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Promoting the Adoption Dynamics of Autonomous and Shared Autonomous Vehicles: A Scientific Mixed-Methods Approach

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ABSTRACT

Autonomous vehicles (AVs) and shared autonomous vehicles (SAVs) can solve serious issues like traffic congestion, pollution, and inefficient transportation in Jakarta, Depok, Tangerang, Bogor, and Bekasi (JABODETABEK). This comprehensive scientific study examines the intricate spectrum of factors that affect AV and SAV acceptability in this ever-changing environment. These include knowledge, attitudes, relevance, subjective norms, behavioral control, and intents. This study synergizes quantitative analysis with qualitative interview observations. It seeks to explain the complicated spectrum that drive AV and SAV adoption in JABODETABEK. The findings show that when people learn more, they regard AVs and SAVs as less important but safer and more advantageous. Knowledge also affects intentions, emphasizing the need for education and information exchange to lower worries and boost acceptance. In contrast, the perception of relevance negatively impacts attitudes and intentions toward AVs and SAVs, emphasizing the need for customized approaches to improve the perceived relevance of these revolutionary technologies in JABODETABEK. This scientific study adds quantitative and qualitative insights to autonomous transportation technology discussions. It also illuminates how knowledge, attitudes, cultural norms, and perceived importance affect the adoption of these technologies in a dynamic urban region. This scientific study sheds light on sustainable spectrum and efficient mobility solutions.

1. Introduction

People are facing transportation issues such as traffic danger and congestion. In addition to the expanding number of private automobiles, human error is a significant factor in vehicle collisions [1]. Autonomous vehicles (AVs), driverless or self-driving cars, do not require a human driver. AVs provide a hopeful solution, giving society a safer and more sustainably operated mode of transportation [2].

Automakers and information technology firms have been developing AV systems [3]. AVs are set to usher in a new mobility paradigm, such as shared autonomous vehicles (SAVs), in the age of the

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sharing economy [4,5]. Passengers are not required to wait in a specific location for SAVs to pick them up. The idea converts cars from consumer goods to flexible on-demand services [6]. When compared to individual vehicles, AVs have lower acquisition, travel, and parking expenses because they do not require a human driver [7].

Several studies have emphasized AV technology's potential excellent and disadvantages on existing transportation networks, but widespread deployment may be years away. AVs could improve road safety, reduce traffic congestion, and save energy by, for example, reducing excessive braking and increasing following safe distances [8]. If AVs and SAVs were widely available, people would take more journeys and travel farther since they would not have to worry about driving themselves. This would make motorized travel more accessible to people of all ages and capacities. This could result in more traffic and congestion due to increased AVs and SAVs on the road [9].

Road congestion may not immediately lessen when AVs first become widely used. Mixed traffic situations and pooled AV fleets have been shown to worsen congestion [10]. However, as AV technology becomes more pervasive and AV penetration on the roads increases, it has the potential to significantly lessen congestion brought on by human driving behavior and improve the efficiency of road transportation as a whole [11]. Travelers' attitudes, acceptability, and preferences will significantly determine how AV technology affects the transportation system, especially in terms of its ability to reduce traffic congestion and accidents. Individuals' transport mode preferences directly impact the efficiency of daily commuting and the technology sector's future growth. In addition, authorities need to examine public preferences to establish what measures are most likely to result in the widespread uptake of environmentally friendly technologies. Therefore, learning about the elements that affect the public's plans to use AVs and SAVs is crucial.

Macro-level analyses, including policy concerns, legislative oversight, SAV dispatch optimization, and the influence on conventional transportation networks, dominate the field of AV research. However, there is an increasing interest in researching individual users' travel mode choice behaviors in AV and SAV mobility [12,13]. Unfortunately, most existing studies use travel mode models that only consider socioeconomic and transport mode factors as explanatory variables, ignoring the inherent significance of individual choice variability [14]. Only a few recent studies have delved into the role of non-cognitive elements, including fear of harm, interest in new technologies, or environmental consciousness. There appears to be a dearth of high-quality theoretical research into why people utilize AVs and SAVs.

1.1 Aims and Contributions of the Study

To thoroughly comprehend travel mode choice behavior, it is imperative to employ a theory-based model that methodically identifies the determinants of individual behaviors. Recent studies on decision-making models have brought attention to psychological factors in behavior modification research [15,16]. The theory of planned behavior (TPB) is a widely recognized conceptual framework utilized for comprehending individuals' preferences about different modes of transportation [17]. The expanded version of the TPB model incorporates attitudes, subjective norms, and perceived behavioral control, which are essential factors in understanding the complex decision-making process involved in travel mode selection [18]. This study examines the factors contributing to individuals' intentions to utilize AVs or SAVs during their travels within Indonesia.

The purpose of this research is to expand on TPB by looking at the factors that influence travelers' decisions about whether or not to utilize AVs or SAVs. Ajzen's original proposal of TPB [19], which is grounded in the theory of reasoned action, provided a robust framework for studying and forecasting individual and group behavior [20,21]. Knowledge and perceived risk are two additional external components contributing to the triangular relationship between attitudes, subjective norms, and perceived behavioral control [22,23].

This research acknowledges the value of including psychological aspects that affect decision-making alongside the TPB framework. Previous research has largely ignored the inherent significance of individual choice variation, which has instead primarily concentrated on socioeconomic and transport mode variables.

The following research hypotheses are offered based on the TPB framework and the requirement to account for psychological factors such as knowledge, perceived relevance, intentions, attitudes, subjective norms, and perceived behavioral control:

i. H_{1a}: There is a relationship between "knowledge" and "perceived relevance";
ii. H_{1b}: "Knowledge" impacts "intentions";
iii. H_{1c}: "Knowledge" influences "attitudes";
iv. H_{1d}: "Knowledge" affects "subjective norms";
v. H_{1e}: "Knowledge" influences "perceived behavioral control";
vi. H_{2a}: "Perceived relevance" impacts "attitudes";
vii. H_{2b}: "Perceived relevance" influences "subjective norms";
viii. H_{2c}: "Perceived relevance" impacts "perceived behavioral control";
ix. H_{2d}: "Perceived relevance" affects "intentions";
x. H_3: "Attitudes" are influenced by "intentions";
xi. H_{4a}: "Subjective norms" impact "intentions";
xii. H_{4b}: "Subjective norms" influence "attitudes";
xiii. H_{5a}: "Perceived behavioral control" affects "intentions";
xiv. H_{5b}: "Perceived behavioral control" influences "attitudes".

These hypotheses aim to provide a deeper understanding of the determinants of travelers' intention to use AVs or SAVs, considering both the TPB framework and the influence of psychological factors (Fig. 1). By examining these factors, this study seeks to contribute to developing targeted measures and interventions to encourage the adoption of innovative and sustainable AV technologies.

1.2 Organization of the Study

The remaining part of the paper is organized as follows. Section 2 offers an extensive literature analysis of the studies about AV and SAV travel modes. Section 3, presents the survey design as well as the sample and data collection. The results are provided in Section 4. Section 5 discusses the findings and compares them to previous state-of-the-art studies. Section 6 summarizes the study's main findings, provides implications, elaborates on the limitations, and suggests future research areas.

2. Literature Review

While the general public does not currently have widespread access to AV technology, numerous studies have been conducted to explore the potential impact of AVs and SAVs on travel mode selection and behavior. Stated preference methodologies have been employed to investigate travelers' responses toward different attributes of travel mode alternatives, including factors like time and cost. The impact of AVs on transit demand and long-distance travel preferences was investigated by Wang *et al.* [24] through the modification of existing planning models. Xu *et al.* [25] considered various factors, such as the duration of walking and the time spent searching for parking spaces, when evaluating the effectiveness of free-floating carsharing services and SAVs. Ding *et al.* [26] conducted a stated choice experiment in Australia wherein participants were tasked with selecting a transportation mode for a reference trip. The participants were required to consider the presence of shared and non-shared AVs, as well as their initial mode of transportation. Chattopadhyay *et al.* [27] conducted empirical investigations employing agent-based simulations to examine the selection of AV and semi-AV modes. Nevertheless, the ability of the studies to effectively incorporate data on AV technology, calibrate the models, and evaluate their performance was impeded by either making assumptions or relying on previous trip surveys.

