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Veterans' Perceptions of Shared Autonomous Electric Shuttles: A Pre- and Post-Exposure Assessment

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Abstract: Veterans often face transportation barriers, but advances in technology enable real-world testing of shared autonomous electric vehicles as potential energy-efficient solutions. While previous research has assessed civilians' perceptions of autonomous vehicles (AVs), veterans—due to unique military experiences and health conditions—represent a distinct demographic. This study investigates veterans' perceptions of autonomous shuttles (ASs) to assess whether these innovations may foster sustainable transportation behaviors. Leveraging data from the Autonomous Vehicle User Perception Survey (AVUPS), this study assessed AS perceptions among 77 veterans across four Florida cities before and after exposure. Results indicated significant increases in intention to use and total acceptance and a decrease in perceived barriers, with no change in well-being. Urban veterans showed improvements across multiple subscales, while rural veterans only showed reduced perceived barriers. Those with initially low total acceptance scores demonstrated greater improvements, particularly in intention to use and perceived barriers. The analysis of survey items showed increased trust, greater willingness to multitask, improved safety perceptions, and reduced concerns about declining driving abilities and hesitations toward AVs, with the latter three items remaining significant after correction. Overall, AS exposure positively influenced veterans' perceptions, and the results point to the potential of ASs as a sustainable transportation option for veterans.

Keywords: sustainable transportation; autonomous shuttle; veterans; autonomous vehicle acceptance; shared transport

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1. Introduction

Veterans frequently encounter various healthcare challenges, with transportation being a critical barrier to accessing necessary services. This issue is particularly prevalent among minority groups, individuals with disabilities, and those residing in rural areas, who often report significant difficulties in securing reliable transportation to medical appointments [1,2]. These transportation limitations contribute to a range of negative health outcomes, including missed appointments, delayed care, and poor management of chronic conditions [1,3]. The consequences of inadequate transportation are far-reaching, leading to worsened health conditions and overall reduced quality of life for many veterans [4]. This problem is exacerbated in rural areas, where long distances and limited public transit options create additional challenges, making it even harder for veterans to access timely healthcare [1,2].

In response to these challenges, the Department of Veterans Affairs (VA) has implemented various programs designed to support veterans' transportation needs. The

Veterans Transportation Program (VTP) includes several sub-programs, such as the Veterans Transportation Service (VTS) and the Beneficiary Travel Program, which aim to assist veterans in reaching VA medical facilities [5]. Despite these efforts, there remain significant gaps in transportation services, particularly for veterans living in areas where the VTS is unavailable or where wheelchair-accessible vehicles are limited, posing additional obstacles for those with mobility impairments [6]. Furthermore, while legislative efforts, such as the CHOICE Act (Veterans Access, Choice, and Accountability Act) and the MISSION Act (Maintaining Internal Systems and Strengthening Integrated Outside Networks Act), have expanded veterans' options for receiving care from non-VA providers, navigating eligibility criteria and the coordination of transportation with non-VA providers remain hurdles [7]. These persistent transportation challenges highlight the need for innovative solutions to ensure that veterans can access the healthcare services they require.

Autonomous vehicle technology, particularly AS technology, presents a promising and sustainable solution to address transportation challenges faced by veterans. With a growing population and increasing urbanization, the demand for efficient and sustainable transportation solutions has become more pressing. The US transportation system grapples with challenges such as aging infrastructure, congestion mitigation, inadequate public transit options, and disparities in access to transportation services, which all point to necessitating innovative solutions to ensure universal access to safe and reliable transportation options [8]. Automated vehicle technology is classified by the Society of Automotive Engineers (SAE) into six levels, ranging from Level 0 (no automation) to Level 5 (full automation) [9]. Levels 0–3 require some degree of human control, and Levels 4 and 5 allow for full automation in specific (Level 4) or all environments (Level 5). Level 4, which operates autonomously in controlled environments, holds particular promise for enhancing mobility, reducing human error in driving, and improving road safety [10]. Autonomous shuttles operating at this level can act as first- or last-mile service providers, thus connecting passengers to public transportation hubs or to their final destinations, enhancing mobility options, and contributing to a more equitable and sustainable transportation system [11,12]. However, challenges related to infrastructure, regulations, and public acceptance must still be addressed for widespread deployment [13].

Diverse sociodemographic groups exhibit different perceptions and adoption intents toward AV technology, as commuters tend to value different aspects of AVs [14]. A study involving civilian participants showed a statistically significant increase in acceptance, safety, and trust following 15 min exposure to an AS traveling at a speed of 12 km/h within a large clinic area in Berlin, Germany, as indicated by post-exposure survey data [15]. Salonen and Haavisto found that younger and middle-aged drivers initially had negative perceptions of ASs, but exposure from riding in an AS on a university campus in Finland improved their attitudes, as revealed by post-exposure interview data [16]. Similarly, a post-exposure survey conducted among Brussels residents revealed that over 70% of passengers riding in an AS operating in mixed traffic had no concerns about AVs, with positive experiences with the shuttle largely influenced by factors like driving behavior and comfort [17].

While these studies highlight the potential of AS technology for civilians, veterans, distinguished by their military-related exposure, training, and health conditions, constitute a unique population [18]. One study has specifically explored the experiences of sighted and visually impaired veterans with an AS [19]. Although veterans positively responded to their shuttle experience, the study, using a questionnaire, only assessed post-exposure perceptions. While post-exposure assessments provide insights into user experiences with ASs, an assessment considering both pre- and post-exposure perspectives is important to ascertain the impact of AS exposure on users' AV perceptions. Given the limited research

on veterans' AS perceptions, a prior study conducted by our research team assessed both pre- and post-exposure perceptions of veterans in Gainesville, Florida following their exposure to an AS [20]. The current study expands upon that work by including additional participants from The Villages, Lake Nona, and Port St. Lucie, Florida.

The Autonomous Vehicle User Perception Survey (AVUPS), designed to assess perceptions of individuals exposed to SAE Level 4 and 5 AVs, was used in this study to measure veterans' perceptions before and after exposure to AS technology across these four locations. The AVUPS has undergone content, face, and construct validity assessments, achieving high internal consistency and reliability [21,22]. The survey generates three subscales—intention to use, perceived barriers, and well-being, along with a total acceptance score. The intention to use subscale, comprising the most items (13), assesses concepts including trust, perceived usefulness, intention to use, perceived ease of use, cost, authority, and safety. The perceived barriers subscale, containing six items, was developed to measure obstacles related to trust, perceived ease of use, intention to use, driving self-efficacy, and safety. The well-being subscale, which includes four items, assesses how AVs may influence their ability to stay active, participate in their community, and enhance their quality of life. The total acceptance score combines responses from all three subscales. By utilizing both retrospective [20] and prospective AVUPS data, this study evaluated changes in veterans' perceptions across these subscales and the total score.

This study aimed to uncover insights into perceptions influencing AS acceptance among veterans, a population whose unique needs have been underexplored in the context of AV technology. This study assessed whether exposure to an AS changed veterans' perceptions, specifically their overall acceptance of the technology (i.e., AVUPS-Total Acceptance). Findings from this research offer guidance for VA decision makers (e.g., VA medical centers), VA transportation stakeholders (e.g., the Veterans Transportation Service), and industry partners (e.g., AS manufacturers and service providers) regarding the next steps for considering AS deployment as part of transportation solutions for veterans.

