 years each: 18-39, 40-59, 60-79, and 80-100. Educational attainment was recategorized from eight levels to four separate categories (i.e., high school or less, some college or associate's degree, bachelor's degree, graduate or professional degree) to provide sufficient samples in each group and to correspond to ACS categories. Race was considered for weighting and was consolidated into white alone and all other races and ethnicities categories. This categorization clearly over-generalizes several discrete heterogeneous races and ethnicities into one homogeneous group. However, each independent non-white racial group represented only a small fraction of the Wisconsin population and a smaller fraction of the study sample. For example, 6% of Wisconsin adults are black and only 2% of the study respondents were black. All non-white racial and ethnic groups were under-represented in a study. Due to only two non-white respondents in the 80+ age category, weighting based on age and racial category would be challenging and race was dropped from the weighting procedure, but is shown in the following figures for reference.

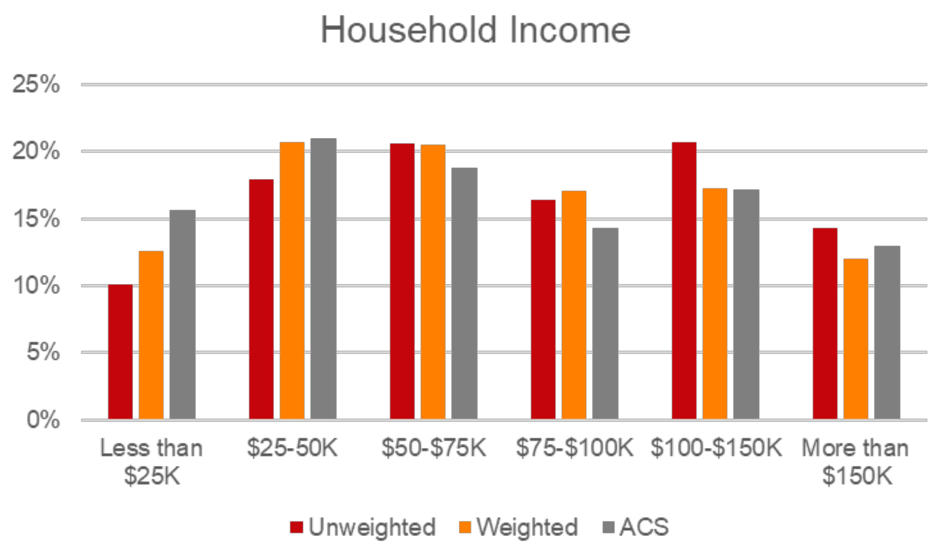


Figure 3: Comparison of unweighted, weighted and ACS distributions of Household Income in Wisconsin

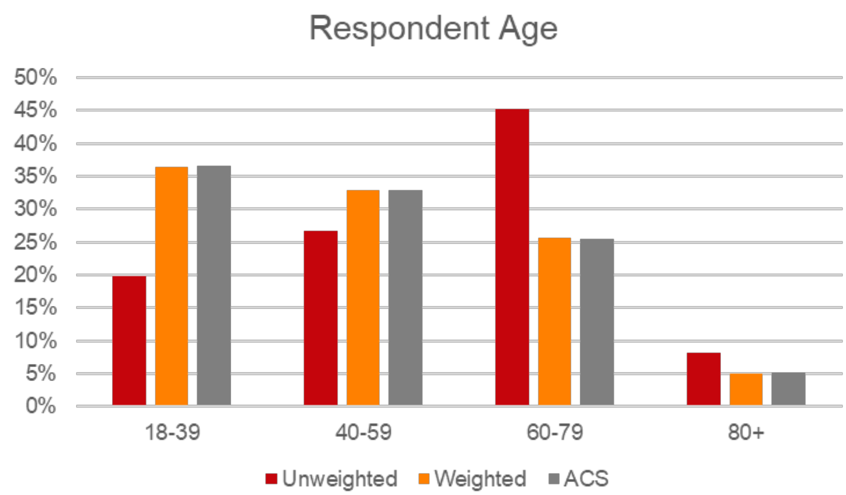


Figure 4: Comparison of unweighted, weighted and ACS distributions of Age in Wisconsin

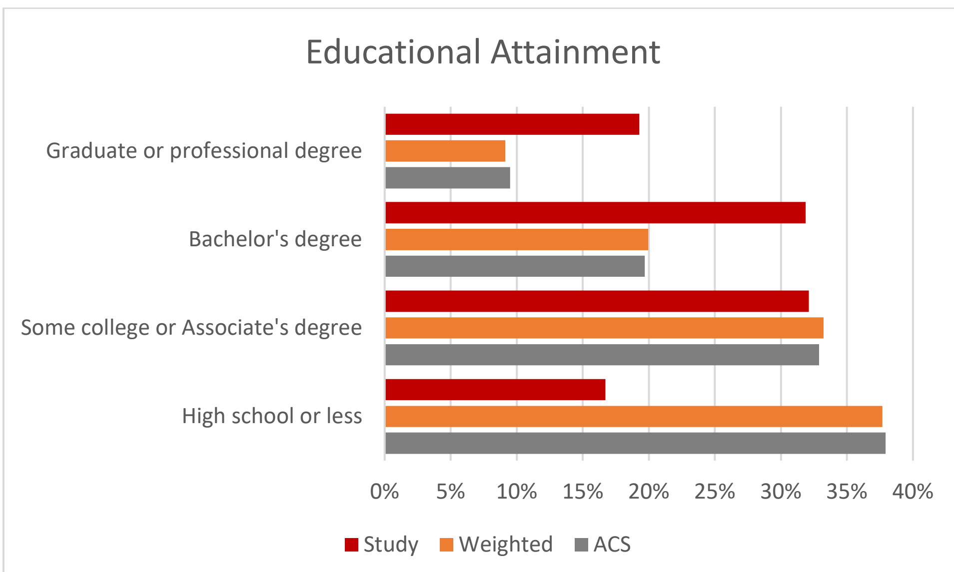


Figure 5: Comparison of unweighted, weighted and ACS distributions of Educational Attainment in Wisconsin

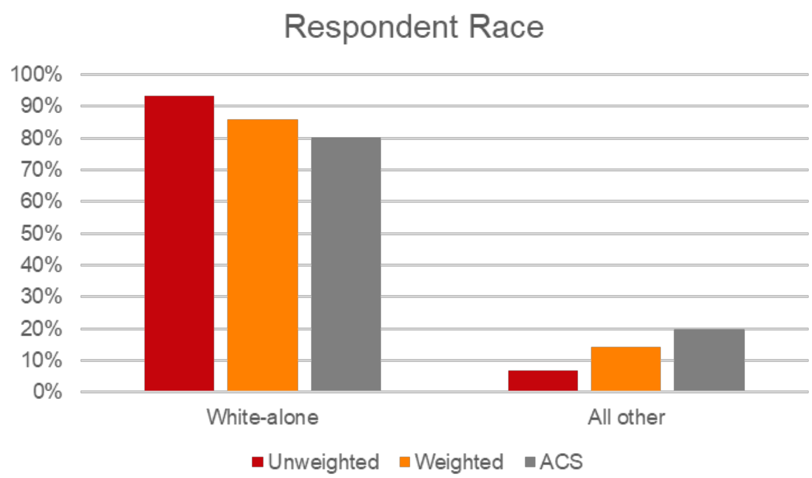


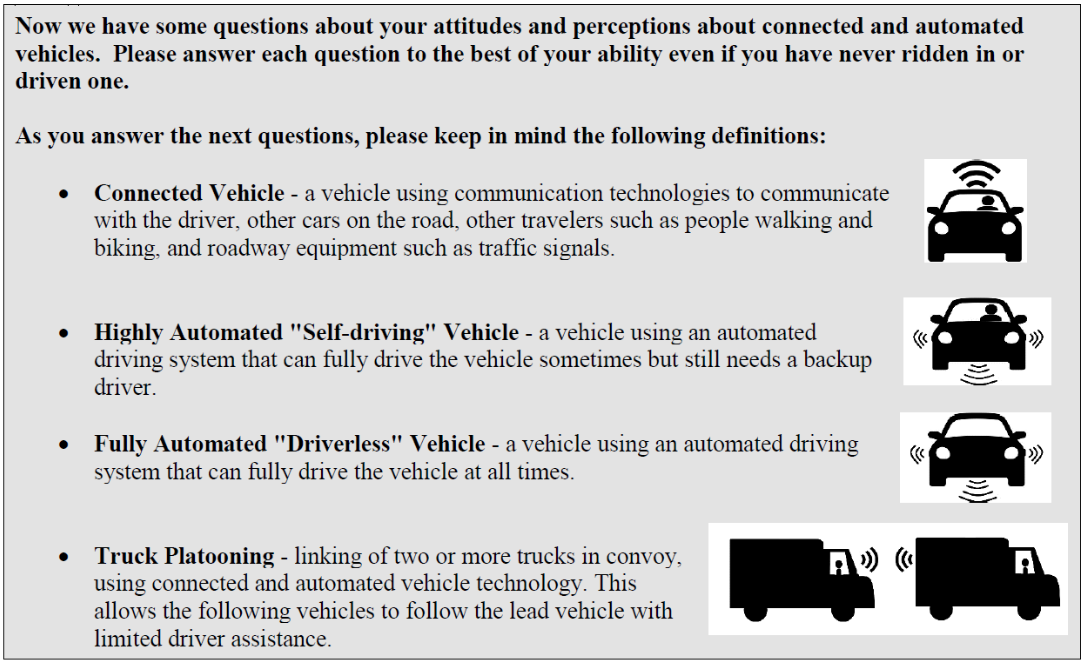
Figure 6: Comparison of unweighted, weighted and ACS distributions of Race in Wisconsin

One last important consideration involved whether individual weights should be used. The sampling frame used in this study was households in Wisconsin, but ultimately, the study is concerned with opinions of all adults in Wisconsin. Adults living in households with several adults would be under-represented in this sampling strategy as only one adult per household could complete the survey and therefore a correction would be needed. However, there could also be an increased chance for responses in households with multiple adults, as there are other adults to take the survey if one adult in the household refuses. This would increase the odds of a household with multiple adults being included in the final sample. As information about adults in household was not available from the American Community Survey, no individual weights were applied to the raking weights.

4. Results

Overall Population Results

The initial analysis of the survey results consisted of analyzing the distribution of responses across key questions included in the survey. It is important to note that before asking the questions reviewed in this section, the survey provided some simple definitions, as shown in **Figure 7**. These were provided to help overcome issues learned from previous studies where the ambiguity of new technology terms lessens the validity of results.



Now we have some questions about your attitudes and perceptions about connected and automated vehicles. Please answer each question to the best of your ability even if you have never ridden in or driven one.

As you answer the next questions, please keep in mind the following definitions:

- **Connected Vehicle** - a vehicle using communication technologies to communicate with the driver, other cars on the road, other travelers such as people walking and biking, and roadway equipment such as traffic signals.
- **Highly Automated "Self-driving" Vehicle** - a vehicle using an automated driving system that can fully drive the vehicle sometimes but still needs a backup driver.
- **Fully Automated "Driverless" Vehicle** - a vehicle using an automated driving system that can fully drive the vehicle at all times.
- **Truck Platooning** - linking of two or more trucks in convoy, using connected and automated vehicle technology. This allows the following vehicles to follow the lead vehicle with limited driver assistance.

Figure 7: Definitions of CAV Technologies Provided in Study Survey

After providing these definitions, the survey asked about respondents' familiarity (Q11) and experience (Q12-13) with these technologies. The results are provided in **Figure 8** and **Figure 9** below. Overall, Wisconsinites are most familiar and experienced with ADAS technologies, followed by CV, and least familiar and experienced with AV technologies. One interesting finding is despite 82% of Wisconsinites reporting to have ridden in a vehicle with ADAS, their reported familiarity was lower with only 57% reporting to be very to extremely familiar with adaptive cruise control and even lower familiarity with other new ADAS technologies. Anti-lock braking systems (ABS) have the highest familiarity with 67% reporting to be very to extremely familiar. This technology was not included as an example of ADAS technology in Q12 since ABS has been in use since the 1970s and standard on new vehicles since the 1990s and the research team wanted to focus on experience with emerging ADAS technologies. ABS was included in Q11 to gage respondents' familiarity with an established ADAS technology. Although their relatively high familiarity with ABS compared to newer technologies is expected, their absolute level of familiarity with a 30+ year old technology is still lower than expected. This could reflect a respondent-acknowledged gap between their awareness that the technology is in use and a more complete understanding of how the technology works. Experience is related to familiarity. When considering familiarity to adaptive cruise control of respondents who have either ridden or driven a vehicle with ADAS, 62% reported very to extreme familiarity compared to only 30% of those who hadn't ridden or driven in an ADAS equipped vehicle. However, experience does not guarantee familiarity as 8% of those who have ridden or driven in an ADAS equipped vehicle reported little to no familiarity across all four newer ADAS technologies. The red bars on **Figure 9** and subsequent figures represent a 95% Wilson score confidence interval. The results provided in this study are one weighted sample of the population. If the study sampling procedure was repeated the weighted results would likely vary by some degree. Under repeated measurement, this confidence interval represents the range of values where the study's estimated proportions would fall within 95% of the time.