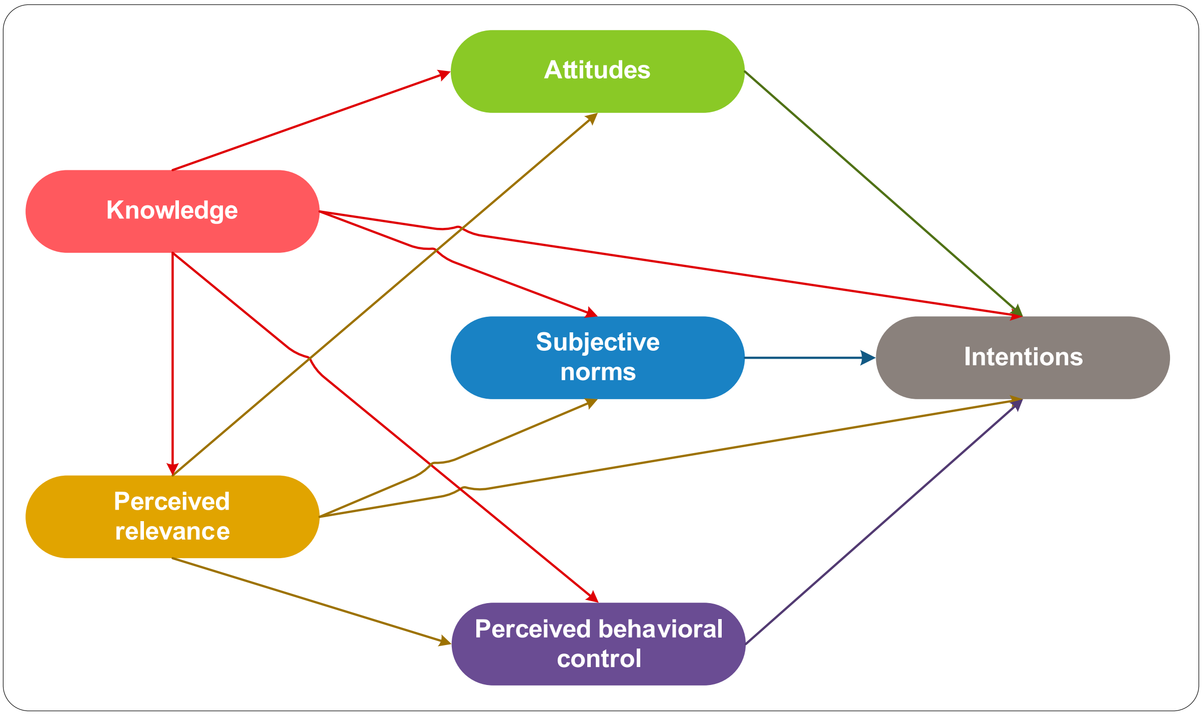

Fig. 1. Theoretical framework

Psychological factors also influence intentional mode choice. Jing *et al.* [28] conducted a study utilizing a stated preference questionnaire in China. The study revealed that enjoyment of driving, environmental concern, and a positive attitude towards AVs significantly influenced individuals' choices regarding the acquisition and utilization of AVs. Jiang *et al.* [29] conducted a study utilizing a stated preference survey to analyze the viewpoints of the public regarding public and private transportation in China. They discovered that individuals who exhibited environmentally-friendly travel behaviors and understood mobility-on-demand services demonstrated a heightened inclination toward adopting SAVs. However, the apprehensions regarding public safety imposed constraints on their capacity to thoroughly evaluate the full range of alternatives at their disposal. In their study, Goldbach *et al.* [30] categorized AVs into two types: gasoline-powered and electric-powered. They discovered that considerations of safety and environmental concerns influenced the decision-making process for selecting AVs. Meyer-Waarden & Cloarec [31] conducted a stated-choice experiment in France to investigate the influence of AVs on the utilization of last-mile public transportation. The study considered instrumental qualities, socioeconomic variables, and attitude indicators.

Table 1 presents various studies about AV and SAV travel modes. This table provides an overview of these studies' objectives, influential factors, and methodologies. Previous studies have examined several crucial factors influencing individuals' inclination to adopt AV-based or SAV-based modes. These factors encompass demographic variables such as age, gender, income, educational attainment, and individuals' perspectives on these novel transportation modes [26, 32].

Table 1
Overview of the studies about AV and SAV travel modes

Author(s)	City/Country	Research objects	Influence factors	Method
Clewlow [33]	USA	Transit and self-driving cars with parking and repositioning	Quality of a trip	A strategy with four stages
Liu *et al.* [34]	Austin, USA	Transit, SAVs, and vehicles driven by humans	Quality of a trip	To simulate with agents
Zhang *et al.* [35]	California, USA	Current automobiles, private AVs, and SAVs	Statistics, latent variables, and travel characteristics	Experiment with SP
Gilbert [36]	Dubai, UAE	Mobile carsharing and shared-economy vehicles	Demographics and trip characteristics	Experiment with SP
Wang *et al*. [37]	China	Ridesharing, carpooling, and finding trips in AVs	Hidden factor	Experiment with SP
Bürstlein *et al.* [38]	Canada	Rideshare, public transit, and bicycle	Statistics, latent variables, and travel characteristics	Experiment with SP
Horowitz & Kahn [39]	USA	Self-driving cars, ridesharing cars, and public transportation	Demographics, characteristics of trips	Experiment with SP
Jose & Chidambaram [40]	USA	Automobile- and plane-based transportation	Quality of a trip	A strategy with four stages
Wilson *et al.* [41]	USA	Vehicular, ambulatory, and commuting	Quality of a trip	To simulate with agents
Our work	*Indonesia*	*Factors influencing the intention to adopt AVs*	*Statistic, latent variable, TBP, demographic, travel characteristic, awareness*	*Experiment with SP*

Descriptive, univariate analyses of user demographics and trip attribute samples from surveys have been the backbone of AV and SAV research until now. This study aspires to contribute to the existing work using latent psychological characteristics in statistical sample analysis. This will allow us to study how factors like income and personality shape people's inclinations when choosing a method of transportation.

3. Materials and Methods

The study employs a mixed-methods approach to investigate preferences for travel mode choice in relation to AVs and SAVs. This technique combines the advantages of both revealed and asserted preference methods, together with qualitative analysis. This versatile strategy aims to offer a thorough and subtle comprehension of the intricate elements that influence personal preferences and behaviors in the context of future transportation technology.

a) Quantitative phase – methods for revealed and stated preferences

i. Survey on revealed preferences – This phase of the research is dedicated to gathering empirical data on individuals' past travel mode choices and habits. The revealed preferences, which are obtained from directly observed behaviors, provide vital insights into present transportation patterns and establish a standard for comprehending existing preferences;
ii. The expressed preference survey complements the revealed preferences by capturing persons' anticipated preferences and intentions for AVs and SAVs. Participants are given hypothetical situations and sets of choices that simulate possible future circumstances. This approach enables participants to articulate their preferences for different modes of transportation, including cutting-edge possibilities such as AVs and SAVs, offering valuable insights into projected behaviors in hypothetical future situations.

The utilization of these two quantitative methodologies allows the investigation to embrace both the present condition of transportation options (revealed preferences) and the potential future patterns (stated preferences). This dual method enables a comprehensive and nuanced examination of transport mode preferences, especially in a field where the practical implementation of new technology is still in its early phases.

b) Qualitative phase – enhancing comprehension through individual reflections

After conducting the quantitative analysis, the investigation proceeds to a qualitative phase. The purpose of this phase is to provide context and enhance the comprehension of the quantitative data.

The study employs qualitative approaches such as in-depth interviews and focus groups to investigate personal experiences, perceptions, and attitudes toward AVs and SAVs. This method offers a medium for individuals to express their ideas, worries, and anticipations using their language thus providing a more profound understanding of the subjective elements that impact their preferences.