2. Materials and Methods

2.1. Ethics

The retrospective and prospective data were obtained as part of two studies, hereafter referred to as parent studies, both of which were submitted for full board review to the ethics committee and received approval from the University of Florida's Institutional Review Board, the North Florida/South Georgia Veterans Affairs Human Research Protection Office, and the Office of Rural Health. In both studies, participants provided informed consent by signing IRB- and VA-approved documents, including the Informed Consent Form (ICF) and the Health Insurance Portability and Accountability Act (HIPAA) form, and as such confirmed their agreement to participate voluntarily in the research.

2.2. Study Design

The study used existing data from two parent studies [20]. We conducted a secondary data analysis of quantitative survey responses to assess veterans' perceptions of ASs before and after their exposure to the technology.

2.3. Autonomous Shuttle

The parent studies utilized either the EasyMile EZ10 (Figure 1) or the Navya AS (Figure 2). Both shuttles are electric, classified as SAE Level 4, and equipped with a suite of sensors, including LiDAR, cameras, radar, and GPS, to support safe navigation and obstacle detection. Their boxy design maximizes interior space, accommodating both seated and standing passengers, and they are accessible for individuals with limited mobility.

Operating along predefined routes without manual control, these shuttles lack a steering wheel but feature a remote-control interface, such as a joystick, that allows a safety operator to manually control the vehicle if necessary. Both shuttles have a speed limit of 10 miles per hour.



Figure 1. EasyMile EZ10 AS and remote control.



Figure 2. Navya AS.

The EasyMile EZ10 and Navya AS differ in passenger capacity and ramp operation. The EasyMile EZ10 can carry up to twelve passengers, typically configured with six seated and six standing, while the Navya AS accommodates up to fourteen passengers, usually ten seated and four standing. Both shuttles offer wheelchair accessibility with low-floor designs, but the EZ10 features an automatic ramp, whereas the Navya AS uses a manual ramp.

2.4. Study Population

In the parent studies, the inclusion criteria encompassed veterans who had served or were actively serving in the US military (regardless of combat experience), were 18 years or older, proficient in English, resided in Florida, and were able and willing to travel to one of the study locations (i.e., Gainesville, The Villages, Lake Nona, and Port St. Lucie). Veterans were excluded if they had medical conditions preventing them from completing a 25 min seated shuttle ride.

As part of the parent studies, veterans were compensated for their participation. Participants were recruited using convenience and snowball sampling strategies by leveraging various community contacts, such as Student Veteran organizations, Wounded Warrior Project sites, clinics, and Department of Veterans Affairs centers. Recruitment efforts

were supported by a combination of outreach methods, including flyers, online platforms, and targeted outreach through the VA Informatics and Computing Infrastructure (VINCI) database, ensuring a diverse and representative sample of veterans.

This study used the quantitative AVUPS data collected from these participants, with only veterans who completed both pre- and post-AVUPS surveys included in the analysis.

Sample Size

In the parent studies, the sample size for survey data was determined through an a priori power analysis using G*Power 3 software [23]. With an alpha level of 0.05, a power of 0.80 for matched pairs with two measures (pre- and post-AS exposure), and a medium effect size of Cohen's d = 0.53, a sample size of 30 participants was identified. The effect size was estimated based on previous interim findings (i.e., AVUPS-Total Acceptance) comparing older adults' perceptions via the AVUPS pre- and post-AS exposure. Therefore, this study aimed to include a minimum of 30 participants from the parent studies to maintain 0.80 power for detecting a pre- and post-AVUPS difference in the AVUPS-Total Acceptance score.

2.5. Procedure—Data Source and Description

The research team compiled a comprehensive dataset from the parent studies conducted between 2021 and 2023 [20]. This dataset contains quantitative data from pre- and post-AVUPS assessments. Eligibility criteria were applied to ensure the inclusion of individuals with complete data. In the parent studies, the collection of quantitative data took 1.5 h to be completed. Participants completed various study-related documents, including the ICF, the HIPAA form, the payment form, a demographic/medical survey, and additional questionnaires, such as the AVUPS and The Motion Sickness Assessment Questionnaire (MSAQ) [24]. The MSAQ was included as a safety precaution to monitor participants' susceptibility to motion sickness during the study, ensuring that any discomfort experienced while using the ASs could be appropriately managed. Following completion of the paperwork, participants experienced the AS ride and again completed the AVUPS and the MSAQ.

The shuttle ride duration averaged approximately 25 min, except in The Villages, which had a 10 min route in accordance with approvals by the National Highway Traffic Safety Administration (NHTSA). Despite the difference in the duration of the route, The Villages' route ensured comparable exposure and experience, incorporating busy roads, stop signs, and pedestrian interactions like the other study locations. All routes were vetted and approved by the NHTSA and followed a loop configuration, with two shuttles operating simultaneously in real-world traffic. The AS deployment route in Gainesville began at the Southwest Downtown Parking Garage (Figure 3). The AV route started at the parking garage between SW 2nd and 3rd St., turned right on SW 2nd Ave., and continued to the roundabout at 10th St., where it looped around and returned to the SW 2nd St. parking garage. At The Villages, the route constituted a loop around the UF Health The Villages Hospital, with a one-stop station for boarding and alighting (Figure 4). Lake Nona participants completed the CANVAS route, which started on Landon St., turned right on Tavistock Lakes Blvd., and turned left on Sachs Avenue, where it lopped around and retuned to Landon St. (Figure 5). In Port St. Lucie, the deployment route started on SW Village Pkwy, turned left on SW Discovery Way, right on SW Community Blvd, and right on SW Meeting St., where it looped around, returning to SW Village Pkwy (Figure 6). All routes were designed to expose participants to typical urban environments with comparable traffic volumes, featuring moderate levels of vehicle and pedestrian activity. During the shuttle

rides, participants were instructed to remain seated, accompanied by a safety operator and a research assistant.

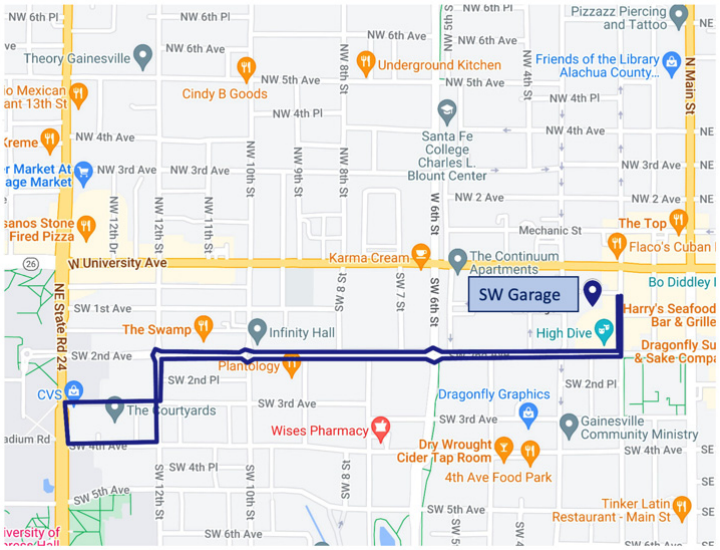


Figure 3. Autonomous shuttle deployment in the City of Gainesville.