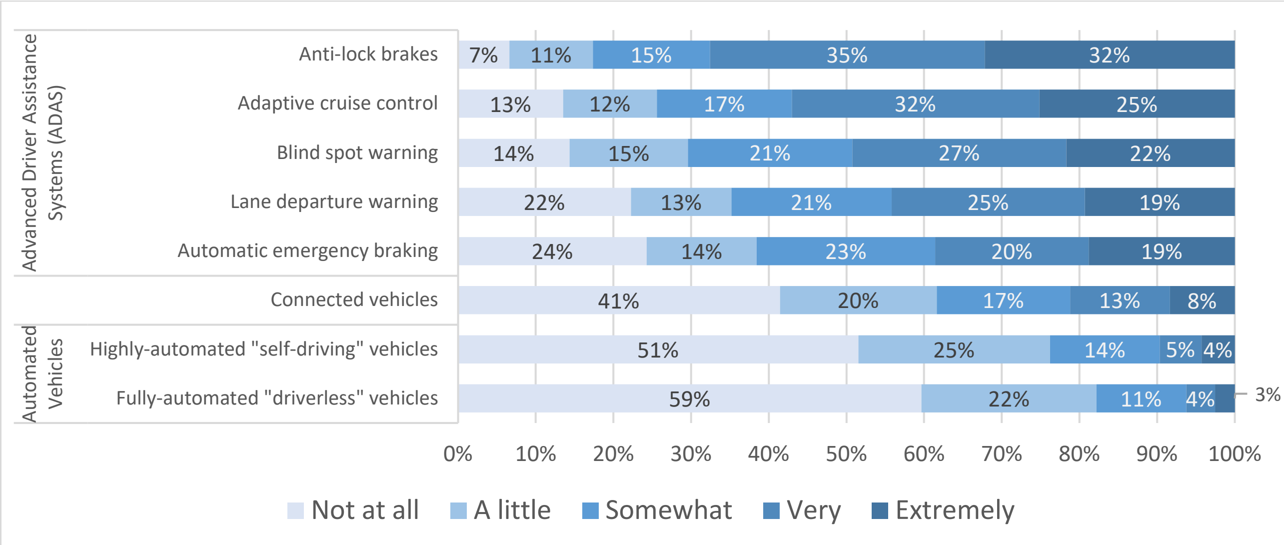


Figure 8: Wisconsin's familiarity to CAV technologies

An unexpectedly large share of respondents believe they have ridden (39%) or driven (32%) in a vehicle with CV technologies despite a very small percentage of vehicles currently including CV on-board units. This is likely due to confusion over the term "connected vehicle". Some respondents may have assumed that vehicles with in-vehicle infotainment systems with Bluetooth or WIFI are connected vehicle technologies. While this is not necessarily incorrect, these more widely used technologies do not have the real-time communication benefits of fully-fledged CV technologies this study was hoping to analyze. **It is important to remember this misconception when considering responses to CV-related questions within this study.** While this would certainly affect responses to questions on general willingness to use and CV effects, it may not substantially affect more specific questions related to specific data elements or concerns.

A similar misunderstanding may be seen with HAVs and FAVs, although to a lesser extent. 12.4% of respondents reported being in a HAV and 2.3% in a FAV, with 1% believing they have personally driven a FAV. This seems unlikely considering that relatively few AV pilots have been deployed in Wisconsin and no passenger AVs are commercially available in the U.S. These respondents may have participated in AV testing in other states or are referring to driver assistance systems like Tesla's *Autopilot*, Chevrolet's *Super Cruise,* Nissan's *ProPilot*, or Volvo's *Pilot Assist*. The 2023 AAA study on U.S. attitudes towards AVs found a similar pattern of 22% of respondents incorrectly expecting these technologies to drive by themselves without supervision (Moye, 2023). This remains a relatively small portion of the population of this study, but care will be taken in later results to account for this misconception in the results.

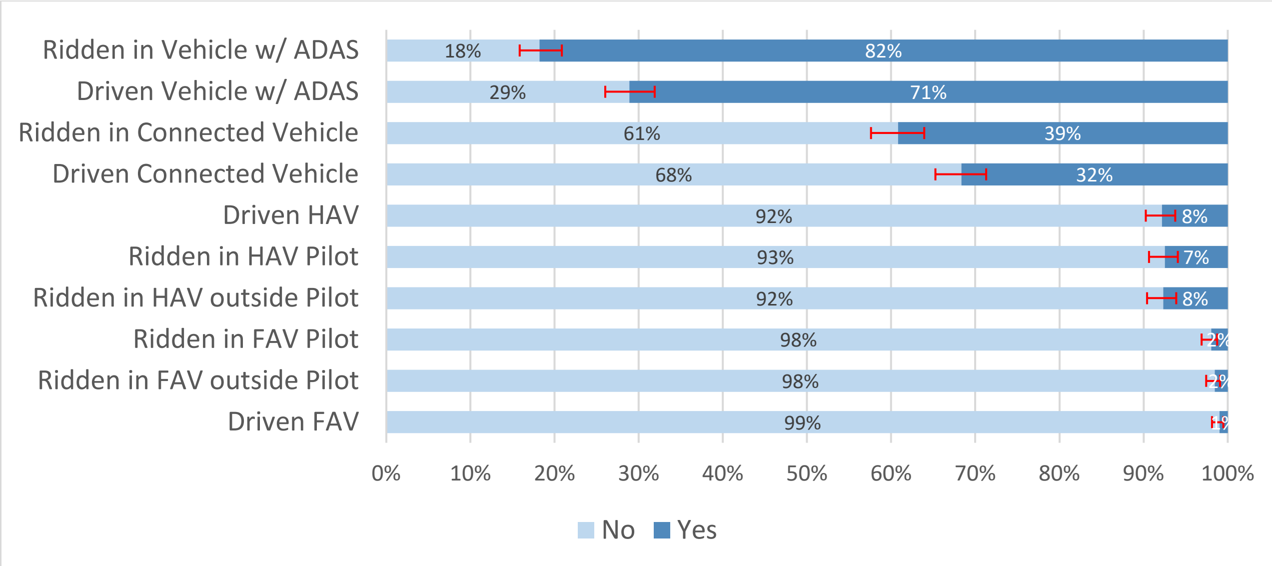


Figure 9: Wisconsin's experience with CAV technologies

The results shown in **Figure 10** relies on responses to Question 18, 19, and 20 in the survey and compares the comfort Wisconsinites feel sharing the road with various vehicle technologies under different contexts:

- driving or riding in a vehicle on a neighborhood street
- driving or riding in a vehicle on a 65-mph highway
- walking or biking on a neighborhood street

First, the differences in responses across contexts were analyzed. No significant differences in the distribution of responses were seen across the two driving/riding context (i.e., driving or riding either on a neighborhood street or 65-mph highway). Significant distributional differences were observed between the driving/riding and walking/biking contexts for all vehicle technologies except for FAVs. Where significant differences did exist across context, generally respondents felt less comfortable sharing the road with a given vehicle technology while walking when compared to driving/riding.

Second, the differences in responses across vehicle technologies were compared. In general, respondents were more comfortable with traditional passenger vehicles than newer CAV technology. Using driving/riding on a 65-mph highway as an example, the following shows the percentage of Wisconsinites who are very or extremely comfortable sharing the highway with each technology:

- 81% - Passenger Vehicle
- 76% - Vehicle with ADAS
- 51% - Connected Vehicle (CV)
- 15% - Highly Automated Vehicle (HAV)
- 12% - Fully Automated Vehicle (FAV)

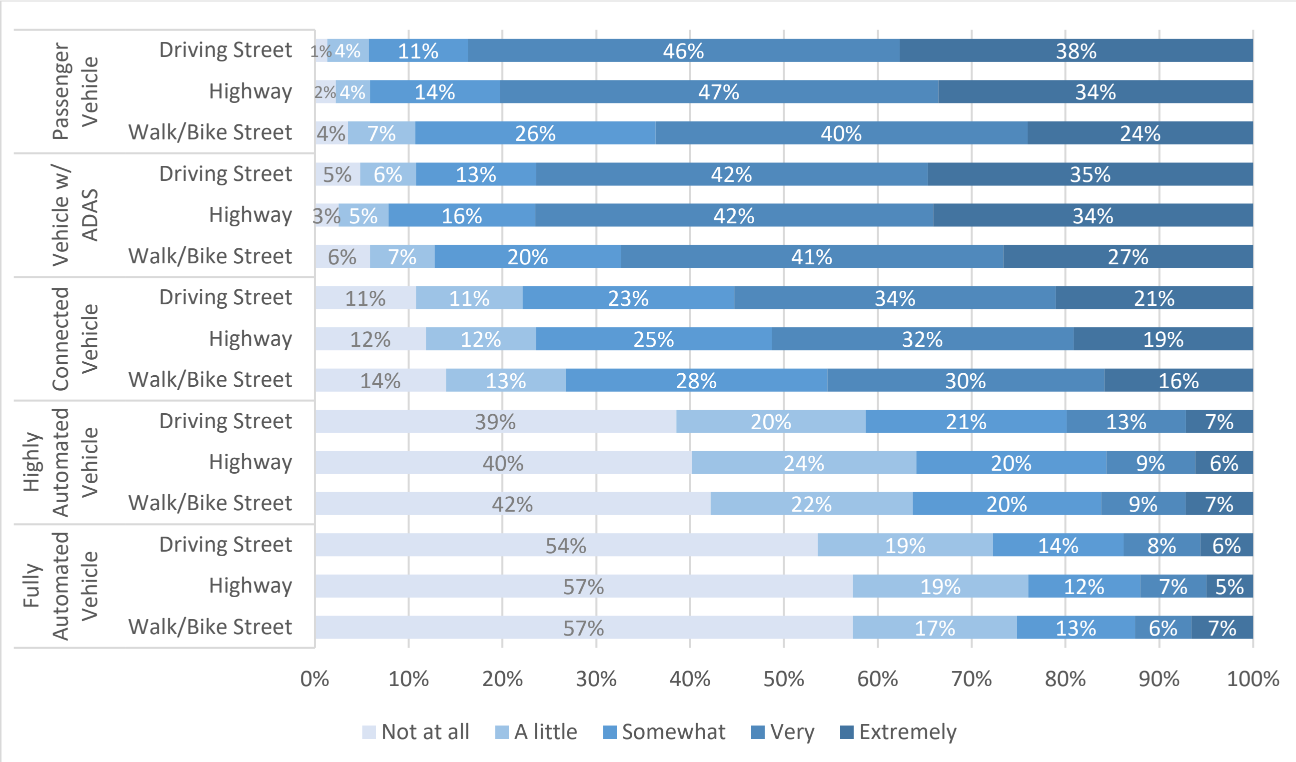


Figure 10: Wisconsin's comfort sharing the road with CAV technologies across context

The next analysis considers respondents' willingness to use CAV technologies and the results can be found in **Figure 11**. Compared to comfort sharing the road, generally Wisconsinites were less willing to use these CAV technologies themselves. The ranking of technologies for willingness to use is similar to comfort sharing the road with vehicles. ADAS technologies are the most preferred followed by CV, HAV, and FAV. Different use cases of HAVs and FAVs did not see large deviation within each type of vehicle technology. For example, the distributions of a highly automated personal vehicle and highly automated shuttle were not significantly different. The same is true for fully automated vehicles. Although a direct comparison to national surveys cannot be made due to differences in question wording and sampling, a general comparison can be made. The AAA annual automated vehicle survey last conducted its national survey of vehicle owning adults in January 2023 (Moye, 2023). When respondents were asked whether they would trust a self-driving vehicle to drive itself while they were in it, 9% responded they would trust the vehicle, 23% indicated they were unsure, and 68% responded they would be afraid. This result tracks fairly closely with the Wisconsin population results. In this study, 14% of Wisconsinites are very-extremely willing to use a personal FAV, 26% were a little or somewhat willing, and 60% were not at all willing. Please note that the 5-item AAA survey used the term "self-driving cars" in this item, but did not define the term and did not ask this question on varying levels of automation. This ambiguity makes a distinction between trust in HAV and FAV difficult. If the more appropriate comparison is with personal HAV, then Wisconsinites would be generally more agreeable to them than the AAA U.S.-based sample would reflect. In this study, 17% of Wisconsinites are very-extremely willing to use a personal HAV, 30% were a little-somewhat willing, and 52% were not at all willing.