The qualitative data undergoes a comprehensive process of thematic analysis, which involves discovering and analyzing the underlying patterns and themes. This research facilitates comprehension of the underlying reasons for the quantitatively collected preferences and intents, providing a comprehensive perspective on the elements that influence travel mode choices.

c) Combining quantitative and qualitative insights

The amalgamation of quantitative and qualitative findings is crucial in this mixed-methods approach. The qualitative insights are used to authenticate, elucidate, and occasionally question the results derived from the quantitative phase. This comprehensive methodology guarantees a more resilient and thorough comprehension of the factors influencing the selection of travel modes for AVs and SAVs, offering significant perspectives for policymakers, urban planners, and transportation sector stakeholders.

3.1 Quantitative Phase
3.1.1 Survey design

The survey design was constructed to gather relevant data on individuals' travel mode choice preferences, focusing on AVs and SAVs. The survey instrument used questions and choice scenarios to capture respondents' attitudes, perceptions, and intentions regarding travel modes. The survey questionnaire was divided into several sections, each addressing specific aspects of the travel mode choice. The sections included demographic information, current travel behavior, awareness and knowledge of AV and SAV technologies, attitudes toward transportation, and preferences for different travel modes.

Stated preference scenarios were presented to elicit participants' preferences for AVs and SAVs. These scenarios described hypothetical travel situations and asked participants to choose between alternative travel modes, including traditional vehicles, public transportation, AVs, and SAVs. The scenarios were designed to vary relevant attributes such as travel time, cost, convenience, and safety, allowing for a comprehensive analysis of respondents' mode choice preferences.

In addition to the stated preference scenarios, the survey incorporated attitudinal questions to gauge respondents' perceptions and beliefs about AV and SAV technologies. These questions explored safety, trust, environmental impact, and comfort, aiming to capture the underlying psychological and behavioral factors influencing travel mode preferences. The survey instrument underwent a rigorous pilot testing phase to ensure clarity, comprehension, and face validity. Feedback from the pilot study participants was carefully analyzed and used to refine and improve the questionnaire. The final questionnaire covers perceptions of AVs and SAVs through attitudes, subjective norms, perceived behavioral control, knowledge, perceived risk, intention to use, trust, sustainability, and enjoyment (Table 2).

The survey aimed to capture comprehensive and reliable data on individuals' travel mode choice preferences, particularly regarding AVs and SAVs. The combination of demographic information, stated preferences, and attitudinal measures provided a robust foundation for analyzing the factors influencing mode choice behavior and informing future policy and decision-making in the transportation sector.

3.1.2 Sample and data collection

This study investigated the factors influencing the intention to adopt AVs in Indonesia, specifically in the Jakarta, Bogor, Depok, Tangerang, and Bekasi (JABODETABEK) areas. A cross-sectional study design was employed to collect data from 1500 respondents. This sample size was determined to provide a robust representation of the population in JABODETABEK areas, as well as to ensure sufficient statistical power for data analysis and enhance the generalizability of the study findings.

The sampling procedure involved a multi-stage cluster sampling technique. In the first stage, several districts and municipalities within the JABODETABEK area were randomly selected. In the second stage, several neighborhoods were randomly chosen within each selected district or municipality. Finally, households within the selected neighborhoods were selected using a systematic sampling method. A total of 10 neighborhoods were included; i.e. neighborhood 1 (n=150), neighborhood 2 (n=156), neighborhood 3 (n=144), neighborhood 4 (n=160), neighborhood 5 (n=174), neighborhood 6 (n=160), neighborhood 7 (n=140), neighborhood 8 (n=159), neighborhood 9 (n=134), and neighborhood 10 (n=123). These neighborhoods were selected to guarantee a diverse representation of the JABODETABEK region and to provide a sufficient sample size for data analysis.

Respondents had to meet the following criteria to be included in the study:

i. reside in the JABODETABEK area;
ii. be at least 18 years old;
iii. possess a valid driver's license.

Data collection took place over three months using an online recruitment method. Potential participants were recruited by sending personalized e-mails and WhatsApp texts to individuals who met the inclusion criteria. The target sample size was 1500 respondents, with a target acceptance rate of 9%.

The e-mail and WhatsApp text invitations explained the purpose of the study and provided a link to an online questionnaire hosted on a secure platform. The emails and WhatsApp texts assured the recipients of the confidentiality and anonymity of their responses. Participation in the study was voluntary. The respondents were informed that they could withdraw from the survey at any point without any consequences.

Upon clicking the provided link, participants were directed to the online questionnaire. The questionnaire was structured and included sections covering demographic information, as well as measures of the extended TPB, as noted in Table 2.

Table 2
Research questionnaire

Constructs	Items	Source
Attitudes towards AVs/SAVs	I believe using AVs/SAVs for travel is favorable I have a positive perception of AVs/SAVs I find the idea of using AVs/SAVs desirable	Feys *et al.* [42]
Subjective norms	People who are vital to me expect me to use AVs/SAVs The individuals significant to me support my use of AVs/SAVs If people around me use AVs/SAVs, I am more likely to use them too	Ackaah *et al.* [43]
Perceived behavioral control	I feel I have sufficient opportunities to use AVs/SAVs when traveling The decision to use AVs/SAVs when traveling is entirely up to me I have the necessary resources (financial means) to use AVs/SAVs when traveling	Yuen *et al.* [4]
Knowledge about AVs/SAVs	I am familiar with the procedures and distance capabilities of AVs/SAVs I am knowledgeable about the cost associated with using AVs/SAVs I understand the advantages of AVs/SAVs compared to traditional cars, such as improved safety and reduced traffic congestion	Tan *et al.* [44]
Perceived risk associated with AVs/SAVs	I am concerned about potential risks when using AVs/SAVs I fear experiencing financial and time losses when using AVs/SAVs I worry that the functionality and system of AVs/SAVs may cause me trouble	Zou *et al.* [45]
Travelers' choice intention to use AVs/SAVs	I firmly intend to use AVs/SAVs as a mode of transportation I will likely choose AVs/SAVs for my travel needs in the future I am actively considering using AVs/SAVs as my preferred mode of transportation I would prioritize using AVs/SAVs over other transportation options when they become available	Cordera *et al.* [46]
Trust in AVs/SAVs	I believe that AVs/SAVs will protect the well-being of passengers and pedestrians I have confidence in the technology and systems used in AVs/SAVs I trust that AVs/SAVs will make informed and rational decisions while driving	Lee & Lee [47]
Sustainability of AVs/SAVs	Adopting AVs/SAVs can decrease fuel consumption and the need for fossil fuels I perceive AVs/SAVs as a sustainable solution for urban mobility and transportation challenges I believe that AVs/SAVs can promote a shift toward cleaner and greener transportation options I think that AVs/SAVs can contribute to a more sustainable and eco-friendly future	Dirsehan & Can [48]
Enjoyment of driving AVs/SAVs	I find driving AVs/SAVs to be a pleasurable and enjoyable experience I enjoy the freedom and control that comes with driving AVs/SAVs I find the experience of operating AVs/SAVs engaging and entertaining I feel a sense of excitement and enjoyment when driving AVs/SAVs	Hegner *et al.* [49]

Several measures were taken to ensure data quality and avoid duplication or fraudulent responses. Firstly, the online questionnaire was designed to include attention checks and validation questions. Secondly, participants were requested to provide unique identifiers, such as e-mail addresses or unique codes, to prevent multiple entries from the same individual. Lastly, data-cleaning procedures were implemented to identify and remove any suspicious or inconsistent responses.

3.2 Qualitative Phase

The qualitative component of this study plays a crucial role in validating and giving background to the quantitative findings. Quantitative data provides a general grasp of trends and patterns in attitudes towards AVs and SAVs, while qualitative insights provide a more in-depth understanding of the reasons behind these trends. The purpose of this phase is to explore the intricate viewpoints, incentives, and concerns that individuals hold regarding the implementation of AVs and SAVs, thereby enhancing the overall understanding of the topic.

3.2.1 Participant selection strategy

A meticulously chosen purposive sample of 25 participants will have a pivotal role in this qualitative investigation (Table 3). The sample will consist of a heterogeneous group of stakeholders, encompassing government officials, researchers, lecturers, and real users of AVs/SAVs.