Figure 4. Autonomous shuttle deployment in The Villages.

2.6. Theoretical Frameworks

To explore adults' perceptions of and attitudes toward adopting AVs, the AVUPS was developed based on six different models, which guided the data collection of this study. The survey items were informed by key models, including the Technology Acceptance Model (TAM; [25]), the Unified Theory of Acceptance and Use of Technology (UTAUT; [26]), the Car Technology Acceptance Model (CTAM; [27]), the 4P Acceptance Model [28], the Safety Critical Technology Acceptance Model (SCTAM; [29]), and the Self-Driving Car Acceptance Scale (SCAS; [30]). The AVUPS was developed to include 11 constructs: (a) intention to use, (b) perceived ease of use, (c) perceived usefulness, (d) perceived safety, (e) trust and reliability, (f) experience with technology, (g) control and driving efficacy, and (h) external variables, such as media influence, governing authority, social norms, and cost. These constructs were included to align with the above principles while reflecting practical considerations relevant to AV technology.

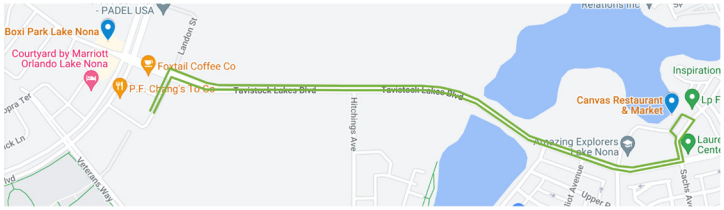


Figure 5. Autonomous shuttle deployment in Lake Nona—CANVAS route.

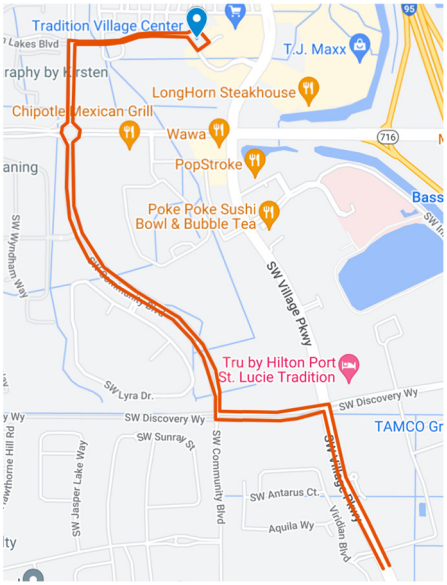


Figure 6. Autonomous shuttle deployment in Port St. Lucie.

2.7. Data Collection

In this study, existing data from the parent studies were used to assess veterans' perceptions before and after exposure to an AS. The FY21-22 parent study focused on AS perceptions in Gainesville, FL, while the FY22-23 parent study expanded its scope to three additional locations in Florida—The Villages, Lake Nona, and Port St. Lucie—to better ascertain statewide veteran AS perceptions. Data from The Villages were obtained as secondary data from an IRB-approved Florida Department of Transportation study (IRB202101677). Both parent studies followed the same research protocol. Although the parent studies also gathered qualitative data during the second phase to provide a deeper understanding of participants' experiences with an AS, the findings from this phase are beyond the scope of the current research article and will be presented in a separate publication.

In the parent studies, participants completed various questionnaires, including the demographic questionnaire, the Montreal Cognitive Assessment (MoCA) [31], the Military to Civilian Questionnaire [32], the Technology Readiness Index 2.0 [33], the Technology Acceptance Model [25], the AVUPS [21,22], and the MSAQ [24]. The demographic questionnaire, the MoCA, and the AVUPS were used for data analysis. The other questionnaires, such as the Military to Civilian Questionnaire, the Technology Readiness Index 2.0, and the Technology Acceptance Model, were included to gather broader insights but were not analyzed in this context. Additionally, the MSAQ was used as a precautionary measure rather than for analytical purposes.

In this study, the independent variables included MoCA scores and demographics (age, gender, rurality, marital status, military branch). Notably, rurality is determined by the VA using Rural–Urban Commuting Area (RUCA) codes, which consider population density and commuting patterns to provide detailed insights into the distance of rural communities

from essential health care services in more populated areas [4]. Participants from The Villages completed a different demographic questionnaire, gathering information on age, gender, rurality, race/ethnicity, education, employment, and health-related impairment. This incongruence in demographic forms occurred because the correct questionnaire was inadvertently omitted from the data collection method for that site, as the data from The Villages were originally collected as part of a separate study. This issue is further addressed in the analysis and results sections of this paper. The dependent variable in this study was veterans' perception of AS technology, measured using the AVUPS pre- and post-shuttle exposure.

The MoCA is a widely used cognitive screening tool for detecting mild cognitive impairment (MCI) across various domains, including attention, concentration, memory, language, visuospatial skills, and executive functions [31]. The psychometric properties of MoCA have been extensively studied, and it is a reliable and valid tool for detecting MCI in various populations, including veterans [34]. Although all participants in the parent studies were included regardless of MoCA scores, these data were collected for transparency and to ensure that the results of the study are not confounded by cognitive deficits.

The AVUPS, a 32-item questionnaire, includes a 28-item visual analog scale and four open-ended questions [21,22]. This study focused on the visual analog scale data. The visual analog scale is a 100 mm horizontal line ranging from disagree to agree. The AVUPS has strong psychometric properties, with excellent internal consistency ($\alpha = 0.95$) and test–retest reliability ($\rho = 0.76$, ICC = 0.95) and a strong Mokken scale (Hscale = 0.51). While the survey's visual analog scale consists of 28 items, for the analysis in this paper, and as recommended by the Mokken scale analyses [22], only 20 out of the 28 items are used to assess total acceptance and the three subscales. The AVUPS is a reliable and valid tool, with its subscales offering valuable insights into the factors influencing user acceptance of AVs [21,22].

2.8. Data Management

The research team employed strategies to support the security and confidentiality of the data that were obtained from the parent studies. For example, participant responses to questionnaires were securely stored in password-protected systems or locked cabinets within a secure VA research office, adhering to VA and university information security policies. Furthermore, the existing data used for analysis were de-identified to protect the privacy of the participants.

2.9. Data Analysis

The quantitative data obtained from the parent studies were analyzed in RStudio using R 4.3.1 [35]. Descriptive statistics were conducted for all study participants on the overlapping demographic variables: age, gender, and rurality. As The Villages used a different demographic questionnaire, and considering the limited count of overlapping variables, a detailed description of demographic variables was additionally provided for each study location. The descriptive statistics by study location included the following demographic variables: age, gender, race/ethnicity, education, rurality, marital status, military branch, employment, health-related impairment, and MoCA scores. Categorical data were presented as count (n) and proportion (%), while continuous data were displayed as mean (*M*) and standard deviation (*SD*) or median and interquartile range (*IQR*) if analysis assumptions were violated.