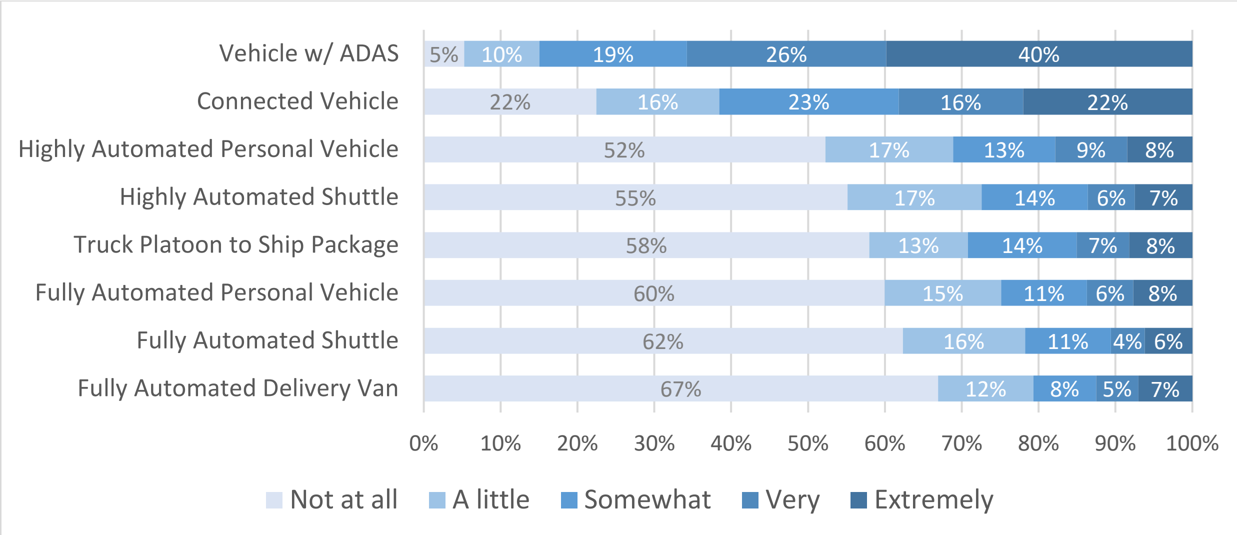


Figure 11: Wisconsin's willingness to use (WTU) CAV technologies

In both of these questions' texts no information is provided about the presence of a vehicle operator. While this may not be relevant for a personal vehicle use case, a future shuttle application could certainly be applied with or without a vehicle operator, if legally allowed. Question 15 and 16 specifically addressed this concern by asking willingness to use a HAV on a 65-mph highway and neighborhood street, respectively, under four operator conditions. **Figure 12** shows the results of these items. Overall, respondents preferred operators to be in the driver's seat than to be elsewhere in the vehicle or remotely controlling the vehicle. Generally, the roadway context type (street or highway) did not significantly affect the willingness to use. When compared to the previous figure's results for willingness to use an HAV shuttle without specifying whether an operator would be in the driver's seat, it is clear that this distinction is important. In that figure, 55% of Wisconsinites have no willingness to use a HAV shuttle, while only 34% of Wisconsinites would be unwilling to use a HAV shuttle if an operator was in the driver's seat. This significant increase in willingness to use a HAV with an inclusion of an operator in the driver's seat represents an important consideration for future AV pilots in Wisconsin.

The research team considered the relationship between familiarity, experience, and willingness to use CAV technologies. ADAS and AV technologies saw a significant positive relationship between experience and willingness to use. This makes some sense as people more willing to use a technology will be more likely to seek out experiences for it and likewise, with greater experience typically comes greater comfort using a new technology. For ADAS, the relationship is as follows:

- With experience – 73% very to extremely willing to use
- Without experience – 32% very to extremely willing to use

For HAVs, the relationship is as follows:

- With experience – 33% very to extremely willing to use
    - There is still a larger share (34%) not at all willing to use
- Without experience – 16% very to extremely willing to use
    - This population represents some level of latent demand who are very to extremely willing to use HAVs but haven't had the chance yet

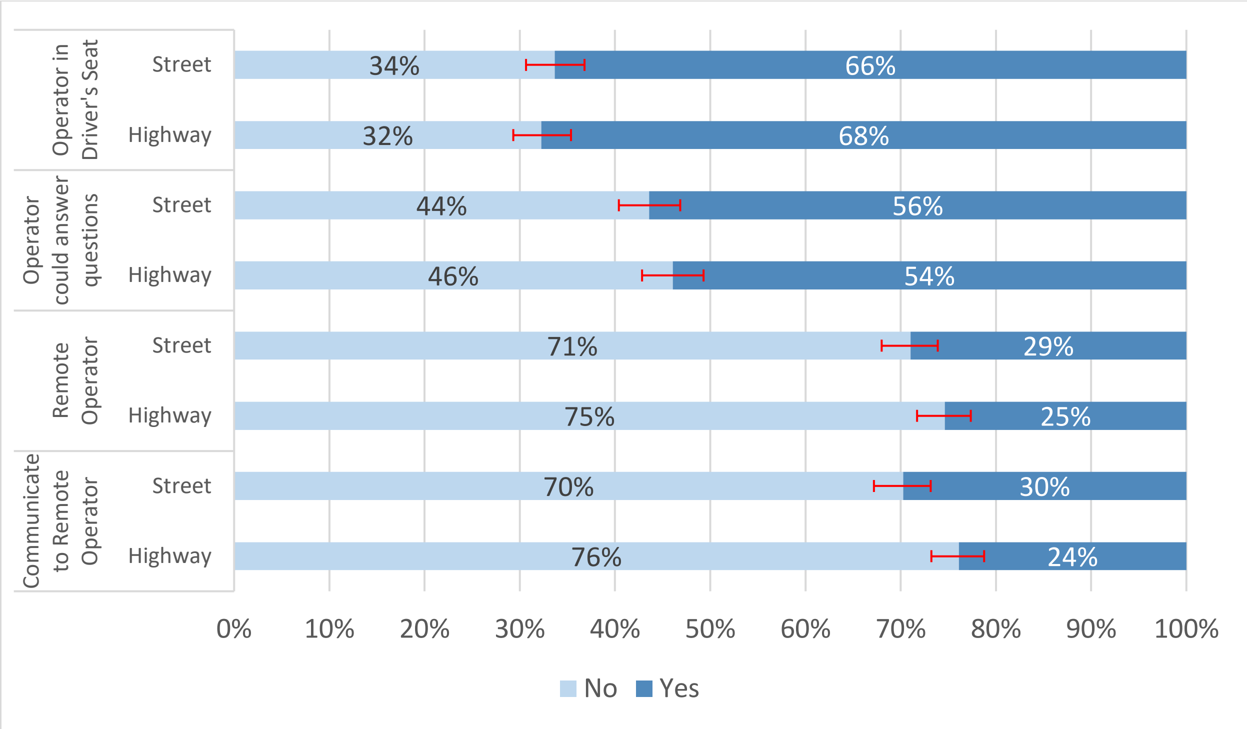


Figure 12: Wisconsin's willingness to use HAV under varying operator conditions

Another important consideration for future pilots of CAV technologies is which data elements are Wisconsinites willing to share. Question 17 asks which of nine data elements a respondent is willing to share for a CV application that could increase their safety. **Figure 13** shows that Wisconsinites were generally more willing to share short-term sensor data (i.e., wiper, headlight, braking, traction, and onboard diagnostics), make/model, and mileage information than more sensitive information like vehicle ownership, trajectories, trip location, and speed. 20% of respondents indicated that they would not share any information while 37% would share all nine data elements. The majority of Wisconsinites (55%) are willing to share the following data for a safety-related CV application: wiper and headlight intensity, onboard diagnostics, braking intensity and traction, mileage, make and model, and speed.

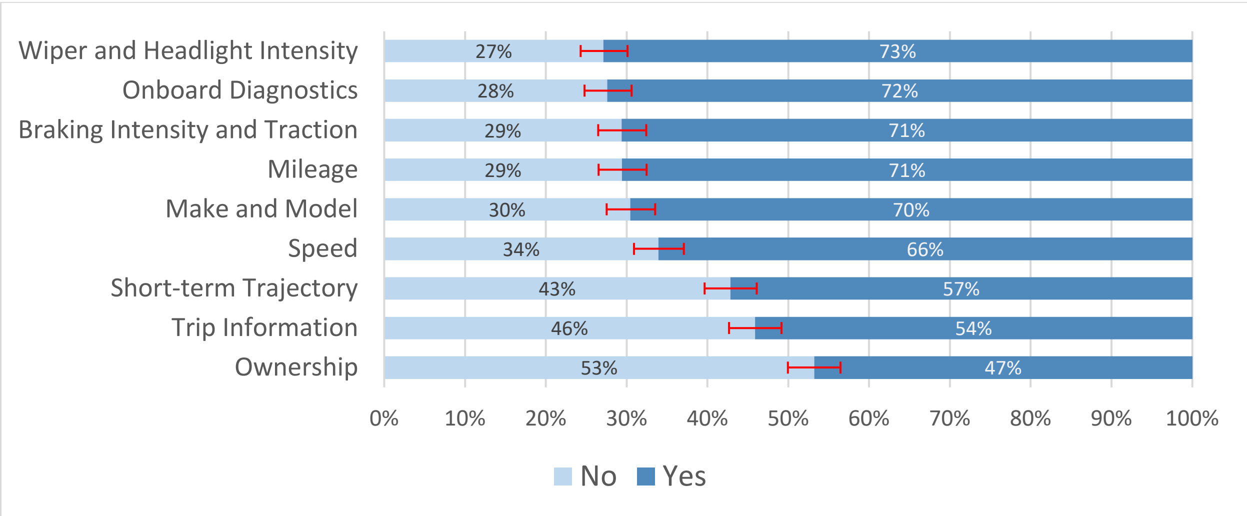


Figure 13: Wisconsin's willingness to share data elements for CV safety application

Questions 22 and 23 asked respondents to consider how HAVs and CVs, respectively, would affect six issues areas: transportation safety, mobility for non-drivers, congestion, air quality, privacy, and greenhouse gas emissions. **Figure 14** shows the results of this comparison with the width of the choice "about the same" held constant to highlight the variations of positive and negative impacts. The issues and technologies with the highest perceived *positive* impact were HAVs effect on non-driver mobility and CVs effect on traffic safety. The issues and technologies with the highest perceived *negative* impact were HAVs effect on traffic safety and CAVs effect on privacy. There is still considerable uncertainty about the effect of these technologies on issues. 10 of the 12 combinations see the "about the same" option selected as the most common with 5 having this option chosen by the majority of respondents.

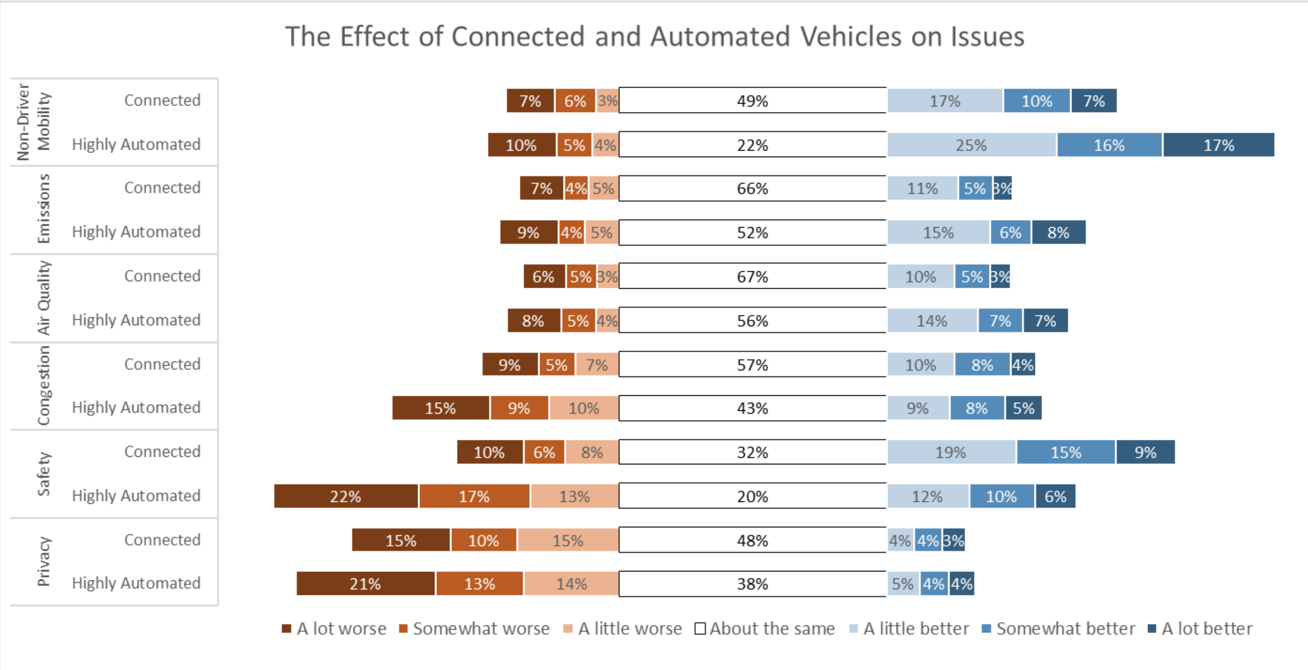


Figure 14: Wisconsin's perceptions of CV and HAV impacts on issue areas

This analysis focused on the overall weighted population and did not delve into subpopulation analysis (e.g., breakdowns by age, gender, education). While subpopulation analysis is useful to begin to understand relationships in the data, analyzing a single variable at a time may mask a more complete multidimensional causal relationship. For this multivariate analysis a latent class clustering model was used that is documented in the next section.

Latent Class Analysis Modeling

A latent class cluster analysis (LCCA) was performed on the survey data to provide a grouping of Wisconsin residents by unique views across a range of CAV topics. This information can be used to create typical profiles of a manageable set of groups. These profiles could be used to target messages to groups. There are several approaches to effectively classifying respondents into groups. One option is using a cluster algorithm such as k-means or k-medoids to cluster groups across n dimensions using n continuous variables. This option was considered for this study, but was not used for two main reasons. The first and predominant reason is that these algorithms can only use continuous variables, which would limit the use of ordinal variables and prohibit the use of nominal variables. The second issue is a methodological one. While LCCA uses a model-based approach to produce probabilities on respondent assignment across clusters, these other cluster algorithms do not. Thus, using LCCA offers higher fidelity, enables statistical test, and allows for the measurement of how responses change over time.