Table 3
Demographic information

No.	Initials	Gender	Age	Educational level	Group
1	J.D.	Male	45	PhD	Government official
2	S.L.	Female	38	Master's	Government official
3	A.K.	Male	41	Master's	Government official
4	M.G.	Female	50	PhD	Government official
5	D.W.	Male	36	PhD	Researcher
6	E.M.	Female	29	Bachelor's	Researcher
7	F.T.	Male	54	PhD	Researcher
8	G.H.	Female	47	PhD	Researcher
9	H.I.	Male	31	Master's	Lecturer
10	I.J.	Female	34	Master's	Lecturer
11	K.L.	Male	43	PhD	Lecturer
12	L.M.	Female	39	PhD	Lecturer
13	M.N.	Male	52	Master's	AV/SAV user
14	N.O.	Female	26	Bachelor's	AV/SAV user
15	O.P.	Male	48	PhD	AV/SAV user
16	P.Q.	Female	37	Master's	AV/SAV user
17	Q.R.	Male	44	Bachelor's	AV/SAV user
18	R.S.	Female	30	Bachelor's	AV/SAV user
19	S.T.	Male	55	Master's	AV/SAV user
20	T.U.	Female	42	PhD	AV/SAV user
21	U.V.	Male	35	Bachelor's	AV/SAV user
22	V.W.	Female	28	Master's	AV/SAV user
23	W.X.	Male	53	PhD	AV/SAV user
24	X.Y.	Female	32	Bachelor's	AV/SAV user
25	Y.Z.	Male	40	Master's	AV/SAV user

Every group provides a distinct perspective:

i. Government officials possess valuable knowledge that can provide valuable insights into policy perspectives, regulatory problems, and the wider socio-economic ramifications;
ii. Researchers – This group can offer a more specialized and forward-thinking perspective, addressing the possible progress and technological challenges in the development of autonomous and semi-autonomous vehicles;
iii. Lecturers serve as intermediaries, effectively connecting theoretical knowledge with practical applications by providing an educational viewpoint on the implementation of these technologies;
iv. Real users of AVs/SAVs offer direct experiences and perspectives that reflect the viewpoint of the end-user. This is crucial for comprehending the problems related to public acceptance and usability.

Table 3 shows all qualitative participants. Each of these groups plays a crucial role in developing a complete understanding of the complex dynamics involved in the adoption and implementation of AVs and SAVs. The inclusion of their varied viewpoints will enhance the comprehensive examination, guaranteeing that the research encompasses a wide range of perspectives and experiences about these developing forms of transportation.

3.2.2 Data collection methods

Qualitative data was collected through in-depth and semi-structured interviews, each lasting approximately 45-60 minutes. The questions asked are given in Table 4.

Table 4
Semi-structured questionnaire

Sections	Questions
Background information	1. Can you briefly describe your experience with AVs/SAVs? Have you ever used them, and if so, in what capacity? 2. How familiar are you with the concept and technology behind autonomous vehicles?
Personal experiences	3. Can you share a specific experience you have had with an AV/SAV? What stood out to you about this experience? 4. How did using an AV/SAV make you feel in terms of safety, convenience, and control?
Perceived benefits	5. In your view, what are the primary benefits of AVs/SAVs? 6. How do you think AVs/SAVs can impact urban mobility and the environment?
Perceived risks and concerns	7. What concerns or risks do you associate with the use of AVs/SAVs? 8. Have you had any negative experiences or heard of any incidents involving AVs/SAVs that have influenced your perception?
Technological advancements	9. What advancements in AV/SAV technology do you anticipate or hope to see in the near future? 10. How do you think these technological advancements will change your perception?
Attitudes towards policy and regulation	11. What are your thoughts on the current policies or regulations governing AVs/SAVs? 12. In your opinion, what kind of policies or regulations should be implemented?
Trust and reliability	13. How much do you trust the technology behind AVs/SAVs? 14. Can you describe any factors or features that would increase your trust?
Comparison with traditional vehicles	15. How do you compare your experiences with AVs/SAVs to those with traditional vehicles? 16. Are there aspects of traditional vehicles that you think AVs/SAVs cannot replicate?
Future outlook	17. How do you envision the future of transportation with the integration of AVs/SAVs? 18. Would you consider shifting permanently to AVs/SAVs if they meet your expectations?
Personal impact	19. How do you think the widespread adoption of AVs/SAVs will impact your daily life? 20. Do you have any personal hopes or concerns regarding the future of AVs/SAVs?

These interviews were designed to be open yet guided, providing participants with the freedom to express their thoughts while ensuring that all relevant topics were covered. The main areas of discussion included personal experiences with AVs/SAVs, perceived benefits and risks, expectations of technological advancements, and attitudes toward policies and regulations in the context of autonomous transportation.

3.2.3 Analytical approach

The qualitative data will be interpreted primarily using thematic analysis. This method will entail a thorough scrutiny of the transcripts to discern, analyze, and document recurring themes and patterns. The study will follow an iterative process, which will entail multiple readings of the data to ensure a thorough comprehension of the underlying narratives. The identified themes will be compared with the quantitative data to determine their level of agreement or divergence, thereby offering a comprehensive perspective on the findings.

4. Results

4.1 Quantitative results

The survey sample consisted of respondents with socio-demographic characteristics (Table 5).

Table 5
A comprehensive summary of the respondents' demographic information

Variables	**Frequencies**	**Percentages** (%)
Gender		
Male	805	53.67
Female	695	46.33
Age		
18–25	450	30.0
26–35	435	29.0
36–45	273	18.20
> 45	342	22.80
Educatio		
Junior school and below	96	6.40
High school	217	14.47
College	394	26.27
Bachelor	696	46.40
Master or above	97	6.47
Income		
< $178.6	480	32.0
$178.6–$250	430	28.67
$250–$321.5	300	20.0
$321.5–$392.9	130	8.67
> $392.9	160	10.67
Awareness of AVs/SAV technology		
Strongly agree	136	9.07
Agree	405	27.0
Undecided	601	40.07
Disagree	168	11.20
Strongly disagree	60	4.0

Among the surveyed respondents, 53.67% were male and 46.33% were female. The age distribution showed that 30.0% of respondents were aged 18-25, 29.0% were aged 26-35, 18.20% were aged 36-45, and 22.80% were above 45 years old. In terms of education, most respondents had relatively high educational attainment. Regarding personal monthly income, the majority of respondents (32.0%) reported earnings below $178.57. In terms of awareness of the AVs/SAV technology, most respondents were undecided (40.07%), followed by those who agreed (27.0%), disagreed (11.20%), strongly agreed (9.07%), and strongly disagreed (4.0%).

4.1.1 Analyzing varying levels of respondent engagement

Fig. 2 presents the distribution of responses for the following three variables: trust, sustainability, and enjoyment of driving. Looking at the results, it is identified that the respondents' perceptions vary across these variables. In terms of trust, most respondents (48.80%) expressed a low level of trust in AVs/SAVs, indicating skepticism and concerns about the reliability and safety of these vehicles. However, a significant number of respondents (29.13%) reported a high level of trust, suggesting a belief in the potential benefits and capabilities of AVs or SAVs. A smaller proportion of respondents (22.07%) fell in the middle category, expressing medium trust.

Regarding sustainability, a considerable number of respondents (30.47%) perceived that AVs and SAVs have low sustainability. This perception likely reflects concerns about environmental impact and the use of fossil fuels. However, a larger group of respondents (42.07%) held a medium perception of sustainability, believing that AVs or SAVs could reduce fuel consumption and promote greener transportation options. A smaller portion of respondents (27.46%) considered AVs and SAVs as highly sustainable.