The current study is powered to assess the pre- and post-AS differences in AVUPS-Total Acceptance, which is the primary outcome variable. Secondary analyses were conducted to explore pre- and post-differences in the AVUPS subscales (intention to use, perceived

barriers, and well-being) for all participants, as well as for rural vs. urban veterans. Additionally, a subset analysis was conducted on a group of participants (n = 30) exhibiting the lowest total acceptance scores, assessing pre- and post-AVUPS data differences. Those with the lowest total acceptance scores are the most resistant to the technology or the least accepting and thus have the most to gain from riding in an AS. Lastly, the research team conducted an analysis investigating the specific survey items contributing to each of the three AVUPS subscales. To control for a false discovery rate ($q < 0.05$), the research team used the "p.adjust" function in R with the Benjamini–Hochberg method, which is a multiple testing correction method that adjusts the *p*-values for each test based on the number of tests being conducted [36].

The primary outcome variable, total acceptance of AS technology among veterans (pre- and post-AVUPS data), was assessed for normality via visual analysis (i.e., histograms, Q-Q plot, boxplots) and statistical tests (i.e., Levene's test, skewness and kurtosis indices, and Shapiro–Wilk's test). Because the normality assumptions were violated for the AVUPS data, a series of Wilcoxon rank-sum tests were used to assess within-group differences for the three AVUPS subscales and the total acceptance score ($p \leq 0.05$). The research team assessed within-group differences for all study participants and further stratified the analysis to compare rural and urban participants, aiming to explore potential influences of rurality on veterans' perceptions of AVs. A subset analysis (n = 30) was also performed to investigate within-group differences among participants with the lowest total acceptance scores. This analysis specifically aimed to discern pre- and post-AS exposure variations among individuals with lower AS acceptance scores, excluding those already expressing a high level of acceptance.

As previously indicated, the AVUPS data were scored into three Mokken subscales (i.e., intention to use, perceived barriers, and well-being) and the total score, which represents the overall acceptance of AS technology score [22]. Specifically, the Mokken subscales were computed using the rowMeans function in R. This function averaged scores across AVUPS items to calculate both the subscale scores and the total score. The intention to use mean was derived from 13 items, the perceived barriers mean was derived from 6 items, the well-being mean was derived from 4 items, and the overall acceptance score mean was derived from 20 items. To identify specific AVUPS items that significantly contributed to a particular subscale, the research team conducted a series of Wilcoxon rank-sum tests to assess the within-group differences for each AVUPS item within each subscale.

3. Results

3.1. Demographics

Table 1 displays demographic characteristics for all study participants and by study location at baseline. Out of the 113 individuals screened, a total of 77 participants completed Phase I of the study. The AVUPS was administered to veterans before and after exposure to the AS in The Villages (n = 39; 50.7%), Gainesville (n = 23; 29.9%), Lake Nona (n = 13; 16.9%), and Port St. Lucie (n = 2; 2.6%), Florida. The study participants included 66 males and 11 females. The majority of veterans were between 24 and 64 years of age (n = 41; 53%), with a mean participant age of $M = 60.6$, $SD = 16$ years. In terms of rurality distribution, most participants resided in urban areas (n = 63; 83%). The Villages' participants completed a different demographic questionnaire collecting data on different descriptive variables. Table 1 provides the demographic characteristics for participants by study location at baseline. Participants from The Villages, an adult retirement community, were older ($M = 70.9$; $SD = 8.30$), while those from Port St. Lucie, recruited from the general population, were younger ($M = 39.0$; $SD = 4.24$). At each study location, the majority were male (>82%) and lived in urban areas (>76%), except for Port St. Lucie, where two participants evenly

represented both genders and rurality (50%). In The Villages, the majority were White (92%), highly educated (67% with at least a Bachelor's degree), retired (74%), and free from impairments impacting their use of transportation (90%). In Gainesville, most reported divorced marital status (39%), army affiliation (44%), and an average MoCA score of 25 ± 2.8. Lake Nona and Port St. Lucie participants reported mostly married status (>61%) and army affiliation (>53%). While Lake Nona participants had an average MoCA score of 25 ± 3.2, those in Port St. Lucie scored an average of 29 ± 0.0, indicating better cognitive functioning than the comparison group.

Table 1. Descriptive statistics for all study participants and by study location at baseline.

Variable	Study Location				All Participants (N = 77)
	The Villages (n = 39)	Gainesville (n = 23)	Lake Nona (n = 13)	Port St. Lucie (n = 2)	
Age (years)	70.9 ± 8.30	55.3 ± 15.79	42.1 ± 9.39	39.0 ± 4.24	60.6 ± 15.97
24–64	10 (25.64%)	16 (69.57%)	13 (100%)	2 (100%)	41 (53.25%)
65+	29 (74.36%)	7 (30.44%)	0 (0.00%)	0 (0.00%)	36 (46.75%)
Gender					
Male	35 (89.74%)	19 (82.61%)	11 (84.62%)	1 (50.0%)	66 (85.71%)
Female	4 (10.26%)	4 (17.39%)	2 (15.38%)	1 (50.0%)	11 (14.29%)
Rural *					
Rural	7 (18.42%)	2 (8.70%)	3 (23.08%)	1 (50.0%)	13 (17.11%)
Urban	31 (81.58%)	21 (91.30%)	10 (76.92%)	1 (50.0%)	63 (82.89%)
Race/Ethnicity					
White	36 (92.31%)	-	-	-	-
Other	3 (7.69%)	-	-	-	-
Education					
High school graduate or GED	1 (2.56%)	-	-	-	-
Some college, no degree	4 (10.26%)	-	-	-	-
Associate's degree	8 (20.51%)	-	-	-	-
Bachelor's degree	11 (28.21%)	-	-	-	-
Master's degree	11 (28.21%)	-	-	-	-
Doctoral degree	4 (10.26%)	-	-	-	-
Marital Status					
Divorced	-	9 (39.13%)	3 (23.08%)	0 (0.00%)	-
Single	-	7 (30.43%)	1 (7.69%)	0 (0.00%)	-
Married	-	4 (17.39%)	8 (61.54%)	2 (100%)	-
Others	-	3 (13.05%)	1 (7.69%)	0 (0.00%)	-
Military Branch					
Army	-	10 (43.48%)	7 (53.85%)	2 (100%)	-
Marines	-	6 (26.09%)	3 (23.08%)	0 (0.00%)	-
Navy	-	4 (17.39%)	1 (7.69%)	0 (0.00%)	-
Air Force	-	3 (13.04%)	2 (15.38%)	0 (0.00%)	-
Employment					
Work—part-time	5 (12.82%)	-	-	-	-
Work—full-time	3 (7.69%)	-	-	-	-
Military veteran	1 (2.56%)	-	-	-	-
Retired	29 (74.36%)	-	-	-	-
Other	1 (2.56%)	-	-	-	-
Impairment					
None	35 (89.74%)	-	-	-	-
Vision	2 (5.13%)	-	-	-	-
Physical	1 (2.56%)	-	-	-	-
Psychological	1 (2.56%)	-	-	-	-
MoCA Score	-	25.04 ± 2.77	25.69 ± 3.22	29.0 ± 0.00	-

Note. Data reported as no. (% of cohort) or *M* ± *SD*. * Data on residential location (rural or urban) were missing for one participant at The Villages site.