When conducting a LCCA, generally, attitudinal variables are used to determine classes and covariates (such as gender, age, income, race, etc.) are used to describe the makeup of those classes. When the covariates are set to active, they do affect the formation of classes, although to a lesser degree than indicators. There are various options for including the covariates in the model. This analysis adopted a one-step method to generate classes based on respondents' attitudes of CAVs and simultaneously introduce socioeconomic covariates to describe the classes. Initially, 37 indicator variables were chosen to create latent classes:

- Willingness to Use CV and AV (Q14.1 and Q14.5)
- Number of data element willing to share for CV safety application (Q17) (9 items creating one count variable)
- Willingness to share highway with CV and AV (Q18.2 and Q18.5)
- Effect on issues from AVs and CVs (Q22 and Q23) (12 items)
- Concerns with CAVs (Q24) (9 items)
- Actions by Wisconsin State government (Q25) (10 items)
- Technology Readiness Index (Q27 and Q28) (16 items creating one index)

These indicators were chosen from attitudinal items known in the literature to affect CAV sentiment and items specifically related to features of CAVs the research team could use to tailor messages to each group. Sinha et al. (2021) advises to remove variables from the LCCA that are highly correlated with each other (greater than 0.5). Therefore, correlations were generated across all of these variables and those with values greater than 0.5 were removed from the indicator list. At this stage, using factor analysis to combine multiple attitudinal variables was considered, but not initially pursued to see if individual attitudinal survey items stood out as having significant effects on latent class discernment.
Initially, 14 covariates were chosen:

- Helpfulness of methods to learn more about CAV (Q26) (7 items)
- Age (Q29)
- Gender (Q30)
- Race (Q31) transformed to white-alone and other
- Level of Education (Q32)
- Household size (Q33)
- Household Income (Q36)
- Residential Context (Q40) corrected based on survey address

One to 10 clusters were modeled for this set of variables. These cluster results were analyzed across a number of criteria (Sinha et al., 2021):

- Bayesian Information Criterion (BIC) - An index of how well a model fits which seeks to balance the complexity of the model against the sample size
- Entropy - A measure of separation between latent classes
- Minimum size – no cluster should represent less than 5% of the population
- Bivariate residuals (BVR) – local measure of goodness of fit that represents unaccounted for dependency between two variables

Due to remaining correlations between variables, no cluster resulted in satisfactory results. Despite removing variables with high correlations, the primary issue observed with the clustering was high values of bivariate residuals. Latent class models require an assumption of local independence within each class, meaning that variables should not be significantly related to each other within classes. To overcome these issues, an exploratory factor analysis was conducted to develop discrete factors of variables that describe the variation observed in respondents' attitudes. These factors represent interdependencies across the variables within each factor, but are generally unrelated to other factors and the variables that make them. The following attitudinal variables were included in the factor analysis:

- Willingness to Use CV and AV (Q14) (8 items)
- Willingness to share highway with CV and AV (Q18) (6 items)
- Effect on issues from AVs and CVs (Q22 and Q23) (12 items)
- Concerns with CAVs (Q24) (9 items)
- Actions by Wisconsin State government (Q25) (10 items)
- Helpfulness of methods to learn more about CAV (Q26) (7 items)

Only factors with eigenvalues greater than one were included in the initial analysis. The unrotated factor loadings of these factors were analyzed, and only factors that had at least 3 significant (greater than 0.3 or less than -0.3) loadings were included further. This yielded a 6 factor result and the varimax rotated factor matrix is shown below. Each loading represents the weight applied to the variable in creating the linear combination of attributes in each factor. Loadings below 0.3 and above -0.3 are not shown in the table. The sign of the loading (positive or negative) determines whether a variable either adds or detracts from the factor, but the absolute value of the loading is important, as that determines the strength of the relationship.

Table 2: Rotated factor analysis loadings

Q#	Question Topic	Factor					
		AV Accept	CAV Benefits	State CAV Action	CAV Concerns	CAV Education	CV/ADAS Accept
		1	2	3	4	5	6
Q14._	How willing would you be to use…						
Q14.1	...a connected vehicle?	0.38					0.57
Q14.2	...a vehicle with blind spot warning?	0.30					0.61
Q14.3	...a CAV truck platoon?	0.66					
Q14.4	...a highly automated shuttle?	0.85					
Q14.5	...a highly automated vehicle?	0.86					
Q14.6	...a fully automated shuttle?	0.89					
Q14.7	...a fully automated vehicle?	0.88					
Q14.8	...a fully automated delivery van?	0.86					
Q18._	How comfortable are you sharing a 65-mph highway with…						
Q18.1	...a traditional passenger vehicle?						0.51
Q18.2	...a connected vehicle?						0.65
Q18.3	...a vehicle equipped with blind spot warning						0.74
Q18.4	…CAV semitruck platoon	0.53					0.31
Q18.5	...a highly automated	0.72					
Q18.6	...a fully automated	0.74					
Q22.1	AV Impact on Safety	0.52	0.47				

Q22.2	AV Impact on Mobility for non-drivers	0.34	0.48				
Q22.3	AV Impact on Congestion	0.40	0.59				
Q22.4	AV Impact on Air Quality		0.75				
Q22.5	AV Impact on Privacy		0.51				
Q22.6	AV Impact on GHG		0.76				
Q23.1	CV Impact on Safety		0.55				0.37
Q23.2	CV Impact on Mobility for non-drivers		0.60				
Q23.3	CV Impact on Congestion		0.70				
Q23.4	CV Impact on Air Quality		0.85				
Q23.5	CV Impact on Privacy		0.55				
Q23.6	CV Impact on GHG		0.85				
Q24._	Are you concerned about…						
Q24.1	…vehicles not driving as well as human drivers?	-0.34			0.54		
Q24.2	…legal liability in case of a crash?				0.69		
Q24.3	…data privacy?				0.58		
Q24.4	…interactions with other road users?				0.67		
Q24.5	…equal access to these technologies?				0.44		
Q24.6	…sensor equipment failure?				0.79		
Q24.7	…vehicle computer system failure?				0.79		
Q24.8	…vehicle computer hacking?				0.70		
Q24.9	…motion sickness?						
Q25._	How important is it for the Wisconsin government to…						
Q25.1	...provide educational materials?			0.72			
Q25.2	...address cybersecurity concerns?			0.61	0.34		
Q25.3	...fund demonstration projects?			0.75			
Q25.4	...conduct demonstration projects?			0.74			
Q25.5	…oversee safe deployment			0.67			
Q25.6	…maintain equal access to technologies			0.70			
Q25.7	...address data privacy concerns?			0.60	0.34		
Q25.8	...clarify liability in the event of a crash?			0.59			
Q25.9	...fund grants for broadband?			0.60			
Q25.10	…offer money back for purchasing CV?			0.51			
Q26._	How helpful would the following be to learn about CAVs						
Q26.1	Materials posted on website					0.68	
Q26.2	YouTube videos					0.75	
Q26.3	Social media posts					0.65	
Q26.4	Online training					0.77	
Q26.5	In-person driver's education training			0.32		0.65	
Q26.6	In-person demonstration			0.32		0.64	
Q26.7	Newsletters					0.57	

The six factors can be described as follows:

- Factor 1 (*AV Acceptance*)
  - positive factor loadings on willingness to use CVs and AVs, willingness to share the road with AVs, and some benefits of AVs, as well as, a negative loading on question 24.1 – concern about CAVs not driving as well as human drivers
  - although CV, blind spot warning, and CAV semitrucks are included in this measure, their weights are relatively low compared to AVs
- Factor 2 (*CAV Benefits*)
  - positive factor loadings on benefits of CAVs
- Factor 3 (*State CAV Action*)
  - positive factor loadings on actions by Wisconsin State government and in-person training and demonstrations
- Factor 4 (*CAV Concerns*)
  - positive factor loadings for CAV concerns and Wisconsin State government actions to address cybersecurity and data privacy
- Factor 5 (*CAV Education*)
  - positive factor loadings on methods to learn more
- Factor 6 (CV/ADAS Acceptance)
  - positive factor loadings on willingness to share the road with vehicles, CVs, vehicles with blind spot warning, and CAV semitrucks; willingness to use CVs and blind spot warning; and benefits of CVs on safety

It should be noted that many of these factors reflect high correlation between multiple questions within one of the survey sections. For example, factors 2, 3, 4, and 5 are each, at least, primarily composed of questions within one section. This may reflect more consistent attitudes towards these areas of interest. For example, respondents who indicate that one state government action is needed are more likely to respond that other state actions are also needed. Another potential explanation is yea-saying and nay-saying bias, which is a biased tendency for respondents to answer similarly to a set of questions even if their actual attitudes differ between them. A drawback of using these factors in lieu of the individual item responses is that the results lose nuanced preferences for particular items that may be averaged out when incorporated into the larger factor. For example, a respondent who is very concerned about data privacy and hacking, but not concerned about other CAV issues, may have a marginal score for factor 4 (CAV Concerns). While their score may hide this particular pattern, if enough respondents displayed this preference, those items would become their own factor. A benefit of this decreased precision is that errors are also averaged out and the factors indicate generalized preferences along a continuous scale. For example, if a respondent answered Q25.3 that it is extremely important for state government to fund demonstration projects, but then answered Q26.6 that it is not at all helpful to have in-person demonstrations to learn more about CAVs, factor 3 will average these responses along with other items to produce a less extreme score. A similar effect can be observed in factor 2 with CAVs' effects on issues. It would be ideal to use individual issue areas to cluster respondents. For example, clustering respondents with extreme views on CAVs' effect on privacy or transportation safety could be helpful when creating messages that are interesting to them. However, because many of these responses are correlated with each other, the factor analysis approach generates one overall factor for these issues areas that will have a high score for respondents who think CAV will benefit issues and low scores for respondents who think CAVs will make them worse. Individual responses to issue areas are still retained for the description of clusters later in the analysis.

The five factors were introduced to the LCCA as indicators along with the Technology Readiness Index (TRI), and the number of data elements shared for a CV safety application. Factor 5 was not included in the model to allow individual communications mechanisms to affect the clustering in the covariates instead of a generalized score for willingness to learn about CAVs, as factor 5 represents. Initially, 30 covariates were chosen:

- Use of different modes of transportation including walking, personal vehicle, rideshare, and transit (Q4.1, 4.4, 5.1, and 5.3)
- Involvement in crash in last 10 years (Q9)
- Number of vehicles (Q10)
- Familiarity with CVs, ADAS, and AVs (Q11.1, 11.2, and 11.7)
- Experiences with CV, ADAS, and AVs (Q12.2, Q12.4, Q13.3, and Q13.5)
- Helpfulness of methods to learn more about CAV (Q26) (7 items)
- Age (Q29)
- Gender (Q30)
- Race (Q31) transformed to white-alone and other
- Level of Education (Q32)
- Household size (Q33)
- Number of children (Q34)
- Number of teenagers (Q35)
- Household Income (Q36)
- Residential Context (Q40) corrected based on survey address

The LCCA iterative process used in this study consisted of the following:

1. Generate 1-10 cluster models for a given set of variables
2. Evaluate the BIC for each model and select the number of clusters based on lowest BIC or significant reduction in BIC compared to the model with one less cluster
3. For the model selected in the former step, review the p-values of indicators and covariates, and remove indicator or covariate with the highest p-value above 0.05
    - If appropriate, move indicator to active covariate
4. If all variables have p-values less than 0.05, review the bivariate residuals to determine if any exceed 3. If several residuals exceed 3 for a given variable, remove the variable. If one exceeds 3, remove that interaction from the model.

Throughout the process, the 3-class model generally saw the most significant BIC improvement compared to the models with 4 or more classes. This is one common way to identify the number of classes based on the point of diminishing returns. The 5-class and 6-class models saw the lowest BIC index overall. The LCCA process was completed for the 5-class model and a comparable 3-class was created to comparison.

Latent Class Analysis Results

The following provides the results of the LCCA process and documents the clusters provided in the 5-class and 3-class models. The final models both included three indicator variables:

- Number of data element willing to share for CV safety application (Q17) (9 items creating one count variable)
- Factor for AV Acceptance (primarily consists of items related to willingness to use and share the road with AVs)
- Willingness to use ADAS vehicles (Q14.2)

These variables can be described as acceptance of three distinct technologies: CV, AV, and ADAS. Each variable is a different type. CV acceptance is represented as a count variable of the number of data elements a respondent is willing to share. AV acceptance is measured by a factor score comprised of various items primarily related to willingness and share the road with AVs. Willingness to use ADAS vehicles is a single survey item. Some sensitivity analysis was performed on whether other similar variables would produce similar or improved results, but the aforementioned variables produced the best cluster models. The final models differed on the covariates included, but both included the following:

- Frequency of ridesharing (Q5.1)
- Helpfulness of an in-person demo for learning about CAVs (Q26.6)
- Gender (Q30)
- Technology Readiness Index (TRI) (Q27 and Q28)
- Household size (Q33)

Note that although the TRI was originally included as an indicator variable, due to correlations with other variables it was changed to a covariate. The 5-factor model also included two additional covariates:

- Frequency of walking (Q4.1)
- Race (Q31) transformed to white-alone and other

These covariates were not significant in the 3-cluster model and as can be seen below, help explain some of the sub-clustering differences between the 3-class and 5-class models. First, this analysis explored how the two models compared to each other. In this case, it was important to identify which 5-class model clusters made up the 3-class model clusters. **Table 3** below shows how the percentage of the 5-class model match up with the 3-class model.