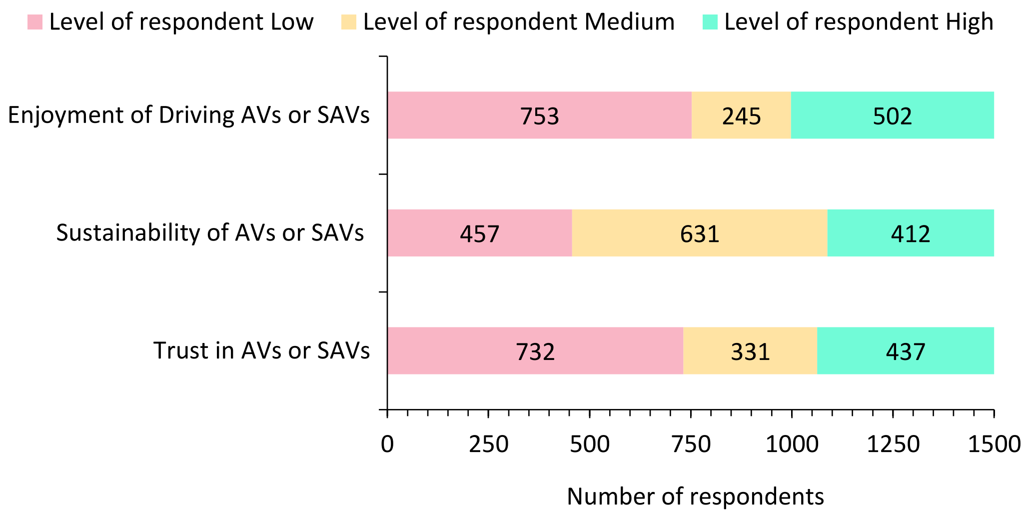

Fig. 2. Perception levels of trust, sustainability, and enjoyment in AVs/SAVs among the respondents

Regarding enjoyment, most respondents (50.20%) expressed high enjoyment of AVs and SAVs. This suggests that many individuals find the experience engaging and pleasurable. On the other hand, a smaller number of respondents (16.33%) indicated a moderate level of enjoyment, while a relatively larger group (33.47%) reported a low level of enjoyment, potentially indicating concerns or dissatisfaction with the driving experience.

4.1.2 Reliability and validity of the questionnaire

The data presented in the study were analyzed using IBM SPSS v21.0 and WarpPls to test models and hypotheses related to attitudes toward AVs/SAVs. Before conducting the hypothesis tests, the fitness of the model was assessed. Confirmatory factor analysis (CFA) was performed to examine the reliability and validity of the measurement model. The internal consistency of the items within each construct was evaluated using Cronbach's alpha and composite reliability (CR).

The results indicated that all constructs exhibited good internal consistency, with Cronbach's α values ranging from 0.75 to 0.89 and CR values ranging from 0.84 to 0.90. These values exceeded the recommended minimum of 0.70, indicating that the items reliably measured the underlying constructs (Table A1 in Appendix).

Standardized factor loadings and average variance extracted (AVE) were examined to assess convergent validity. The standardized factor loadings, representing the relationship between observed variables and their respective constructs, were above 0.5, indicating a high explanatory power for each observed variable. Moreover, the AVE values for all constructs exceeded the recommended minimum of 0.50, indicating that the constructs accounted for more variance in the observed variables than measurement error (Table 6). Discriminant validity was evaluated by comparing the AVE values with the inter-construct correlations. All AVE values exceeded the inter-construct correlations, providing evidence of good discriminant validity. This finding suggests that each construct had stronger correlations with its observed variables than with the observed variables of other constructs.

Table 6
Discriminant validity test.

Constructs	ATT	SN	PBC	KN	PR	INT	TRU	SUS	ENJ
ATT	0.836								
SN	0.703	0.736							
PBC	0.623	0.691	0.786						
KN	0.554	0.254	0.222	0.811					
PR	0.278	0.598	0.538	0.235	0.829				
INT	0.692	0.712	0.727	0.669	0.296	0.782			
TRU	0.671	0.689	0.712	0.635	0.333	0.753	0.825		
SUS	0.589	0.604	0.647	0.578	0.336	0.712	0.779	0.742	
ENJ	0.642	0.661	0.658	0.617	0.399	0.736	0.802	0.769	0.815

* ATTitudes (ATT), ENJoyment (ENJ), INTentions (INT), KNowledge (KN), Perceived Behavioral Control (PBC), Perceived Relevance (PR), Subjective Norms (SN), SUStainability (SUS), TRUst (TRU).

4.1.3 Structural model and hypothesis tests

A structural equation model was developed to explore the connections between concepts. The model's fit is typically assessed with chi-square/degree of freedom (2/df), comparative fit index (CFI), Tucker-Lewis index (TLI), root mean squared error of approximation (RMSEA), and standardized root mean square residual (SRMR). If the overall model's CFI and TLI are above 0.90 as well as SRMR and RMSEA are less than 0.08, then the model is considered adequate or exceptional. In this investigation, the AV/SAV model has excellent model fit indices, since 2/df = 3.819, CFI = 0.978, TLI = 0.970, RMSEA = 0.055, and SRMR = 0.068.

Table 7 shows the hypothesis testing results. The result indicates several significant relationships among the variables. Firstly, perceived relevance is found to be negatively influenced by knowledge, with the standardized estimate (SE) equal to -0.2, *CR*=-7.62, and *p*<0.001, indicating that as knowledge increases, perceived relevance decreases. This finding supports hypothesis H_{1a}. Secondly, intentions are positively influenced by knowledge, with *SE*=0.12, *CR*=4.28, and *p*=0.001, suggesting that an increase in knowledge is associated with higher intentions. This result supports hypothesis H_{1b}. Thirdly, attitudes are positively influenced by knowledge, with *SE*=0.08, *CR*=3.01, and *p*=0.003, indicating that higher levels of knowledge are related to more positive attitudes. This finding supports hypothesis H_{1c}.

Table 7
Standardized path coefficients and significance levels of the AV/SAV model.

Hypotheses	Paths	Standardized estimates	Composite reliabilities	p	p < 0.05
H_{1a}	*PR ← KN*	−0.20	−7.62	***	✓
H_{1b}	*INT ← KN*	0.12	4.28	0.001	✓
H_{1c}	*ATT ← KN*	0.08	3.01	0.003	✓
H_{1d}	*SN ← KN*	0.10	3.80	***	✓
H_{1e}	*PBC ← KN*	0.09	3.50	0.002	✓
H_{2a}	*ATT ← PR*	−0.18	−3.92	***	✓
H_{2b}	*SN ← PR*	−0.65	−18.32	***	✓
H_{2c}	*PBC ← PR*	−0.63	−17.88	***	✓
H_{2d}	*INT ← PR*	−0.25	−7.11	***	✓
H_3	*INT ← ATT*	0.15	5.25	***	✓
H_{4a}	*INT ← SN*	0.42	11.45	***	✓
H_{4b}	*ATT ← SN*	0.52	12.92	***	✓
H_{5a}	*INT ← PBC*	0.31	10.12	***	✓
H_{5b}	*ATT ← PBC*	0.30	9.75	***	✓

[*] ATTitudes (ATT), INTentions (INT), KNowledge (KN), Perceived Behavioral Control (PBC), Perceived Relevance (PR), Subjective Norms (SN).

Furthermore, subjective norms are positively influenced by knowledge, with *SE*=0.1, *CR*=3.8, and *p*<0.001, suggesting that increased knowledge is associated with stronger subjective norms. This result supports hypothesis H_{1d}. Similarly, perceived behavioral control was positively influenced by knowledge, with *SE*=0.09, *CR*=3.5, and *p*=0.002, indicating that higher levels of knowledge are related to greater perceived behavioral control. This finding supports hypothesis H_{1e}. Additionally, attitudes are found to be negatively influenced by perceived relevance, with *SE*=-0.18, *CR*=-3.92, and *p*<0.001, suggesting that as perceived relevance increases, attitudes decrease. This result supports hypothesis H_{2a}.

Subjective norms are also found to be negatively influenced by perceived relevance, with *SE*=-0.65, *CR*=-18.32, and *p*<0.001, indicating that higher levels of perceived relevance are associated with weaker subjective norms. This finding supports hypothesis H_{2b}. Similarly, perceived behavioral control is negatively influenced by perceived relevance, with *SE*=-0.63, *CR*=-17.88, and *p*<0.001, suggesting that as perceived relevance increases, perceived behavioral control decreases. This result supports hypothesis H_{2c}. Furthermore, intentions are negatively influenced by perceived relevance, with *SE*=-0.25, *CR*=-7.11, and *p*<0.001, indicating that higher levels of perceived relevance are associated with lower intentions. This finding supports hypothesis H_{2d}.