3.2. The Four AVUPS Scores

Table 2 displays the within-group comparisons of the four AVUPS domains (i.e., intention to use, perceived barriers, well-being, and total acceptance) between baseline and post-exposure to the AS for all study participants (N = 77) and a subset of participants (n = 30) with the lowest total acceptance scores. At baseline, the majority of participants displayed scores exceeding 65 (out of 100) on the AVUPS for the primary outcome variable,

i.e., total acceptance. Additionally, most participants scored 69 (out of 100) or higher on the AVUPS in the domains of intention to use and well-being, while the perceived barriers domain median score was 35 (out of 100) on the AVUPS. Following exposure to the AS, statistically significant differences (improvements in perceptions) were observed in all domains, except for well-being. Specifically, intention to use and total acceptance displayed a statistically significant increase between pre- and post-AS exposure, while perceived barriers showed a significant decrease. Descriptively, well-being showed an increase post-exposure, although this change did not reach statistical significance. In the subset analysis, a similar pattern emerged, with all domains displaying statistically significant differences between pre- and post-AS exposure, except for the well-being scale. Notably, the subset group exhibited a larger magnitude in the differences between pre- and post-AS exposure, indicating a more substantial increase in intention to use and total acceptance, as well as a more pronounced decrease in perceived barriers among participants with lower AS acceptance scores at baseline compared to the overall study population.

Table 2. Within-group differences in the four AVUPS domains among veterans before and after shuttle exposure.

	All Participants (N = 77)			Subset of Participants (n = 30) [a]		
AVUPS Domains	**Pre-AS**	**Post-AS**	***p***	**Pre-AS**	**Post-AS**	***p***
Intention to Use	70.1 (22.8)	71.0 (21.5)	0.011 *	52.9 (12.3)	57.7 (16.7)	0.046 *
Perceived Barriers	35.0 (28.3)	29.5 (26.3)	0.003 *	47.8 (13.0)	37.9 (18.5)	0.001 *
Well-Being	69.0 (25.5)	73.2 (29.2)	0.094	47.0 (31.0)	56.0 (30.0)	0.127
Total Acceptance	65.8 (25.6)	68.8 (21.8)	0.007 *	48.9 (7.81)	56.8 (17.6)	0.023 *

Note. AS = autonomous shuttle; data reported as median score (*IQR* = interquartile range); Wilcoxon signed-rank test to assess before and after shuttle within-group differences. * Significant results, $p < 0.05$. [a] Subset analysis (n = 30) to investigate within-group differences among participants with the lowest total acceptance scores.

Table 3 displays the within-group comparisons for the four AVUPS domains between baseline and post-AS exposure for urban (n = 63) and rural veterans (n = 13). Descriptively, urban veterans consistently displayed higher median scores for intention to use, well-being, and total acceptance both at baseline and post-AS exposure compared to their rural counterparts. Conversely, rural veterans exhibited higher median scores for perceived barriers when compared to urban veterans at both baseline and post-AS exposure. Urban veterans demonstrated a statistically significant increase post-AS exposure in intention to use and total acceptance and a decrease in perceived barriers. For rural veterans, statistical significance was observed only for perceived barriers, showing a decrease post-AS exposure, which indicates more positive perceptions. The well-being domain did not exhibit statistically significant differences for either the urban or rural veterans.

Table 3. Within-group differences in the four AVUPS domains among urban and rural veterans before and after shuttle exposure.

	Urban Veterans (n = 63)			Rural Veterans (n = 13)		
AVUPS Domains	**Pre-AS**	**Post-AS**	***p***	**Pre-AS**	**Post-AS**	***p***
Intention to Use	71.1 (25.4)	73.1 (20.7)	0.009 *	55.4 (12.0)	59.5 (27.7)	0.906
Perceived Barriers	32.7 (27.8)	27.2 (22.0)	0.026 *	45.3 (16.7)	39.2 (10.8)	0.034 *
Well-Being	71.2 (22.1)	77.2 (27.5)	0.256	46.8 (37.8)	59.2 (28.5)	0.275
Total Acceptance	69.0 (24.6)	72.0 (17.6)	0.009 *	49.0 (14.5)	57.1 (20.2)	0.906

Note. AS = autonomous shuttle; data reported as median (*IQR* = interquartile range); Wilcoxon signed-rank test to assess before and after shuttle within-group differences. Data on residential location (rural or urban) were missing for one participant. * Significant results, $p < 0.05$.

Table 4 presents the within-group differences in AVUPS items comprising the three AVUPS subscales—intention to use, perceived barriers, and well-being—for all study

participants. Within the intention to use domain, 4 out of 13 items showed statistically significant differences from pre- to post-AS exposure. Specifically, participants displayed a significant increase in trust ($p = 0.005$) and willingness to engage in other tasks while in an AV ($p = 0.004$), a heightened perception of safety for other road users ($p = 0.048$), and an elevated sense of safety while riding in the AV ($p < 0.001$). However, after controlling for multiple comparisons, only the item related to positive feelings of safety while riding in an AV (AVUPS item #27, see Table 4) remained statistically significant ($p = 0.006$). In the perceived barriers domain, two out of six items showed significant decreases from pre- to post-AS exposure. Participants demonstrated a reduction in perceived barriers post-AS exposure, which was particularly related to concerns about the potential decline in individual driving abilities ($p = 0.004$) and hesitations about AV use ($p < 0.001$). These two items within the perceived barriers domain retained their significance after adjusting for multiple comparisons. Within the well-being domain, significant mean differences were not detected for any of the four AVUPS items.

Table 4. Within-group differences of AVUPS items constituting the three AVUPS subscales for all study participants.

AVUPS Subscales	AVUPS Items	Time		*p*	Adjusted *p*-Value
		Pre-AS	Post-AS		
Intention to Use	4. I am open to the idea of using automated vehicles	88.0 (20.0)	90.0 (15.0)	0.372	0.719
	6. I believe I can trust automated vehicles	58.0 (43.0)	79.0 (40.0)	0.005 *	0.056
	7. I will engage in other tasks while riding in an automated vehicle	69.0 (39.0)	81.0 (41.0)	0.004 *	0.054
	8. I believe automated vehicles will reduce traffic congestion	77.0 (43.0)	85.0 (43.0)	0.085	0.676
	9. I believe automated vehicles will assist with parking	85.0 (21.0)	87.0 (26.0)	0.303	0.719
	13. I expect that automated vehicles will be easy to use	80.0 (25.0)	83.0 (18.0)	0.077	0.676
	15. I would use an automated vehicle on a daily basis	55.0 (37.0)	73.0 (44.0)	0.248	0.719
	17. Even if I had access to an automated vehicle, I would still want to drive myself	50.0 (54.0)	49.0 (53.0)	0.719	0.719
	20. I will be willing to pay more for an automated vehicle compared to what I would pay for a traditional car	46.0 (53.0)	47.0 (50.0)	0.229	0.719
	21. If cost was not an issue, I would use an automated vehicle	78.0 (38.0)	80.0 (31.0)	0.564	0.719
	22. I would use an automated vehicle if National Transportation Safety Association deems them as being safe	78.0 (38.0)	84.0 (35.0)	0.373	0.719
	25. When I'm riding in an automated vehicle, other road users will be safe	70.0 (37.0)	78.0 (39.0)	0.048 *	0.480
	27. I feel safe riding in an automated vehicle	70.0 (41.0)	85.0 (34.0)	<0.001 *	0.006 *
Perceived Barriers	5. I am suspicious of automated vehicles	25.0 (56.0)	19.0 (41.0)	0.067	0.269
	14. It will require a lot of effort to figure out how to use an automated vehicle	27.0 (49.0)	22.0 (48.0)	0.469	0.554
	16. I would rarely use an automated vehicle	26.0 (45.0)	21.0 (43.0)	0.206	0.554
	19. My driving abilities will decline due to relying on an automated vehicle	47.0 (54.0)	42.0 (56.0)	0.004 *	0.021 *
	26. I believe that automated vehicles will increase the number of crashes	15.0 (40.0)	15.0 (25.0)	0.554	0.554
	28. I feel hesitant about using an automated vehicle	30.0 (49.0)	15.0 (36.0)	<0.001 *	0.001 *