Table 3: Latent class clustering 3-class and 5-class model overlap

		3-Class Model		
		1	2	3
5-Class Model	1	**80%**	20%	0%
	2	**100%**	0%	0%
	3	2%	0%	**98%**
	4	2%	**98%**	0%
	5	0%	**100%**	0%

Overall, the clusters from the 5-class model nest very well in the 3-class model with four of the clusters (2, 3, 4, and 5) nearly entirely matching one of the 3-class model clusters. Cluster 1 in the 5-class model generally related to cluster 1 in the 3-class model, but had about 20% in cluster 2 in the 3-class model. The predominant nesting of the two models can generally be described as the following:

- Cluster 1 (3-class) - 44% of the population who are accepting of ADAS, moderately accepting of CVs and not very accepting of AVs
    - Cluster 1 (5-class) – 27% of population who are more accepting of AV and ADAS than their 3-class average
        - Higher share of women (77%)
        - Higher share of people not exclusively white (20%)
        - Generally, don't walk very frequently (34% never walk, while 11% walk daily)

- Cluster 2 (5-class) – 24% of population who are less accepting of AV and ADAS than their 3-class average
  - Lower share of women (39%)
  - Higher share without college degree (78%)
  - Lower share of people not exclusively white (4%)
  - Generally, walk more (15% never walk, while 30% walk daily)
- Cluster 2 (3-class) – 35% of the population who are accepting of all CAV technology
  - Cluster 4 (5-class) – 20% of population who are less accepting of AV and ADAS than their 3-class average
    - Average share of men (49%)
    - Lower share of people not exclusively white (8%)
    - Slightly above average TRI (3.1)
  - Cluster 5 (5-class) - 8% of population who are more accepting of AV and ADAS than their 3-class average
    - High share of men (85%)
    - Higher share of people not exclusively white (22%)
    - Very high TRI (3.8)
- Cluster 3 (3-class) – 21% of the population who are not accepting of CAV technology
  - Cluster 3 (5-class)

Figure 15 below provides a profile plot of the five clusters with normalized (0-1) mean values across the three indicator variables. For example, Q17 is a count variable ranging from 0-9 so the normalized average value for each cluster is the average response for members of each cluster divided by 9. For comparative purposes, the line type represents the approximate nesting into 3-class model clusters previously mentioned. There is generally moderate to high support for willingness to use ADAS across clusters ranging from 0.52 to 0.98. There is a tighter grouping of the high willingness to share CV data among clusters 1, 2, 4, and 5. Cluster 3 represents the outlier in this dimension as members of that cluster are generally not willing to share any data for a CV safety application. There is large variation across clusters for the AV acceptance factor ranging from 0.21 to 0.84. Cluster 5 has the highest acceptance; cluster 4 has moderate acceptance; and there is a grouping of cluster 1, 2, and 3 with generally low AV acceptance.

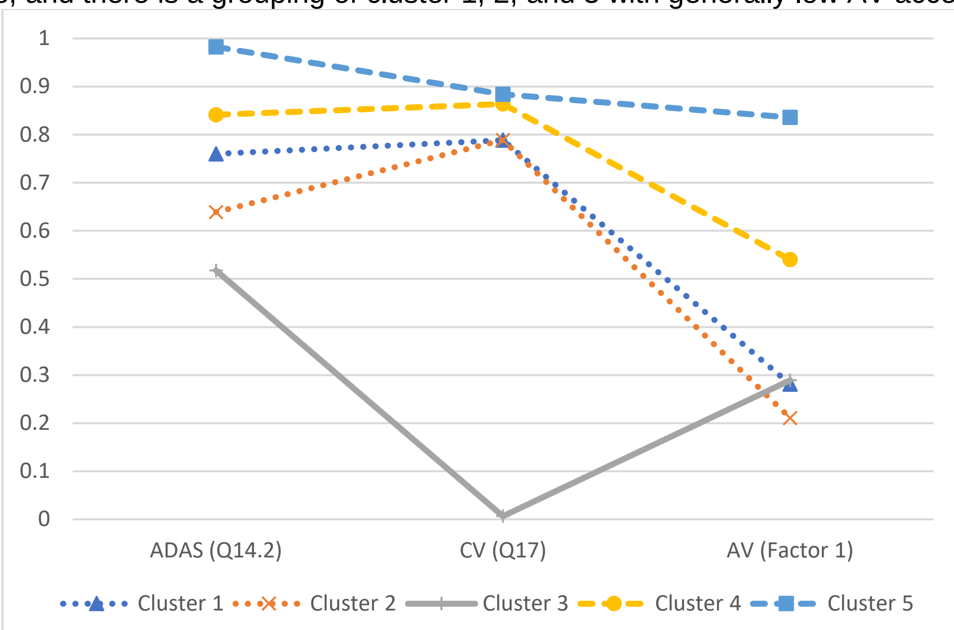


Figure 15: Normalized mean values of 5-class clusters across indicators

Table 4 below provides the proportion of each cluster along with 35 variables that describe differences between clusters. Variables in bold were specifically included in the LCCA, while others are included to show useful, but inactive patterns that emerged from the LCCA. The table is organized by technology area, CAV concerns and impacts, state role, and demographics.

There can be observed large variation in responses to questions within CV technology. For example, despite having similar numbers of data items willing to share for a CV safety application across clusters 1, 2, 4, and 5, clusters 1 and 2 see much lower proportions of willingness to use and share the road with CVs than clusters 4 and 5. This may be partially due to cluster 1 and 2's larger concern over computer hacking, and to a lesser degree, data privacy. It may also be due to their less optimistic view of the safety benefits of CVs. Thus, while they are willing to share similar amounts of data for a CV application, they are generally less willing to use or share the road with CVs until hacking and privacy concerns are addressed and/or safety benefits are shown.

Attributes associated with AVs generally show a consistent deviation across clusters. Cluster 5 is extremely accepting of AVs due to perceived benefits to safety, non-drivers' mobility, and congestion, while having few concerns about AVs not driving well. Cluster 4 is moderately accepting of AVs, showing a large reduction from cluster 5, despite having similarly optimistic views of AV benefits on key issues. One potential explanation for this reduction is the cluster 4's relatively higher concern about CAV liability in a crash and system failure. Thus, while this group sees high potential in AVs benefits to safety and mobility for non-drivers, they will need early stage issues of liability and reliability to be addressed before broadly accepting. The remaining 72% of the population in clusters 1, 2, and 3 see much lower benefits from AVs on top issue areas and much higher concerns from CAVs not driving as well as humans, liability in a crash, system failure, and computer hacking. They will need to see considerable changes to alter they acceptance of AVs.

Table 4: 5-class cluster results with relevant attributes

Proportion			27%	24%	21%	20%	8%
Variable	**Description**	**Metric**	**1**	**2**	**3**	**4**	**5**
Q14.2	**Very-Extremely willing to use ADAS**	Percent	73%	55%	39%	85%	100%
Q18.3	Very-Extremely willing to share road with ADAS	Percent	79%	78%	54%	87%	97%
Q17	**Number of CV data items shared**	Average	7	7	0	8	8
Q14.1	Very-Extremely willing to use CV	Percent	41%	23%	15%	58%	82%
Q18.2	Very-Extremely willing to share road with CV	Percent	51%	42%	30%	70%	83%
Factor 1	**Factor scores for AV acceptance**	Average	-0.35	-0.72	-0.31	1.00	2.54
Q14.5	Very-Extremely willing to use HAV	Percent	2%	0%	3%	44%	98%
Q18.5	Very-Extremely willing to share road with HAV	Percent	5%	3%	3%	32%	86%
Q14.7	Very-Extremely willing to use FAV	Percent	1%	0%	1%	28%	96%
Q18.6	Very-Extremely willing to share road with FAV	Percent	2%	3%	3%	21%	79%
Factor 2	Factor scores for CAV Benefits	Average	-0.25	0.17	-0.47	-0.05	0.44
Q22.1	AVs will have positive impact on safety	Percent	45%	30%	33%	76%	86%
Q22.2	AVs will have positive impact on non-drivers	Percent	56%	55%	41%	72%	84%
Q22.3	AVs will have positive impact on congestion	Percent	17%	11%	14%	41%	62%
Q23.1	CVs will have positive impact on safety	Percent	45%	42%	20%	58%	63%

Factor 4	Factor scores for CAV `Concerns	Average	-0.10	0.14	0.28	-0.14	-0.37
Q24.1	Very-Extremely concerned about CAV not driving as well as human drivers	Percent	59%	64%	73%	30%	18%
Q24.2	Very-Extremely concerned about CAV liability in crash	Percent	66%	74%	70%	55%	21%
Q24.3	Very-Extremely concerned about data privacy	Percent	46%	51%	79%	40%	29%
Q24.7	Very-Extremely concerned about computer failure	Percent	72%	82%	79%	60%	38%
Q24.8	Very-Extremely concerned about computer hacking	Percent	60%	71%	78%	47%	48%
Q25.3	State funding demonstration projects is very-extremely important	Percent	61%	56%	44%	56%	63%
Factor 5	Factor scores for CAV education	Average	0.28	0.23	-0.32	0.16	0.01
Q26.2	CAV YouTube videos very-extremely helpful	Percent	41%	43%	25%	50%	73%
Q26.4	CAV online training very-extremely helpful	Percent	49%	38%	23%	47%	49%
Q26.6	**In-person demo very-extremely helpful**	Percent	60%	64%	36%	60%	48%
Q4.1	**Walk more than once a week**	Percent	29%	53%	35%	52%	37%
Q5.1	**Use rideshare or taxi**	Percent	39%	15%	22%	54%	59%
Q29	Proportion age 18-39	Percent	36%	20%	26%	53%	62%
Q30	**Proportion of women**	Percent	77%	39%	39%	49%	15%
Q31	**Proportion not exclusively white**	Percent	20%	4%	8%	8%	22%
Q32	Proportion without a college degree	Percent	69%	78%	78%	56%	57%
Q40	Proportion living in suburb or large city	Percent	53%	40%	37%	52%	55%
TRI	**Index of technology readiness**	Average	2.91	2.57	2.52	3.10	3.82
Q33	**Household size**	Average	2.1	2.2	2.3	3.0	2.8

Cluster membership can also provide insight about possible state actions and communications. Cluster 3 currently has very little interest in learning more about CAV technologies. Clusters 1, 2, and 4 (71% of the population) seem very open to learning more about CAVs with roughly 60% of the members (43% of population overall) considering in-person demonstrations of CAV technology to be very to extremely helpful. Cluster 5 already has wide acceptance of CAVs, and 73% indicated CAV YouTube videos would be very-extremely helpful.

Demographics seem to have an impact on CAV attitudes. Younger populations (18-39) made up 53-62% of clusters 4 and 5 and may have contributed to these clusters willingness to accept CAV technologies. While clusters 1, 2, 4, and 5 all saw high willingness to share the road with ADAS vehicles, cluster 2 saw a large decrease in willingness to use ADAS technologies. A similar discrepancy can be seen in cluster 2's willingness to use and share the road with CVs. Although the full cause is unknown, a portion of these discrepancies may be caused by the generally more rural residential context, lower TRI, and older age of cluster 2 and 3's members.

Keeping in mind the misconceptions about CV and AV technology presented in Section 4, cluster membership was analyzed with respect to experience using CV and AV technology. Specifically, the distribution of responses to Q12.1 and Q13.1, experience driving a connected vehicle and high automated vehicle, respectively, were analyzed and the results are shown in **Table 5**. No cluster sees a majority of its members made up of respondents who reported driving CV or HAV. This is reassuring as it avoids a clustering where most of one or multiple clusters inaccurately understands their experience with this technology. Cluster 5 sees the highest proportion of its members reporting driving these technologies, with 50% stating they have driven a CV and 23% reporting they have driven an HAV. It is expected to see this cluster with the highest composition of reported experience with these technologies as they are very accepting and willing to use new and CAV technologies. This is indeed higher than the population averages of 32% and 8%, respectively, but doesn't make up the great majority of the cluster.

Table 5: Stated experience driving CV and HAV by 5-class cluster

	Cluster				
Experience Driving Technology	1	2	3	4	5
Driven CV	34%	28%	22%	34%	50%
Not Driven CV	66%	72%	78%	66%	50%
Driven HAV	7%	4%	6%	10%	23%
Not Driven HAV	93%	96%	94%	90%	77%

Experience with these technologies generally follow their ranking for corresponding indicators. This is logical as willingness to use these technologies, will likely result in experience, even if the definitions of these technologies vary between respondents.

5. Implications for WisDOT Action

There are several implications for WisDOT to consider. From the overall results on CAV familiarity, Wisconsinites lack exposure to CAVs with 76% reporting little to no familiarity with HAVs, and 61% reporting little to no familiarity with CVs. ADAS technologies saw higher experience and familiarity, but still saw 25-38% of respondents with little to no familiarity with new ADAS technologies. From data on willingness to use and comfort sharing the road with CAV technologies Wisconsinites are generally accepting of ADAS technologies, on the fence about CV, and still wary of AV technologies with the percent of respondents reporting very or extreme comfort sharing the road with each technology as 76%, 51%, and 15%, respectively. Wisconsinites willingness to use these technologies followed the same ranking, albeit with less willingness to use the technologies than to travel next to them. 66%, 38% and 13%, respectively, were very to extremely willing to use ADAS, CV, and AV technologies.