Intentions are positively influenced by attitudes, with *SE*=0.15, *CR*=5.25, and *p*<0.001, suggesting that more positive attitudes are associated with higher intentions. This result supports hypothesis H_3. Similarly, intentions are positively influenced by subjective norms, with *SE*=0.42, *CR*=11.45, and *p*<0.001, indicating that stronger subjective norms are associated with higher intentions. This finding supports hypothesis H_{4a}. Additionally, attitudes are positively influenced by subjective norms, with

SE=0.52, *CR*=12.92, and *p*<0.001, suggesting that more positive attitudes are associated with stronger subjective norms. This result supports hypothesis H_{4b}.

Furthermore, intentions are positively influenced by perceived behavioral control, with *SE*=0.31, *CR*=10.12, and *p*<0.001, indicating that greater perceived behavioral control is associated with higher intentions. This finding supports hypothesis H_{5a}. Similarly, attitudes are positively influenced by perceived behavioral control, with *SE*=0.30, *CR*=9.75, and *p*<0.001, suggesting that more positive attitudes are associated with greater perceived behavioral control. This result supports hypothesis H_{5b}.

4.2 Results of the Qualitative Phase

Our thematic analysis involved a meticulous examination of interview transcripts to identify, analyze, and document recurring themes and patterns. This iterative process was essential to achieve a comprehensive understanding of the narratives and their implications. The identified themes were juxtaposed with quantitative data to ascertain their consistency and uncover deeper insights, ensuring a robust, multi-dimensional analysis.

4.2.1 Diverse perceptions of autonomous vehicles/shared autonomous vehicles

This theme reflects a wide spectrum of societal perspectives on AVs/SAVs, revealing a complex tapestry of opinions that range from enthusiastic endorsement to cautious skepticism. Such diversity underscores the multifaceted nature of public responses toward emerging technologies, particularly in the realm of autonomous transportation. This variance in perceptions is critical in understanding the broader societal context in which AVs/SAVs are being introduced and the diverse factors influencing public opinion.

a) Government officials' perspectives

J.D.'s insights bring to light the broader socioeconomic impacts of AV/SAV. His analysis goes beyond the immediate technological implications, delving into the far-reaching effects on employment, urban planning, and economic structures. This perspective underscores a holistic understanding of the societal transformation that may accompany the widespread adoption of AVs/SAVs: *"The real challenge in implementing AVs and SAVs lies in their adaptation to the diverse and dynamic nature of urban environments. Each city has its unique layout, traffic patterns, and cultural context. Our solutions need to be as flexible and adaptable as the environments they're designed for"*.

S.L. highlights the imperative of equitable access in the adoption of AVs/SAVs. Her focus is on the social justice aspects of technological adoption, emphasizing the need for policies that do not marginalize certain groups and ensure equal access for all strata of society. This viewpoint is particularly salient in the context of urban planning and public policy, where technological advancements must be balanced with equitable societal benefits: *"Our goal in embracing AV and SAV technology must extend beyond innovation for its own sake. We must ensure that these advancements do not create or exacerbate social inequities. It is crucial to develop policies that guarantee equitable access to these technologies, making sure that they serve as a tool for social empowerment rather than exclusion"*.

b) Researchers' viewpoints

E.M. addresses the challenges of adapting AVs/SAVs to varied urban landscapes. This perspective points to an acute awareness of the complex relationship between technology and the environment it operates within. E.M.'s focus on the adaptability and contextual application of AVs/SAVs highlights the need for flexible and context-sensitive technological solutions that can cater to diverse urban settings: *"The real challenge in implementing AVs and SAVs lies in their adaptation to the diverse and dynamic nature of urban environments. Each city has its unique layout, traffic patterns, and cultural context. Our solutions need to be as flexible and adaptable as the environments they're designed for".*

F.T. discusses the potential of artificial intelligence (AI) in enhancing the functionality of AVs/SAVs, especially in unpredictable and dynamic urban environments. This optimism about technological advancements reflects confidence in the capabilities of AI to revolutionize transportation. F.T. sees AI not merely as a tool for automation but as a means to enhance the safety, efficiency, and adaptability of AVs/SAVs in complex, real-world scenarios: *"Artificial intelligence is at the heart of revolutionizing AV and SAV technology. Its potential extends far beyond automating vehicles; it's about creating systems that can intelligently and safely navigate the unpredictability of real-world scenarios. AI is the key to making AVs/SAVs not just viable but also efficient and adaptable to a myriad of urban challenges".*

The diverse viewpoints of government officials and experts highlight the wide range of factors that must be taken into consideration while developing and implementing AVs and SAVs. The diverse range of perspectives encompasses several aspects such as the socioeconomic consequences, social fairness, adaptability to technology, and the promise of artificial intelligence, providing a thorough understanding of the complex nature of this technological progress. This thematic study offers a comprehensive comprehension of the various perspectives of AVs/SAVs, emphasizing the necessity of a multidisciplinary approach in tackling the difficulties and opportunities presented by this growing technology.

4.2.2 Perceived benefits and risks

The thematic findings in this area present a nuanced understanding of the potential benefits and risks associated with AVs and SAVs. This balanced perspective not only showcases an awareness of the potential positive impacts of these technologies but also a realistic appraisal of the challenges and concerns they pose. Such an approach is instrumental in comprehensively grasping the dual nature of technological advancements, particularly in a field as transformative and dynamic as autonomous transportation.

a) Benefits

The participants, notably T.U. and R.S., highlighted several key advantages of AVs/SAVs. Their insights pointed towards a significant potential in reducing traffic-related accidents, suggesting a leap forward in road safety and public health. Additionally, they emphasized the role of these technologies in lowering carbon emissions, underlining their contribution to environmental sustainability. This perspective not only reflects optimism about technological advancements but also aligns with global efforts to combat climate change and promote safer urban environments.

T.U. *"The advent of AVs and SAVs marks a significant milestone in enhancing road safety and public health. By reducing human error, we're looking at a future with significantly fewer traffic accidents, a change that has the potential to save thousands of lives every year".*

R.S. "*AVs and SAVs are more than just a convenience; they're a step towards a greener future. Their optimized driving patterns and potential for electric propulsion can substantially reduce carbon emissions, contributing to our fight against climate change*".

b) Risks

In contrast, the concerns articulated by N.O. and Q.R. shed light on the inherent risks and vulnerabilities of AVs/SAVs. The apprehensions about system reliability, especially under extreme conditions, point to the need for rigorous testing and robust engineering. The risk of hacking and data breaches, a critical aspect raised, highlights the emerging cybersecurity challenges in an increasingly interconnected and digital world. These viewpoints underscore the necessity of addressing technological vulnerabilities proactively to ensure the safe and secure adoption of AVs/SAVs.

N.O. "While the potential of AVs/SAVs is immense, we must not overlook the challenges. Ensuring system reliability, particularly in extreme conditions, is crucial. We need rigorous testing and continuous improvement in engineering to build public trust in these technologies".

Q.R. *"The integration of AVs/SAVs into our digital infrastructure raises significant cybersecurity concerns. The risk of hacking and data breaches can't be taken lightly. We need robust security protocols to protect against these vulnerabilities".*

The interplay between these perceived benefits and risks forms a crucial component of the thematic analysis, underscoring the importance of a balanced view in the evaluation and adoption of AV/SAV technologies. Recognizing the multifaceted implications of these technologies is essential in guiding their development, policy-making, and public acceptance, ensuring that the benefits are maximized while the risks are effectively mitigated.