Table 4. *Cont.*

AVUPS Subscales	AVUPS Items	Time		*p*	Adjusted *p*-Value
		Pre-AS	Post-AS		
Well-Being	10. I believe automated vehicles will allow me to stay active	71.0 (40.0)	73.0 (43.0)	0.199	0.398
	11. Automated vehicles will allow me to stay involved in my community	76.0 (41.0)	75.0 (35.0)	0.704	0.704
	12. Automated vehicles will enhance my quality of life/well-being	75.0 (39.0)	74.0 (30.0)	0.108	0.323
	24. My family and friends will encourage/support me when I use an automated vehicle	58.0 (35.0)	73.0 (42.0)	0.058	0.231

Note. Veterans (N = 77); AS = autonomous shuttle; data reported as median (*IQR* = interquartile range); Wilcoxon signed-rank test to assess before and after shuttle within-group differences. * Significant results, $p < 0.05$.

4. Discussion

This study assessed the perceptions of veterans (N = 77) prior to and after exposure to the EasyMile (EZ10) or Navya AS using existing data from two studies. Specifically, using quantitative methodologies, the research team explored if exposure to an AS changed veterans' perception of such technology when comparing pre-exposure to post-exposure.

4.1. Demographics

The study population consisted primarily of middle-aged to older male veterans, consistent with the broader US veteran demographic [3]. Participants from The Villages were notably older (*M* = 70.90; *SD* = 8.30) compared to participants in the other study locations. This was not surprising, as The Villages is the largest retirement community in the US and houses older adults (over the age of 55) who are seeking an active lifestyle [37]. In contrast, participants from Lake Nona were younger (*M* = 42.1; *SD* = 9.39). This reflects the area's focus on productive engagement in industries like medical research, education, and technology [38]. This age diversity supports the study's objective to capture varied perspectives of ASs from veterans of various ages.

Although the majority of participants lived in urban areas (83%), about 25% of US veterans reside in remote (i.e., more than 60 min from the nearest VA) or highly rural locations (i.e., fewer than seven persons per square mile) [4]. Underrepresentation of rural veterans may be connected to the associated recruitment challenges. Data were collected from four Florida locations to provide insights into the veterans' acceptance of ASs. However, the study's narrow geography limits generalization to communities outside of those that were investigated. As such, a need exists for larger studies to examine a greater number of diverse samples across counties and states to support knowledge generation for AS development and deployment.

Participants from three of the study locations—Gainesville, Lake Nona, and Port St. Lucie (n = 38, 49%)—were primarily army veterans, reflecting general US veteran population trends [3]. Most were married, consistent with national statistics for veterans [3]. The average MoCA score indicated mild signs of cognitive limitations, consistent with older age and participants' history of military exposure. In The Villages (n = 39, 51%), the majority of participants were White, highly educated, and retired, reflecting the population statistics of The Villages [37]. Discrepancies in demographic data across locations, particularly in The Villages, arose due to a different demographic questionnaire being used in The Villages.

4.2. The Four AVUPS Scores

The study's initial assessment of all participants revealed generally favorable perceptions toward ASs at baseline, reflected in scores above 65 (out of 100) for the domains of

intention to use, well-being, and total acceptance. Conversely, scores below 35 (out of 100) in the perceived barriers domain indicated that relatively few barriers were perceived. These descriptive data indicate that the majority of participants already held a positive view of the AS even before riding in the shuttle. This pre-existing positive orientation might be attributed to self-selection bias, as individuals opposed to the implementation of AVs might have been less likely to participate in the study.

The statistically significant change in the AVUPS-Total Acceptance score indicated that exposure to the AS positively influenced participants' overall acceptance of the technology. Additionally, a significant increase was observed for AVUPS-Intention to Use, particularly with regard to enhanced safety. These findings align with the existing research, emphasizing the role of safety in fostering positive perceptions of AVs [39]. However, one item under AVUPS-Intention to Use, specifically "I am open to the idea of using automated vehicles" (item #4), did not reach statistical significance, despite the overall domain AVUPS-Intention to Use showing a statistically significant improvement. This suggests the need for caution in interpreting the results. It is essential to note that acceptance of the technology, as measured by AVUPS-Total Acceptance, does not directly translate to the participants' intention to use the technology in the future. Acceptance signifies positive attitudes or beliefs toward AVs, but intention to use reflects actual willingness to adopt an AS. Therefore, while participants may accept the technology, this does not guarantee their intention to use it in the future. As such, research is necessary to examine the actual *adoption* vs. just acceptance of the AS technology.

AS exposure also reduced perceived barriers, particularly concerns about the potential decline in individual driving abilities and hesitations about AV use. These findings suggest that the practical experience of interacting with AV technology through the shuttle ride positively influenced participants' perceptions pertaining to barriers and made them more receptive to the AS as a viable transportation option. Additionally, these findings are consistent with prior research that explored AS users' perceptions and attitudes, which also reported an increase in positive perceptions and acceptance of ASs after experiencing the technology firsthand [15–17,19]. Although the intention to use, perceived barriers, and total acceptance domains showed a significant difference between pre- and post-AS exposure, the actual magnitudes of these differences were relatively small. Specifically, the changes did not exceed 6 mm on the AVUPS scale, which is measured on a 0–100 mm horizontal analog scale ranging from disagree to agree. However, specific items within these domains (AVUPS-Intention to Use items #6, 7, 25, and 27 and AVUPS-Perceived Barriers items #19 and 28), as demonstrated in Table 4, displayed substantial significant differences, ranging from 5 to 21 mm. This suggests that these specific items might serve as more sensitive indicators for capturing nuanced changes in perceptions compared to the broader domains.