While having an operator in the driver's seat is currently a requirement in Wisconsin, for various operation reasons, future AV use cases may wish to move or remove this operator when it is safely and legally possible to do so. However, based on the results of this study, keeping an operator in the driver's seat would currently result in a significantly larger proportion of Wisconsinites willing to use the AV application. According to survey results across multiple questions, 55% of Wisconsinites have no willingness to use a HAV shuttle generally, while only 34% of Wisconsinites would be unwilling to use a HAV shuttle if an operator was in the driver's seat. This potential increase of 21% of the population willing to use an AV shuttle service could be a crucial factor in early stage pilots. It should be noted, however, that most pilots would be deployed in relatively small geographic scopes so further refinements of subarea population attitudes would be needed.

From the latent class clustering analysis (LCCA), attitudes about different technologies and preferences were not consistent across the population. Five distinct clusters of the population were identified with unique attributes. The following describes these clusters and their acceptance, perceived benefits, and concerns of these technologies. This information can be used to target messaging to each group.

Cluster 1

Description

This cluster represents 27% of the population who are accepting of ADAS, moderately accepting of CVs and not very accepting of AVs. This group generally saw below average concerns and benefits of CAVs. Members of cluster 1 were primarily women (77%) living in 1-2-person households (74%) who tended to live in suburbs or large cities (53%) and had the highest percentage of cluster members reporting daily challenges from lack of accessibility for wheelchair users (20%) and being unable to drive (19%).

Top Methods to Learn More

This cluster had the highest average factor score for interest in learning more about CAVs. They found the highest value with in-person CAV training and demonstrations, with 62% reporting this to be very-extremely helpful. They also found online training and YouTube videos to be helpful with 49% and 41%, respectively, reporting these options as very-extremely helpful.

Top Benefits

Cluster 1 saw the second lowest average factor score for overall CAV benefits. They saw the highest benefits of AVs on non-driver mobility with 56% reporting positive impact. They saw the next highest benefits of CVs on transportation safety with 45% reporting positive impact.

Top Concerns

Cluster 1 also saw the third lowest average factor score for overall CAV concerns. They expressed the highest concern with sensor and computer failure with 77% and 72%, respectively, reporting to be very to extremely concerned. They also expressed concern about legal liability in a crash and vehicles not driving as well as human drivers with 66% and 59% reporting very to extreme concern.

Cluster 2

Description

This cluster represents 24% of the population who are accepting of ADAS, moderately accepting of CVs and not very accepting of AVs. This group generally saw high concerns and benefits of CAVS. Members of cluster 2 were primarily white (94%), older than age 39 (78%), without a college degree (78%), living in 1-2-person households (72%) who tended to live in small cities or rural areas (60%), and used rideshare the least (84% did not use it and 14% used a few times a year). This group had the second lowest average Technology Readiness Index (TRI) of 2.6 on a scale from 1 to 5, indicating that they are generally wary of most new technology, but they appear to be willing to share data for a CV safety-related application due to its perceived benefits.

Top Methods to Learn More

This cluster had the second highest average factor score for interest in learning more about CAVs. They found the highest value with in-person CAV training and demonstrations, with 64% reporting this to be very-extremely helpful. They also found YouTube videos to be helpful with 43% reporting this as very-extremely helpful.

Top Benefits

Cluster 2 saw the second highest average factor score for overall CAV benefits. They saw the highest benefits of AVs on non-driver mobility with 55% reporting positive impact. They saw the next highest benefits of CVs on transportation safety and non-driver mobility with 42% and 33%, respectively, reporting positive impact.

Top Concerns

Cluster 2 also saw the second highest average factor score for overall CAV concerns. They expressed the highest concern with sensor and computer failure with 84% and 82%, respectively, reporting to be very to extremely concerned. They also expressed concern about legal liability in a crash and vehicle hacking with 74% and 71% reporting very to extreme concern.

Cluster 3

Description

This cluster represents 27% of the population who were generally not interested in any of the vehicle technologies and were the least interested in learning more. This group generally saw the high concerns and the lowest benefits of CAVS. Members of cluster 3 were primarily older than age 39 (67%), without a college degree (78%), living in 1-2-person households (68%), who tended to live in small cities or rural areas (63%). This group had the lowest average Technology Readiness Index (TRI) of 2.5 on a scale from 1 to 5, indicating that they are generally wary of most new technology.

Top Methods to Learn More

This cluster had the lowest average factor score for interest in learning more about CAVs. They found the highest value with in-person CAV training and demonstrations, with 40% reporting this to be very-extremely helpful.

Top Benefits

Cluster 3 saw the lowest average factor score for overall CAV benefits. They saw the highest benefits of AVs on non-driver mobility with 41% reporting positive impact.

Top Concerns

Cluster 3 saw the highest average factor score for overall CAV concerns. They expressed the highest concern with sensor and computer failure with 82% and 79%, respectively, reporting to be very to extremely concerned. 70% or more expressed very to extreme concern about all areas of concern except equal access to CAV technology, to which 55% reported this level of concern.

Cluster 4

Description

This cluster represents 20% of the population who are accepting of ADAS and moderately accepting of CVs and AVs. Members of cluster 4 generally live in larger households, who tended to be younger than age 40 (53%), and live in suburbs or large cities (52%). This group has the second highest proportion with a college degree (42%).

Top Methods to Learn More

Like other groups, cluster 4 members generally found the highest value with in-person CAV training and demonstrations, with 60% reporting this to be very-extremely helpful. They also found YouTube videos to be helpful with 50% reporting this as very-extremely helpful.

Top Benefits

Members of cluster 4 saw the highest benefits of AVs on non-driver mobility with 72% reporting positive impact. They saw the next highest benefits of CVs on transportation safety with 58% reporting positive impact.

Top Concerns

Members of cluster 4 expressed the highest concern with computer and sensor failure with 60% and 58%, respectively, reporting to be very to extremely concerned. They also expressed concern about legal liability in a crash with 55% reporting very to extreme concern. Cluster 4 saw relatively higher concern about CAV liability in a crash and system failure when compared to Cluster 5. Thus, while this group sees high potential in AVs benefits to safety and mobility for non-drivers, they will need early stage issues of liability and reliability to be addressed before broadly accepting.

Cluster 5

Description

Members of cluster 5 make up about 8% of the population. Members of cluster 5 generally are primarily men (85%) who live in larger households who tended to be younger than age 40 (62%) and live in suburbs or large cities (55%). They have the highest proportion of college graduates (43%) of any cluster. They could be described as CAV enthusiasts, who embrace all CAV technologies and have the highest average TRI score of 3.8 out of a maximum 5.

Top Methods to Learn More

While they generally don't find the methods provided in question #26 to learn more about CAVs helpful when compared to clusters 1, 2, and 4, 73% of this cluster would find YouTube videos very to extremely helpful for learning more about CAVs. This group could use some clarifications on terminologies as 50% of members believe they have driven a CV despite these vehicle technologies being relatively rare.

Top Benefits

Cluster 5 saw the highest average factor score for overall CAV benefits. Members of cluster 5 saw the highest benefits of AVs on non-driver mobility with 72% reporting positive impact. They saw the next highest benefits of CVs on transportation safety with 58% reporting positive impact.

Top Concerns

Cluster 5 saw the lowest average factor score for overall CAV concerns. Members of cluster 4 expressed the highest concern with computer hacking and computer and sensor failure, with 48%, 38%, and 37%, respectively, reporting to be very to extremely concerned.

Importance of State Government Actions

Question 25 asked respondents to indicate how important they thought nine separate Wisconsin state government CAV-related actions are. **Figure 16** shows the results of this question with clarifying liability in a crash, addressing cybersecurity, overseeing safe technology development, and addressing data privacy as the most important actions. These items can generally be categorized as regulatory/information technology actions. The distributions of importance across these top items did not vary strongly across clusters. This is an interesting finding as attitudes about CAV technology varied strongly between clusters, but support for state government action was generally uniformly strong. Maintaining equal access to CAV technology was a regulatory action that did not have as strong of support across the population. Respondents indicated that actions specifically related to government funding were least important, although there was still relatively strong support for all actions.

After regulatory/information technology actions, providing educational materials and conducting demonstration projects were deemed the next important. More detail is provided in **Figure 17** for educational materials. Further analysis was performed to understand what and where demonstration projects would be most important. Respondents living in small cities saw higher importance in demonstration projects than those living in rural areas. Of those residents, 59% reported these projects as very to extremely important compared to 50% in rural areas. No clear patterns emerged on which CAV technologies would be more important to demonstrate, however there was significant positive correlation between the stated importance of demonstration projects and concern over sensor/computer failure. This denotes the importance demonstrating these technologies can reliably operate. High visibility pilots that leverage earned media and showcase user perceptions of the project will help demonstrate the technologies to a larger audience than the geographic limits of the project.

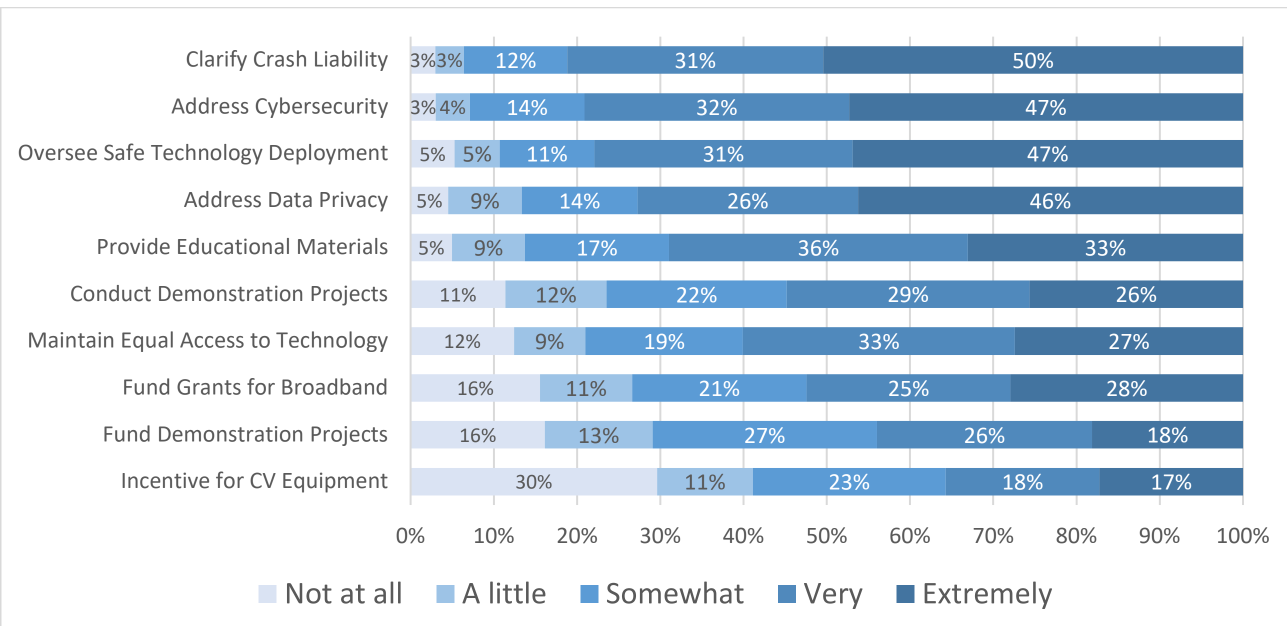


Figure 16: Wisconsin's perceived importance of various state government CAV-related actions

Question 26 asked respondents to indicate how helpful they thought seven separate learning methods are in helping them learn more about CAV technology. **Figure 17** shows the results of this question.