4.2.3 Expectations of technological advancements

This theme encompasses a wide array of predictions regarding the future of AVs and SAVs, representing a complex mixture of optimistic and cautious viewpoints. It presents a sophisticated viewpoint on the development of self-driving transportation technology, recognizing both its potential advantages and the difficulties they may pose. Understanding the integration of AVs/SAVs into society requires evaluating their technological implications as well as the broader social, economic, and ethical repercussions.

a) Advancements

G.H. discusses the anticipated integration of AVs with smart city infrastructures, highlighting a vision for a future where these technologies are seamlessly integrated into urban life. This perspective underscores an expectation of a significant technological leap, with AVs playing a key role in shaping future cities: *"We're heading towards an era where AVs are not just an addition but a fundamental part of smart city ecosystems. This integration will revolutionize urban efficiency and livability".*

L.M. focuses on the expected advancements in battery technology for AVs/SAVs. This insight indicates optimism about the technological advancements that are set to redefine the performance and impact of AVs/SAVs: *"The next big frontier in AV/SAV technology is battery innovation. We're looking at improvements that will not just boost efficiency but also enhance the environmental sustainability of these vehicles".*

b) Concerns

P.Q. highlights the importance of ensuring accessibility in the development of AVs/SAVs. This perspective sheds light on the critical need for inclusive design and equitable access in the world of autonomous transportation: *"Our approach to AVs/SAVs must be inclusive. We need to guarantee that these technologies are accessible to all, including the differently-abled and those in less urbanized areas".*

I.J. points out the need for robust safety standards in AV/SAV technology. This view reflects a concern for the public welfare and the importance of prioritizing safety in the evolution of these technologies: *"Safety is paramount in the advancement of AVs/SAVs. We must establish stringent safety protocols to ensure these technologies are reliable and secure for all users".*

The insights from industry professionals offer a thorough outlook on the future of autonomous vehicles and shared autonomous vehicles. The optimism conveyed by G.H. and L.M. on the prospects of AVs in urban integration and battery technology stands in stark contrast to the cautious perspectives offered by P.Q. and I.J. regarding the importance of accessibility and rigorous safety protocols. Collectively, these perspectives demonstrate the wide range of factors that need to be taken into account while creating and putting into action AVs and SAVs. The complex nature of autonomous transportation technology is shown by the combination of technological innovation and social responsibility. This analysis emphasizes the necessity of adopting a multidisciplinary approach to effectively address the problems and capitalize on the potential associated with AVs/SAVs. This approach will ensure a future where these technologies are both highly developed and readily available.

4.2.4 Attitudes towards policies and regulations

This theme explores the agreement of the necessity of proactive and extensive regulatory frameworks specifically designed for AVs and SAVs. The findings emphasize the importance of governing frameworks that can adapt to rapid technology changes while also protecting the public interest. The emphasis on policy and regulation demonstrates a profound comprehension of the complex relationship between technology, societal dynamics, and legal frameworks. This underscores the various delicate issues and opportunities that AV/SAV technologies bring about.

a) Policy needs

S.T. articulates the necessity for forward-thinking policies in the realm of AV/SAV deployment. This insight advocates for equitable policy development, aiming to ensure that the benefits of AV/SAV technologies are universally accessible and contribute positively to all societal segments: *"There is a pressing need for anticipatory policy-making that proactively addresses the foreseeable challenges in integrating AVs/SAVs. Such policies should encompass not only urban scenarios but also consider the nuances of rural integration, thereby mitigating the technological divide between urban and rural landscapes".*

U.V. echoes the need for comprehensive policy frameworks. This perspective underscores the importance of dynamic and inclusive policy-making in the context of autonomous transportation: *"Our approach to AV/SAV regulation must be holistic, balancing innovation with societal welfare. Policies should be crafted with an eye towards future developments, ensuring they remain relevant and effective in an evolving technological landscape".*

b) Regulatory challenges

W.X. discusses the intricacies of cross-border regulatory issues associated with AVs/SAVs. This viewpoint acknowledges the need for international collaboration in developing regulatory frameworks for AVs/SAVs: *"The global nature of AV/SAV technology introduces complex regulatory challenges, particularly in harmonizing standards across different legal jurisdictions. Effective regulation in this domain requires a concerted effort to navigate these complexities, ensuring consistent and fair practices worldwide".*

Y.Z. highlights the significance of equitable access in the regulatory discourse. This perspective aligns with broader themes of social justice and equity in technological development: *"Our regulatory frameworks must be designed to foster inclusivity and prevent the exacerbation of existing social inequalities. We must create legal structures that ensure equitable access to AV/SAV technologies, promoting equal opportunities for all".*

The thematic findings in this area highlight the need for carefully planned and flexible laws and regulations to ensure the successful deployment of autonomous vehicles and shared autonomous vehicles. These observations collectively emphasize the significance of a cooperative, interdisciplinary approach involving policymakers, technologists, and the general public. Collaboration is crucial to tackling the intricacies and swift advancements of AV/SAV technologies, guaranteeing that regulatory frameworks not only promote innovation but also give priority to societal well-being and fairness.

4.2.5 Trust and reliability: a multidimensional perspective

This theme delves into the crucial issues regarding the trustworthiness and dependability of AVs and SAVs in a detailed and complex manner. The statement emphasizes the crucial significance of trust in the general implementation and approval of these technologies. The findings provide a comprehensive comprehension of the diverse elements that impact public trust in AVs/SAVs, including their interaction with human users and integration within the wider socio-technical systems.

a) Technological trust

A.K. presents a nuanced view of trust in AV/SAV technology, acknowledging its conditional nature. This viewpoint accentuates the necessity for AVs/SAVs to demonstrate competence not only in technical aspects but also in navigating human-centric environments: *"While the technological capabilities of AVs/SAVs are advancing, trust remains contingent upon their ability to interact seamlessly with human behaviors and the unpredictability of real-world scenarios. This necessitates a design focus on comprehensive safety measures to enhance reliability and foster public confidence".*

B.L. echoes the importance of designing AVs/SAVs to be adaptable and reliable in various scenarios. This perspective highlights the imperative of engineering AVs/SAVs that can earn and maintain public trust through consistent performance: *"The challenge lies in ensuring that AVs/SAVs can reliably handle diverse and often unforeseen situations on the road. This demands a concerted effort in developing technologies that are robust and versatile, ensuring safety and reliability in a multitude of driving conditions".*

b) Data security

C.M. addresses the critical issue of data privacy in the context of AVs/SAVsThis insight sheds light on the growing sensitivity towards data security and the importance of responsible data handling in AV/SAV technology: *"As these vehicles collect and process extensive amounts of data, the concerns over data privacy and ethical management of information become increasingly salient. It's vital to implement stringent data protection measures and uphold high standards of data ethics to maintain user trust".*

D.N. highlights the broader implications of data security in AVs/SAVs. This perspective underscores the need for comprehensive strategies to address data security concerns, extending beyond technical solutions to include ethical and legal considerations: *"The potential risks of data misuse and breaches in AVs/SAVs call for a proactive approach to safeguarding digital information. Robust cybersecurity protocols and transparent data policies are fundamental in ensuring that user data is protected and responsibly utilized".*

The thematic findings highlight the intricate and diverse aspects of public acceptability of AV/SAV technology, particularly concerning trust and reliability. They advocate for a comprehensive approach that harmonizes technical dependability with ethical, legal, and social factors. Ensuring and preserving public confidence in autonomous vehicles/self-driving vehicles is of utmost importance for their effective incorporation into society. This requires a comprehensive endeavor that includes not just technology improvement but also strict safety procedures, strong data protection measures, and adherence to ethical guidelines.

4.3 Integration of Qualitative Insights with Quantitative Findings

Combining the qualitative insights with the quantitative findings enhances the depth and breadth of understanding of public sentiments towards AVs and SAVs (Table 8). The demographic attributes obtained from the quantitative survey correspond with the topics explored in the qualitative interviews.

Examining trust and sustainability perspectives in greater detail, the quantitative data uncovers diverse degrees of trust, which are further explained by the qualitative insights provided by A.K. and B.L. on conditional trust in AV/SAV technology. These debates clarify the grounds for the skepticism, which is generally based on concerns about the technology's impact on human behavior and its dependability. The qualitative topic of perceived benefits and dangers, as explained by T.U., R.S., N.O., and Q.R., enhances our comprehension of the diverse perspectives on sustainability, emphasizing both the advantages for the environment and the technological obstacles.