An exploratory analysis was conducted to gain deeper insights into participants' responses, specifically by assessing a subset with the lowest total acceptance scores. This analysis aimed to uncover whether real-world exposure had a more pronounced effect on individuals initially less accepting of AS technology. In the subset analysis of participants (n = 30) with the lowest total acceptance scores, a similar pattern emerged, with all domains displaying statistically significant differences post-AS exposure, except for well-being. Notably, the subset group exhibited a larger magnitude in the differences between pre- and post-AS exposure, indicating a more substantial increase in intention to use and total acceptance and a more pronounced decrease in perceived barriers. Although the magnitude of these differences remained modest (descriptively, 5 to 10 mm), the impact of real-world exposure to ASs appears more meaningful among individuals with initially lower acceptance of AVs. Understanding the differential impact of real-world exposure

on varying levels of acceptance is key to designing tailored strategies to enhance public acceptance. It highlights the potential of exposure to enhance some perceptions, particularly among individuals with lower initial acceptance levels.

Urban veterans (compared to rural veterans) consistently exhibited higher median scores for intention to use, well-being, and total acceptance both before and after AS exposure, indicating a more positive orientation toward ASs. Conversely, rural veterans consistently reported higher median scores for perceived barriers, indicating that they perceive more obstacles to the adoption of AS technology compared to their urban counterparts. These findings are consistent with the broader literature on rural–urban differences in transportation access, highlighting the unique challenges faced by rural populations, such as limited infrastructure, longer travel distances, and potentially less exposure to emerging technologies [40,41]. The statistically significant increase in intention to use and total acceptance scores among urban veterans post-AS exposure is consistent with the overall study population (N = 77), indicating a positive impact of direct experience with ASs on their perceptions of and willingness to accept this technology. However, the actual magnitude of these differences was small, warranting cautious interpretation of their practical implications, as further discussed in the implications section. Interestingly, rural veterans (n = 13) exhibited a statistically significant decrease in perceived barriers post-AS exposure, despite the small sample size. However, none of the other domains—intention to use, well-being, and total acceptance—reached statistical significance for rural veterans. This study was underpowered to detect smaller, yet potentially significant differences in secondary analyses, which may have the potential to increase the presence of Type II errors.

The well-being domain did not exhibit statistical significance for any of the statistical analyses, including the AVUPS items' analyses (four items). A previous study also measuring pre- and post-AS perception differences using the AVUPS similarly found no significant changes in well-being [20]. The type of exposure provided in the study is not consistent with how users would eventually use the technology. For example, if participants were exposed to a real scenario where the shuttle takes them to the VA hospital or somewhere meaningful, their perception might be very different from that tested during this trial. The perceived benefit of AS transportation is partially based on need, and if individuals do not currently have a specific need, they might not see the absolute value in the actual service. Thus, riders may require more exposure to AVs and ASs to recognize potential benefits to their well-being, such as incorporating the shuttle into their daily commute or transportation to and from medical appointments. On the other hand, the well-being scale consistently underperformed in conducted studies when it was utilized [42]. This may indicate that the well-being scale is not adequately sensitive to measure perceived differences in well-being as a result of AS exposure. Moreover, the lack of statistical significance in well-being may also result from the application of the AVUPS in this study's context. While the AVUPS aims to discern perceptions of AVs as a broader category, this study specifically assesses the effect of AS exposure. Thus, using the AVUPS to measure changes due to AS exposure may lack the specificity needed for nuanced responses related to ASs. In fact, post-exposure to an AS, only 3 out of 23 AVUPS items (across all domains) exhibited statistically significant differences after controlling for multiple comparisons (adjusted p-value). Although this study was not specifically powered for this exploratory analysis, it indicates a potential limitation in using AVUPS domains to assess changes in users' perceptions after AS exposure. Relying on AVUPS domains to assess change after AS exposure rather than specific items within each domain may obscure larger differences and practical implications. Some items may not effectively capture the intended meaning of the lived experience when specifically assessing the effect of AS exposure. In turn, analyzing the AVUPS domains (instead of the individual items) could have resulted in diluted findings. Given the limited

number and small magnitude of these differences, additional research specifically focusing on the context of AS transportation, with a measure specifically developed to capture the intended factors influencing (inhibiting or promoting) AS acceptance, is needed.

The results of this study, which focus on the veteran population, closely align with findings from studies on non-veteran populations [15–17,43]. Specifically, non-veteran participants exposed to ASs consistently report high levels of acceptance, perceived safety, trust, and intention to use an electric AS [15,16]. In contrast, the lack of a statistically significant difference in the AVUPS well-being domain among veterans in this study echoes previous findings that ASs are not (yet) perceived as a substantial enhancement to mobility services, which is potentially due to current limitations related to route design and operational flexibility [15,16]. Moreover, while studies on non-veteran populations suggest that ASs could effectively serve as feeder systems to larger public transportation networks in both urban and rural contexts [43], the findings from this study reveal a nuanced perspective, as rural veterans report perceiving greater barriers to adopting ASs than their urban counterparts. The differential perceptions may reflect concerns about the availability, convenience, and adaptability of AS systems to meet the unique mobility needs of rural communities. Although veterans, shaped by their military-related experiences, training, and health conditions, represent a distinct demographic, they share surface-level similarities with non-veteran populations regarding acceptance of and intention to use an AS after first-hand exposure. Nonetheless, these surface similarities warrant deeper examination and potentially a formal analysis to identify any significant differences.

In summary, veterans demonstrated generally positive baseline perceptions toward ASs, with participants reporting high scores of total acceptance, intention to use, and well-being, alongside low perceived barriers. Post-exposure to an AS, there were statistically significant increases in total acceptance and intention to use, suggesting that direct experience positively influenced perceptions, particularly regarding safety. The subgroup analysis showed that individuals with initially lower acceptance levels exhibited more pronounced improvements after AS exposure. Differences emerged between urban and rural veterans, with urban participants reporting more favorable attitudes and fewer barriers compared to their rural counterparts. The well-being domain did not show a statistically significant change post-AS exposure, potentially due to the limited relevance of the AS route to participants' daily needs. Overall, the findings indicate the potential of real-world exposure to enhance perceptions of ASs.

With a sample size of 77 participants, this study was adequately powered (power of 0.80 for matched pairs with two measures, pre- and post-AS exposure survey, and a medium effect size of Cohen's d = 0.53) to detect a significant difference in total acceptance, the primary outcome variable, among all participants. Although the study did show statistical significance in intention to use and perceived barriers, which is consistent with prior research [20,42], the results need to be interpreted with caution, as the study was not specifically powered for these analyses. Additional secondary and exploratory analyses should also be interpreted with caution, even though the Benjamini–Hochberg method was applied to control for multiple comparisons [36].