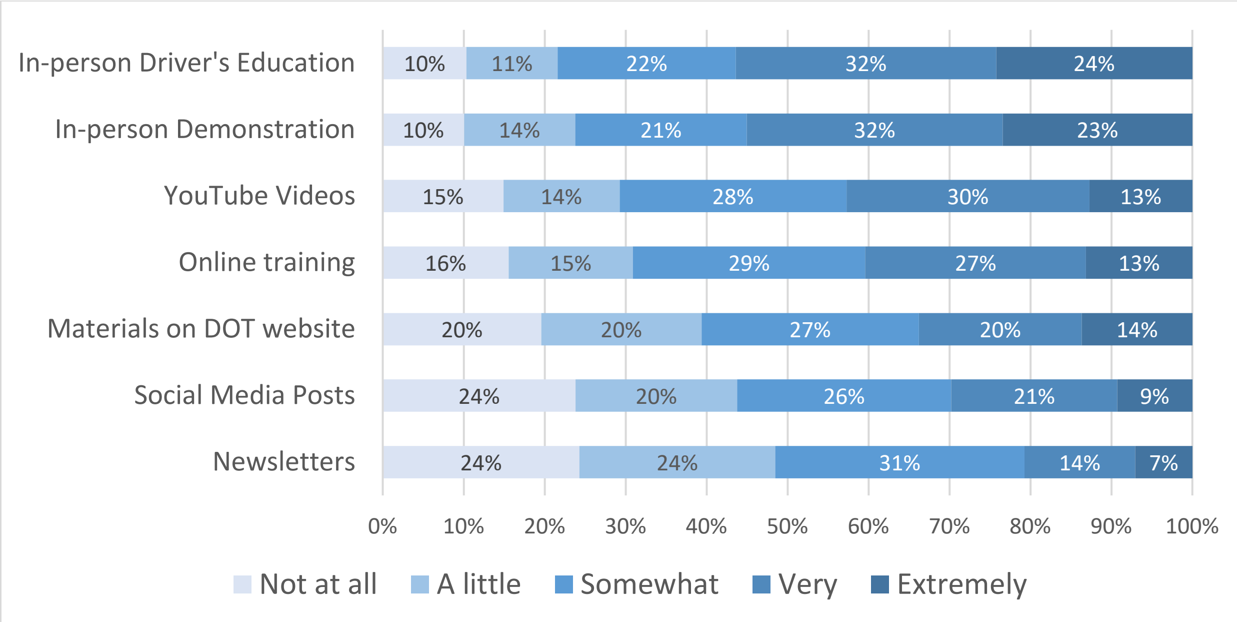


Figure 17: Wisconsin's perceived helpfulness of various methods to learn more

In-person education and demonstrations were deemed the most helpful of all methods, with the majority (56%) of Wisconsinites reporting those methods as very to extremely helpful. Though these methods are helpful and impactful for participants, they could also see higher cost per person than some of the other methods. Online methods were the next most helpful methods and include YouTube videos, training, materials posted on the DOT website, and social media. Some of these methods allow tailored messages to specific groups, such as the clusters identified previously. These targeted and paid advertising messages could focus on clarifying concerns or demonstrating benefits of various technologies that would reach audiences outside of typical communication channels. Nair and Bhat (2021) concluded that if the goal is to increase interest in CAV technologies among those subpopulations less interested (e.g. older people, women, and those with less education) there should be a focus on promoting benefits and usefulness to those subpopulations including the following examples:

- Older people
  - Target a means to avoid difficulties of driving.
- Women
  - Target the time use productivity without the need for a driver and associated potential security concerns, leaving more time for social-recreational activities.
  - Target the safety benefits of CAV technologies.
- People with less education
  - Target policies that promote affordable retraining programs.

6. Conclusions

This work presented the results of a comprehensive study of the Wisconsin public's understanding of CAVs; their acceptance of early testing; their perceived benefits, drawbacks, and barriers to CAV implementation in Wisconsin; and the implications for potential WisDOT action. The study started with a comprehensive literature review to understand current public perception of CAVs and inform this study's design. The research team took these lessons to create a 184-item survey and administer it to 4300 Wisconsin households. The results were cleaned and 915 valid responses were analyzed. First, overall patterns were identified and discussed. Second, an exploratory factor analysis was conducted to reveal six primary factors that help explain variation in Wisconsinite's attitudes toward CAVs. Finally, a latent class cluster analysis was conducted to reveal five unique latent clusters of Wisconsin adults based on their attitudes and attributes. These results can be used to inform WisDOT CAV-related actions to best prepare the state and its people for these emerging technologies.

This study offers a snapshot of attitudes on public CAV attitudes in Wisconsin. Like attitudes towards any new technology, these CAV attitudes will change as new products are introduced and used and as new events occur. The study's design offers the potential to re-administer this survey to its respondents and additional respondents to compare changes in Wisconsinite's attitudes towards CAVs over time.

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Appendix 1

Table A1: Time Duration and Consistent Response Item Flags

Item	Item Weight	Threshold	Respondents	Percent
Duration	1	13 minutes	59	12%
Duration	7	8 minutes	12	4%
Q4	1	0.25	21	2%
Q5	1	0	0	0%
Q6	1	0	0	0%
Q7	1	0.25	158	17%
Q8	1	0	0	0%
Q11	1	0.25	49	5%
Q12	1	0	0	0%
Q13	1	0	0	0%
Q14	1	0.25	88	9%
Q15	1	0	0	0%
Q16	1	0	0	0%
Q17	1	0	0	0%
Q18	1	0.25	73	8%
Q19	1	0.25	84	9%
Q20	1	0.25	80	9%
Q21	1	0	0	0%
Q22	1	0.25	110	12%
Q23	1	0	0	0%
Q24	1	0.25	68	7%
Q25	1	0.25	132	14%
Q26	1	0.25	130	14%
Q27	1	0.25	51	6%
Q28	1	0.25	49	5%

Wisconsin Connected and Automated Vehicles Study

«CODE»

Online and paper response options available until <u>August 16, 2023</u>.
Because we appreciate your time, we will send you $10 in cash once we receive your completed survey.

Instructions on next page ⇨

Dear Wisconsin Resident,

I am asking for your help to understand more about attitudes toward **connected and automated vehicles**. Understanding how Wisconsinites feel about this emerging technology is important to help governments develop policy to serve your needs, and technology developers design products. Your household was selected as part of scientific random sample. We selected households randomly from a pool of all addresses in Wisconsin to participate in this study to accurately represent the state as a whole.

If you would like take this survey online please complete the following by August 16, 2023:

1. Take this booklet to a computer and go to **https://go.wisc.edu/LU8181**
2. Enter your 7 digit code found on the front cover of this packet
3. Complete the survey!

Si desea realizar esta encuesta en línea, complete lo siguiente antes del 16 de agosto de 2023:

1. Lleve esta carta a un ordenador y vaya a **https://go.wisc.edu/363KTZ**
2. Introduzca su código de 7 dígitos que se encuentra en la portada de este paquete
3. Completa la encuesta!

Si prefiere que le enviemos una copia física del cuestionario en español, comuníquenoslo enviando un correo electrónico a ajmcfadden@wisc.edu indicando su preferencia y su código de 7 dígitos.

If you would like to take this survey on paper please complete the enclosed survey and return this whole booklet to us in the paid postage envelope we have provided by August 16, 2023. Because we appreciate your time, we will send you $10 in cash once we receive your completed survey.

- Any one adult Wisconsin resident in your household may complete the questionnaire.
- We will only accept the first complete response received online or on paper from each household and only provide $10 for one completed survey per household.
- Participation in the study consists of completing a questionnaire, which should take about 15 minutes.
- You may ask any questions about the research at any time. If you have questions, concerns, or complaints, or think that participating in the research has hurt you, talk to the research team or contact the Principal Investigator, Professor David A. Noyce, at danoyce@wisc.edu, or Andrew McFadden, a Researcher at the University of Wisconsin TOPS Lab at ajmcfadden@wisc.edu or (608) 890-0509.
- Your answers will be kept *completely confidential* in publications and presentations of the results.
- Your participation is voluntary, and you may skip any questions that you do not want to answer. Completing the questionnaire acts as your consent to participate.
- There are minimal risks to participants. There is a risk of a confidentiality breach, but the research team will minimize the risk for a breach of confidentiality by ensuring data are stored securely and any identifiable information will only be shared with UW-Madison researchers and the Wisconsin DOT. We don't expect any direct benefits to you from participation in this study.
- If you have any questions about your rights as a research participant or have complaints about the research study or study team, call the confidential research compliance line at 1-833-652-2506. Staff will work with you to address concerns about research participation and assist in resolving problems.

Your thoughts and experiences are very important to us. We look forward to receiving your response soon.

Thank you very much for your help,

David A. Noyce, Ph.D., P.E., F. ASCE, F.ITE
Arthur F. Hawnn Professor, Department of Civil and Environmental Engineering
Executive Associate Dean, College of Engineering
Director, Traffic Operations and Safety Laboratory

1. **We begin with a couple of questions to make sure you are eligible for this study.**

   Do you currently live in Wisconsin for half of the year or more?

   ○ Yes
   ○ No

2. **Are you currently 18 years old or older?**

   ○ Yes
   ○ No

If you answered NO to either of the first 2 questions you are not eligible for this study. A different member of your household who meets the criteria can take this survey if they wish. Thank you for your interest!

If you answered YES to both questions, please continue to complete the rest of the questionnaire.

3. **We now have some questions about how you travel.**

   Do you currently have a valid driver's license?

   ○ Yes
   ○ No

4. **How often do you use each of the following to get from place to place?**
   If a type of transportation is not available to you, please select "Not available to me."

	Daily	A few times a week	A few times a month	A few times a year	Never	Not available to me
a. Walking	○	○	○	○	○	○
b. Biking	○	○	○	○	○	○
c. Riding a motorcycle or moped	○	○	○	○	○	○
d. Driving your own personal vehicle such as car, truck, or SUV	○	○	○	○	○	○
e. Borrowing the personal vehicle of a friend, family member, neighbor, coworker, or acquaintance	○	○	○	○	○	○
f. Getting a ride from a friend, family member, neighbor, coworker, or acquaintance, including carpooling	○	○	○	○	○	○

5. Still thinking about how you get from place to place, how often do you use each of the following? If a type of transportation is not available to you, please select "Not available to me."

	Daily	A few times a week	A few times a month	A few times a year	Never	Not available to me
a. Taxi service or rideshare such as Uber or Lyft	○	○	○	○	○	○
b. Rental car or car sharing service such as Zipcar	○	○	○	○	○	○
c. Bus	○	○	○	○	○	○
d. Train	○	○	○	○	○	○
e. Paratransit, that is, specialized, door-to-door transport services for people with disabilities	○	○	○	○	○	○
f. Community transportation service in the community where you live	○	○	○	○	○	○

6. People use many different types of transportation to get to the places they need to go. They might walk, bike, take a bus, train, taxi, drive a car, or get a ride.

In the past 30 days, how often…

	Often	Sometimes	Never
a. ...did you have to reschedule an appointment because of a problem with transportation?	○	○	○
b. ...did you skip going somewhere because of a problem with transportation?	○	○	○
c. ...were you **not** able to leave your home when you wanted to because of a problem with transportation?	○	○	○
d. ...did you feel bad because you did not have the transportation you needed?	○	○	○
e. ...did you worry about inconveniencing your friends, family, or neighbors because you needed help with transportation?	○	○	○
f. ...did problems with transportation affect your relationships with others?	○	○	○

7. How much does each of the following transportation challenges affect your daily life?

	Not at all	A little	Somewhat	Quite a bit	A great deal
a. Congestion or traffic issues	○	○	○	○	○
b. Safety on the roads, crashes	○	○	○	○	○
c. Lack of safe walking routes such as sidewalks or crosswalks	○	○	○	○	○
d. Lack of safe bicycling routes	○	○	○	○	○
e. Limited access to public transportation	○	○	○	○	○
f. Personal safety concerns	○	○	○	○	○
g. Lack of accessibility for wheelchairs, strollers, or people with disabilities	○	○	○	○	○
h. Lack of a vehicle	○	○	○	○	○
i. Being unable to drive	○	○	○	○	○
j. Other challenges. Please tell us: ____	○	○	○	○	○

8. Does each of the following type of impairment affect your use of transportation?

Are you affected by…

	Yes	No
a. …a physical impairment, for example are you unable to turn your neck or keep pressure on the brake or gas pedal?	○	○
b. …a vision impairment, for example trouble driving at night?	○	○
c. …a hearing impairment, for example deafness?	○	○
d. …a cognitive impairment, for example trouble paying attention while driving?	○	○
e. …a psychological impairment, for example stress in heavy traffic?	○	○

f. …some other impairment? ⟶ Please tell us: ____

9. In the last 10 years have you been involved in a traffic crash?

○ Yes
○ No

10. How many working vehicles does your household own or lease? If none, please write "0".

____ Working vehicles

Now we have some questions about your attitudes and perceptions about connected and automated vehicles. Please answer each question to the best of your ability even if you have never ridden in or driven one.

As you answer the next questions, please keep in mind the following definitions:

- **Connected Vehicle** - a vehicle using communication technologies to communicate with the driver, other cars on the road, other travelers such as people walking and biking, and roadway equipment such as traffic signals.

- **Highly Automated "Self-driving" Vehicle** - a vehicle using an automated driving system that can fully drive the vehicle sometimes but still needs a backup driver.

- **Fully Automated "Driverless" Vehicle** - a vehicle using an automated driving system that can fully drive the vehicle at all times.

- **Truck Platooning** - linking of two or more trucks in convoy, using connected and automated vehicle technology. This allows the following vehicles to follow the lead vehicle with limited driver assistance.

11. How familiar are you with…

	Not at all	A little	Somewhat	Very	Extremely
a. ...connected vehicles?	○	○	○	○	○
b. ...blind spot warning?	○	○	○	○	○
c. ...anti-lock brakes?	○	○	○	○	○
d. ...adaptive cruise control?	○	○	○	○	○
e. ...automatic emergency braking?	○	○	○	○	○
f. ...lane departure warning?	○	○	○	○	○
g. ...highly-automated "self-driving" vehicles?	○	○	○	○	○
h. ...fully-automated "driverless" vehicles?	○	○	○	○	○

12. The next questions ask about what experience you have had with these kinds of vehicles.

	Yes	No
a. Have you ever driven a connected vehicle?	○	○

b. Have you ever <u>ridden</u> in a connected vehicle?	○	○
c. Have you ever <u>driven</u> a vehicle with at least one of the following features: blind spot warning, automatic emergency braking, adaptive cruise control, or lane departure warning?	○	○
d. Have you ever <u>ridden</u> in a vehicle with at least one of the following features: blind spot warning, automatic emergency braking, adaptive cruise control, or lane departure warning?	○	○

13. Please continue thinking about your personal experiences with these types of vehicles.

	Yes	No
a. Have you ever <u>driven</u> a highly automated vehicle?	○	○
b. Have you ever <u>ridden</u> in a highly automated “self-driving” vehicle during a demonstration or pilot?	○	○
c. Have you ever <u>ridden</u> in a highly automated “self-driving” vehicle outside of a demonstration or pilot?	○	○
d. Have you ever <u>driven</u> a fully automated "driverless" vehicle?	○	○
e. Have you ever <u>ridden</u> in a fully automated "driverless" vehicle during a demonstration or pilot?	○	○
f. Have you ever <u>ridden</u> in a fully automated "driverless" vehicle outside of a demonstration or pilot?	○	○

14. If it were currently available to you, how <u>willing</u> would you be to use…

	Not at all	A little	Somewhat	Very	Extremely
a. ...a connected vehicle?	○	○	○	○	○
b. ...a vehicle equipped with blind spot warning, automatic emergency braking, adaptive cruise control, or lane departure warning?	○	○	○	○	○
c. ...a connected and highly automated semitruck platoon with a driver in each truck to ship a package on a highway?	○	○	○	○	○
d. ...a highly automated "self-driving" shuttle?	○	○	○	○	○
e. ...a highly automated "self-driving" personal vehicle?	○	○	○	○	○
f. ...a fully automated "driverless" shuttle?	○	○	○	○	○
g. ...a fully automated "driverless" personal vehicle?	○	○	○	○	○
h. ...a fully automated "driverless" delivery van?	○	○	○	○	○

15. Under which of the following conditions would you be willing to use a highly automated "self-driving" vehicle on a highway with a speed limit of 65 mph or higher?

Would you be willing if…

	Yes	No
a. …there was an operator in the driver's seat monitoring vehicle operations?	○	○
b. …there was an operator in the vehicle who could answer your questions?	○	○
c. …the vehicle was remotely monitored by an operator?	○	○
d. …you could communicate with an operator working remotely?	○	○
e. …other condition? ⟶ Please tell us:		

16. Under which of the following conditions would you be willing to use a highly automated "self-driving" vehicle on a neighborhood street?

Would you be willing if…

	Yes	No
a. …there was an operator in the driver's seat monitoring vehicle operations?	○	○
b. …there was an operator in the vehicle who could answer your questions?	○	○
c. …the vehicle was remotely monitored by an operator?	○	○
d. …you could communicate with an operator working remotely?	○	○
e. …other condition? ⟶ Please tell us:		

17. Imagine the following types of information about your travel are needed in order to use a connected vehicle application that could increase your safety.

Would you be willing to share…

	Yes	No
a. …speed information?	○	○
b. …braking intensity and traction information?	○	○
c. …mileage information?	○	○
d. …wiper and headlight intensity information?	○	○
e. …make and model information?	○	○
f. …ownership information?	○	○
g. …trip information such as location, origin, or destination?	○	○
h. …short-term trajectory information such as your location over the last 30 seconds?	○	○
i. …onboard diagnostics such as vehicle condition information?	○	○

18. Imagine you are driving or riding in a vehicle on a highway with a speed limit of 65 mph or higher.
How comfortable would you feel sharing the road with...

	Not at all	A little	Somewhat	Very	Extremely
a. ...a traditional passenger vehicle?	◯	◯	◯	◯	◯
b. ...a connected vehicle?	◯	◯	◯	◯	◯
c. ...a vehicle equipped with blind spot warning, automatic emergency braking, adaptive cruise control, or lane departure warning?	◯	◯	◯	◯	◯
d. ...a connected and highly automated semitruck platoon with a driver in each truck?	◯	◯	◯	◯	◯
e. ...a highly automated "self-driving" vehicle?	◯	◯	◯	◯	◯
f. ...a fully automated "driverless" vehicle?	◯	◯	◯	◯	◯

19. Imagine you are driving or riding in a vehicle on a neighborhood street.

How comfortable would you feel sharing the road with...

	Not at all	A little	Somewhat	Very	Extremely
a. ...a traditional passenger vehicle?	◯	◯	◯	◯	◯
b. ...a connected vehicle?	◯	◯	◯	◯	◯
c. ...a vehicle equipped with blind spot warning, automatic emergency braking, adaptive cruise control, or lane departure warning?	◯	◯	◯	◯	◯
d. ...a highly automated "self-driving" vehicle?	◯	◯	◯	◯	◯
e. ...a fully automated "driverless" vehicle?	◯	◯	◯	◯	◯

20. Imagine you are walking or biking on a neighborhood street.

How comfortable would you feel sharing the road with...

	Not at all	A little	Somewhat	Very	Extremely
a. ...a traditional passenger vehicle?	◯	◯	◯	◯	◯
b. ...a connected vehicle?	◯	◯	◯	◯	◯
c. ...a vehicle equipped with blind spot warning, automatic emergency braking, adaptive cruise control, or lane departure warning?	◯	◯	◯	◯	◯
d. ...a highly automated "self-driving" vehicle?	◯	◯	◯	◯	◯
g. ...a fully automated "driverless" vehicle?	◯	◯	◯	◯	◯

21. How <u>needed</u> do you think the following requirements are for testing a highly automated "self-driving" vehicle on Wisconsin roadways?

	Not at all	A little	Somewhat	Very	Extremely
a. There is an operator in the driver's seat monitoring vehicle operations	○	○	○	○	○
b. The vehicle is remotely monitored by an operator	○	○	○	○	○
c. The vehicle displays a clear indication that it is an automated vehicle	○	○	○	○	○
d. The vehicle saves sensor data before and after any crash occurs	○	○	○	○	○
e. <u>Other requirement</u> → Please tell us:					

22. How much better or worse do you think <u>automated "self-driving" vehicles</u> will make each of the following issues?

	A lot worse	Somewhat worse	A little worse	About the same	A little better	Somewhat better	A lot better
a. Transportation safety	○	○	○	○	○	○	○
b. Mobility for non-drivers	○	○	○	○	○	○	○
c. Congestion	○	○	○	○	○	○	○
d. Air quality	○	○	○	○	○	○	○
e. Privacy	○	○	○	○	○	○	○
f. Greenhouse gas emissions	○	○	○	○	○	○	○

23. How much better or worse do you think <u>connected vehicles</u> will make each of the following issues?

	A lot worse	Somewhat worse	A little worse	About the same	A little better	Somewhat better	A lot better
a. Transportation safety	○	○	○	○	○	○	○
b. Mobility for non-drivers	○	○	○	○	○	○	○
c. Congestion	○	○	○	○	○	○	○
d. Air quality	○	○	○	○	○	○	○
e. Privacy	○	○	○	○	○	○	○
f. Greenhouse gas emissions	○	○	○	○	○	○	○

24. How concerned are you about each of the following issues related to connected and automated vehicles?
Are you concerned about…

	Not at all	A little	Somewhat	Very	Extremely
a. …these vehicles not driving as well as human drivers?	◯	◯	◯	◯	◯
b. …legal liability in case of a crash?	◯	◯	◯	◯	◯
c. …data privacy such as location or destination tracking?	◯	◯	◯	◯	◯
d. …interactions with other road users?	◯	◯	◯	◯	◯
e. …equal access to these technologies?	◯	◯	◯	◯	◯
f. …sensor equipment failure?	◯	◯	◯	◯	◯
g. …vehicle computer system failure?	◯	◯	◯	◯	◯
h. …vehicle computer hacking?	◯	◯	◯	◯	◯
i. …motion sickness?	◯	◯	◯	◯	◯
j. <u>…other issues?</u> → Please tell us:					

25. Next, we ask about your attitudes toward possible interventions meant to prepare for connected and automated vehicles.
How <u>important</u> is it for the Wisconsin State government to…

	Not at all	A little	Somewhat	Very	Extremely
a. …provide educational materials?	◯	◯	◯	◯	◯
b. ...address cybersecurity concerns?	◯	◯	◯	◯	◯
c. ...fund demonstration projects?	◯	◯	◯	◯	◯
d. ...conduct demonstrations projects?	◯	◯	◯	◯	◯
e. …oversee vehicle technology is deployed safely	◯	◯	◯	◯	◯
f. …maintain equal access to technologies	◯	◯	◯	◯	◯
g. ...address data privacy concerns?	◯	◯	◯	◯	◯
h. ...clarify liability in the event of a crash?	◯	◯	◯	◯	◯
i. ...fund grants for increased broadband connectivity?	◯	◯	◯	◯	◯
j. …offer money back for purchasing connected vehicle equipment?	◯	◯	◯	◯	◯

26. How <u>helpful</u> would each of the following be to help you learn more about connected and automated vehicles?

	Not at all	A little	Somewhat	Very	Extremely
a. Materials posted on State Department of Transportation website	◯	◯	◯	◯	◯
b. YouTube videos	◯	◯	◯	◯	◯
c. Social media posts	◯	◯	◯	◯	◯
d. Online training	◯	◯	◯	◯	◯
e. In-person driver's education training	◯	◯	◯	◯	◯
f. In-person demonstration	◯	◯	◯	◯	◯

g. Newsletters	○	○	○	○	○
h. Other ways. ⟶ Please tell us:					

27. Next, we ask about your attitudes on technology.

How much do you agree or disagree with each of the following statements?

	Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
a. New technologies contribute to a better quality of life	○	○	○	○	○
b. Technology gives me more freedom of mobility	○	○	○	○	○
c. Technology gives people more control over their daily lives	○	○	○	○	○
d. Technology makes me more productive in my personal life	○	○	○	○	○
e. Other people come to me for advice on new technologies	○	○	○	○	○
f. In general, I am among the first in my circle of friends to acquire new technology when it appears	○	○	○	○	○
g. I can usually figure out new high-tech products and services without help from others	○	○	○	○	○
h. I keep up with the latest technological developments in my areas of interest	○	○	○	○	○

28. How much do you agree or disagree with each of the following statements?

	Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
a. When I get technical support from a provider of a high-tech product or service, I sometimes feel as if I am being taken advantage of by someone who knows more than I do	○	○	○	○	○
b. Technical support lines are not helpful because they don't explain things in terms I understand	○	○	○	○	○
c. Sometimes, I think that technology systems are not designed for use by ordinary people	○	○	○	○	○
d. There is no such thing as a manual for a high-tech product or service that's written in plain language	○	○	○	○	○
e. People are too dependent on technology to do things for them	○	○	○	○	○
f. Too much technology distracts people to a point that is harmful	○	○	○	○	○

g. Technology lowers the quality of relationships by reducing personal interaction	○	○	○	○	○
h. I do not feel confident doing business with a place that can only be reached online	○	○	○	○	○

29. Finally, we have some questions about you and your household.

What is your age?

☐ Age

30. What is your gender?

○ Man
○ Woman
○ Non-binary
○ Not listed, please tell us: → ☐

31. Check all of the following that describe your race or ethnicity:

☐ American Indian or Alaskan Native
☐ Asian
☐ Black or African American
☐ Hispanic or Latino
☐ Middle Eastern or North African
☐ Native Hawaiian or Other Pacific Islander
☐ White
☐ Other: Please tell us: → ☐

32. What is the highest level of education you have completed?

○ Some high school or less
○ Completed high school or obtained GED
○ Trade school such as Cosmetology school or Electrical school
○ Some college
○ Associate degree or a 2-year college degree
○ Bachelor's degree or a 4-year college degree
○ Master's degree
○ Advanced degree such as a Ph.D, a Law degree or a Medical degree

33. Including yourself, how many people live in your household?

☐ People in household

34. How many children, age 0 to 12, live in your household? If none, please write "0".

Children in household

35. How many adolescents, age 13 to 17, live in your household? If none, please write "0".

Adolescents in household

36. In 2022, including all sources, what was your total annual household income before taxes?

- ○ Less than $25,000
- ○ $25,000 to $49,999
- ○ $50,000 to $74,999
- ○ $75,000 to $99,999
- ○ $100,000 to $124,999
- ○ $125,000 to $149,999
- ○ $150,000 to $174,999
- ○ $175,000 or more

37. Which one of the following best describes your current employment status?

- ○ Employed full time
- ○ Employed part time
- ○ Student
- ○ Unemployed, looking for work
- ○ Unemployed, not looking for work
- ○ Disabled, not able to work
- ○ Retired

Go to question 39

38. How often, if at all, do you work from home?

- ○ Never
- ○ Less than once a month
- ○ About once a month
- ○ About once a week
- ○ 2 to 3 days a week
- ○ 4 to 6 days a week
- ○ 7 days a week

39. In which Wisconsin county do you live most often?

40. Which one of the following best describes the location where you live?

○ Small city or village
○ Large city
○ Suburb near a large city
○ Rural area

41. If you are or have been employed, what is your main job?

42. A smartphone is a mobile phone that performs many of the functions of a computer.

Do you have a smartphone?

○ Yes
○ No
○ Don't know

Thank you for your participation!
Please return the completed questionnaire by <u>August 16, 2023</u> in the postage-paid envelope provided.
You do <u>not</u> have to add a stamp or pay for postage.

The survey team will review your survey to verify if it is complete and will send you $10 in cash in a thank you letter within the next 2 months.