5. Conclusions

This study assessed veterans' perceptions post-AS exposure across four locations in Florida, leveraging quantitative data from two parent studies. Overall, participants exhibited positive perceptions of ASs, with significant increases in total acceptance and intention to use following AS exposure, particularly related to safety perceptions. Perceived barriers decreased, especially concerns about the potential decline in their own driving ability and hesitations about using AVs. The well-being domain did not show significant changes,

suggesting that longer exposure or more practical use scenarios may be needed to impact well-being perceptions. The exploratory analysis of participants with the lowest baseline total acceptance scores revealed larger improvements post-exposure, particularly in intention to use and total acceptance, and a more pronounced reduction in perceived barriers. These findings suggest that AS exposure may be particularly impactful for individuals with lower initial acceptance levels. While urban veterans demonstrated more favorable perceptions compared to rural veterans, both groups benefited from real-world AS exposure. However, the small magnitude of the observed changes suggests the need for further research. Continuous collaboration with industry partners, further field testing, and overcoming ASs' technical and operational challenges (e.g., ASs' weather tolerance) are necessary steps in paving the way for considering AS services for veterans. VA decision makers (e.g., VA medical centers), VA transportation stakeholders (e.g., the Veterans Transportation Service), and industry partners (e.g., AS manufacturers) can leverage these findings to educate, advocate, and address concerns identified in the study's findings. Overall, the study findings point to the potential for considering ASs as a viable, sustainable, and accessible transportation option for veterans. However, second-generation shuttles—with increased seating capacity, speed, and accessibility—along with more flexible route options and expanded operating hours (day and night, seven days a week) must be considered to provide ubiquitous access and benefits to veterans as they use these technologies.

5.1. Limitations

The quasi-experimental design and convenience sampling of the parent studies may have led to selection and spectrum bias, where participants with pre-existing positive views of AVs are overrepresented, which may have had the effect of potentially skewing the study's outcomes. The lack of consistency in demographic data collection across study locations prevented an exploration of how socio-economic indicators, e.g., income variations, may have affected the results. Higher-income areas like Lake Nona and The Villages may have had higher expectations and, consequently, reported more barriers compared to middle- to lower-income areas like Gainesville, which had the highest perceptions of AVs' benefits and intention to use. Additionally, the Lake Nona shuttle had been operational for a longer period compared to other locations, potentially influencing participants' perceptions due to prolonged exposure. In contrast, areas with shorter exposure periods, such as The Villages, may not have developed the same level of familiarity and acceptance, which could have impacted their responses. Participants in The Villages also had a shorter AS ride (10 min versus 25 min in the other study locations), further limiting their exposure to the AS. This limited exposure could have negatively influenced their overall perceptions and acceptance.

Additionally, the technology is still in its developmental phases, and the research team in the parent studies encountered numerous field-related challenges during the study's execution, which are well-discussed in Report # BED31-977-26. For instance, the shuttles were limited by weather conditions, functioning only in light rain, while heavy rain halted operations. During summer, air conditioning drained the battery power, requiring temporary suspensions for recharging. Technical issues, such as shuttle reboots, further disrupted operations, leading to participant rescheduling and study delays. Additionally, the shuttles only operated during daytime hours, posing further scheduling limitations. These operational challenges may have negatively influenced participants' perceptions of AS technology. However, such challenges are inherent in the ongoing development and improvement of AS technology. Although the shuttle offers a first mile–last mile option, it operates on a fixed route and does not fully meet all requirements of the American with Disabilities Act (ADA), a law designed to ensure equal access for individuals with disabili-

ties. For example, the shuttle lacks an automatic ramp for boarding and exiting, which may limit accessibility for veterans, particularly those who use assistive mobility devices.

Treating AVUPS items as continuous variables without distinguishing between low and high intention to use creates artificial hierarchies and limits interpretation. It assumes small differences in scores are meaningful and that all items contribute equally to the overall score, which may not be the case. For example, items like "I am interested in using AVs" and "I am comfortable with AVs operating at night" may reflect different aspects of intention to use, and treating them as part of a single scale assumes that their scores are directly comparable, which can lead to misinterpretations. More nuanced methods, such as item response theory, could provide better insights into these differences and improve the accuracy of the findings.

Although this study was adequately powered to detect differences in AVUPS-Total Acceptance, caution is warranted in interpreting the results of the secondary analyses due to the lack of specific power for these analyses. Moreover, the small sample size and underrepresentation of rural veterans for secondary analyses could lead to Type 2 errors, where an effect may exist but goes undetected due to the limited sample size. Although statistically significant differences were observed in pre- and post-AVUPS total acceptance, their practical implications may be limited due to the relatively small magnitude of this difference. Additionally, the lack of statistical significance in the AVUPS-Well-Being domain may stem from the survey's broader focus, underscoring the need for a nuanced assessment of AS-related perceptions.

5.2. Strengths and Future Directions

Technology-based interventions, such as integrating ASs into community mobility options, hold promise for veterans, particularly those unable or unwilling to drive. This study is among the pioneering efforts to assess veterans' perceptions of and potential acceptance of AS technology in the United States. Conducted across four different locations in Florida, the study's geographic breadth enhances its applicability across different regional contexts, thereby strengthening its generalizability. By leveraging cutting-edge technology and fostering collaboration with transportation stakeholders and industry partners, this research provides unique insights into veterans' perceptions of ASs.

This study has significant implications for research, public health, practice, and sustainability. In terms of research, the modest magnitude of pre- and post-exposure changes in total acceptance, intention to use, and perceived barriers suggests the need for more sensitive, tailored instruments to better capture nuanced shifts in perception. Refining these instruments may generate more accurate data to inform the design and deployment of AS programs, particularly for populations with initially lower acceptance rates. From a public health perspective, the study underscores how AS technology could address critical transportation barriers faced by veterans, particularly in rural areas. Enhanced access to healthcare services and community activities through reliable AS transportation may foster community integration, reduce social isolation, and improve health outcomes. By decreasing reliance on human drivers, AS technology could also reduce transportation-related crashes by minimizing human error and improving overall safety for veterans and the broader public. The findings also have practical implications for industry stakeholders, emphasizing the importance of addressing user concerns, especially among older veterans, who expressed more safety-related concerns. Implementing safety operators aboard AS vehicles during the early phases of deployment could help build user trust and confidence. Additionally, ongoing collaboration with industry partners is crucial to address technical and operational challenges, ensuring that AS systems remain user-friendly, reliable, and accessible for all users.

Sustainability is another critical area impacted by AS technology. A key benefit is the potential reduction in greenhouse gas emissions, as these shuttles are often electric-powered, thus reducing dependency on fossil fuels, particularly when electricity is sourced from renewable energy. Autonomous shuttles improve transportation efficiency by operating on optimized routes and schedules, minimizing energy waste associated with idling, congestion, and inefficient driving behaviors. By serving as first-mile/last-mile solutions, ASs encourage multi-modal transportation, enhancing access to public transit systems and reducing reliance on private vehicles, thereby lowering overall vehicle kilometers traveled. Their small size and shared-use model contribute to easing road congestion, further reducing emissions from stop-and-go traffic. Moreover, ASs align with sustainable urban planning goals by supporting pedestrian-friendly and low-emission zones, thus reducing the spatial and environmental footprint of transportation. However, to maximize these sustainability benefits, challenges, such as lifecycle emissions from vehicle production and ensuring equitable access to ASs, must be addressed. When integrated with policies promoting renewable energy and shared mobility, ASs have the potential to significantly advance sustainability goals.

Future research may benefit from exploring participants' familiarity with the technology, particularly their prior experiences with AVs and how these experiences influence their perceptions. Collecting data on participants' conceptual understanding of AVs may also help identify knowledge gaps that shape perceptions. Additionally, future studies may assess the effects of ride duration, the number of AS trips, and interactions with other road users on participants' perceptions. Such investigations may provide deeper insights into the factors that influence AS acceptance and inform strategies to enhance user experience and adoption.

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