The contributions made by S.T., U.V., W.X., and Y.Z. provide a more profound analysis of the public's awareness and attitudes on policy demands and regulatory issues. The lack of a clear position on AVs/SAVs, as shown by the quantitative data, suggests that the public wants more comprehensive policies and well-informed regulatory frameworks that consider the complex aspects of AV/SAV implementation.

Moreover, the survey's findings on high satisfaction levels align with the qualitative observations regarding technical progress. Insights from G.H. and L.M. regarding the expected incorporation of AVs into smart cities and technological developments, such as enhanced battery efficiency, indicate that these innovations have the potential to improve the overall user experience.

Table 8
Integrated results: understanding public perceptions of AVs/SAVs

Theme	Quantitative findings	Qualitative insights	Combined understanding
Attitudes toward AVs/SAVs	Positive attitudes were observed in the survey	Varied reasons for positivity in interviews, with some concerns about the loss of control and adaptability to new technology	A comprehensive view emerges of mixed attitudes towards AVs/SAVs, combining general positivity with specific apprehensions
Trust and reliability	High levels of trust among respondents	Nuanced concerns about reliability and interaction with unpredictable human behavior in qualitative interviews	A complex picture of trust is painted, combining high general trust levels with underlying apprehensions about reliability and safety
Policy and regulation	Strong recognition of the need for effective regulation and governance	Detailed perspectives from experts on the challenges and intricacies of developing and implementing policies	A deeper understanding of the regulatory needs and challenges, emphasizing the necessity of proactive and comprehensive frameworks
Technological advancements	Optimism about the future advancements in AV/SAV technology	Specific hopes for integration with smart cities and concerns about current technological limitations and safety standards	A balanced view of technological optimism and caution, recognizing the potential for innovation alongside the need for responsible development
Societal impact	Acknowledgement of potential benefits such as improved safety and reduced emissions	Concerns about the socio-economic implications, including job displacement and access disparities	Recognition of both the positive impacts and the challenges, understanding the broader societal context and implications of AV/SAV adoption

5. Discussion

The present study, integrating both qualitative and quantitative approaches, investigates the complex relationships between knowledge, attitudes, perceived relevance, subjective norms, perceived behavioral control, and intentions in the context of AVs and SAVs. This comprehensive analysis enriches the existing body of research on factors influencing individuals' intentions to adopt AVs and SAVs, aligning with and expanding upon previous studies.

The finding that knowledge negatively influences perceived relevance (H_{1a}: $PR \leftarrow KN$) is consistent with the previous research by Charness *et al.* [50]. It highlights the role of knowledge in shaping individuals' perceptions of AVs and SAVs. This suggests that as knowledge about these technologies increases, individuals perceive them as less relevant. This finding supports the notion that familiarity and understanding of AVs and SAVs can negatively impact individuals' perceptions and acceptance of these technologies. It is important to note that while knowledge may decrease perceived relevance, it may also increase perceived safety and usefulness. Therefore, it is crucial to consider the multifaceted nature of knowledge and its impact on individuals' perceptions and acceptance of AVs and SAVs. Future research should explore the specific aspects of knowledge that influence individuals' perceptions and acceptance of these technologies and the potential moderating effects of factors such as age, gender, and prior experience with AVs and SAVs. Overall, this finding underscores the importance of education and awareness campaigns to increase familiarity and understanding of AVs and SAVs, which may ultimately lead to greater acceptance and adoption of these technologies.

In line with the findings of Ribeiro *et al.* [51], the positive influence of knowledge on intentions (H_{1b}: *INT* ← *KN*) indicates that increased knowledge is associated with higher intentions to use AVs and SAVs. This finding emphasizes the importance of knowledge acquisition and dissemination in promoting positive intentions toward autonomous transportation options. It suggests that educational campaigns and informational programs can significantly enhance individuals' intentions to adopt AVs and SAVs. Other studies have also found that knowledge about AV technology and perceived risk are potential obstacles for travelers to use AVs and SAVs [52]. Therefore, it is essential to address these concerns through targeted education and awareness campaigns that provide accurate and comprehensive information about the benefits and risks of these technologies.

The positive relationships between knowledge and attitudes (H_{1c}: *ATT* ← *KN*) and subjective norms ($_{H1d}$: *SN* ← *KN*) support previous research by Qiao & Zhang [53]. These studies highlighted the influence of knowledge on attitudes and social norms toward AVs and SAVs. The present findings underscore the importance of knowledge in shaping individuals' attitudes and subjective norms, which can ultimately impact their intentions to use these technologies. Specifically, individuals with excellent knowledge about AVs and SAVs are more likely to have positive attitudes toward these technologies and perceive them as socially acceptable, increasing their intentions to use them [50]. This highlights the need for educational campaigns and informational programs that provide accurate and comprehensive information about AVs and SAVs and address potential concerns and misconceptions that may affect individuals' attitudes and subjective norms towards these technologies. Additionally, the present findings suggest that social influence plays a significant role in shaping individuals' attitudes and intentions toward AVs and SAVs, highlighting the importance of social norms in promoting the adoption of these technologies.

The positive influence of knowledge on perceived behavioral control (H_{1e}: *PBC* ← *KN*) aligns with the research conducted by Lemonnier *et al.* [54] and Kaye *et al.* [55]. It highlights the role of knowledge in enhancing individuals' perceived control over using AVs and SAVs. This finding suggests that knowledge empowers individuals to feel more confident and capable of adopting and utilizing autonomous transportation options. Specifically, individuals with more knowledge about AVs and SAVs are more likely to perceive themselves as having greater control over using these technologies, increasing their intentions to use them [56,57]. This highlights the need for educational campaigns and informational programs that provide accurate and comprehensive information about AVs and SAVs and emphasize these technologies' potential benefits and capabilities. Additionally, the present findings suggest that perceived behavioral control is a critical factor in promoting the adoption of AVs and SAVs, highlighting the importance of addressing potential barriers and obstacles that may affect individuals' perceived control over these technologies.

The negative influence of perceived relevance on attitudes (H_{2a}: *ATT* ← *PR*) is consistent with the findings of Dalila *et al.* [56]. This indicates that as individuals perceive AVs and SAVs as more relevant, their attitudes toward these technologies decrease. This finding underscores the need to address perceived relevance to foster positive attitudes and enhance the acceptance of AVs and SAVs. Previous studies have shown that attitudinal variables significantly influence individuals' willingness to use AVs and SAVs [54,55]. Therefore, addressing perceived relevance through targeted education and awareness campaigns emphasizing these technologies' potential benefits and capabilities is essential. Additionally, the present findings suggest that perceived relevance is a crucial factor in shaping individuals' attitudes toward AVs and SAVs, highlighting the need to address potential barriers and obstacles that may affect individuals' perceptions of the relevance of these technologies.

The negative relationships between perceived relevance and subjective norms (H_{2b}: *SN* ← *PR*) and perceived behavioral control (H_{2c}: *PBC* ← *PR*) are in line with the studies by Jing *et al.* [28] and Yuen *et al.* [4]. These findings highlight the importance of addressing perceived relevance to strengthen subjective norms and individuals' perceived control over using AVs and SAVs. Specifically, individuals who perceive AVs and SAVs as less relevant are less likely to perceive social pressure to use these technologies and have lower perceived control over using them, decreasing their intentions to use them [58,59]. This underscores the need for educational campaigns and informational programs that provide accurate and comprehensive information about AVs and SAVs, as well as emphasize these technologies' potential relevance and benefits. Additionally, the present findings suggest that subjective norms and perceived behavioral control are critical factors in promoting the adoption of AVs and SAVs, highlighting the importance of addressing potential barriers and obstacles that may affect individuals' perceptions of the relevance of these technologies.

Furthermore, the negative influence of perceived relevance on intentions (H_{2d}: $INT \leftarrow PR$) supports previous research by Lu *et al.* [6], emphasizing the need to address perceived relevance to foster positive intentions towards AVs and SAVs. This finding suggests that individuals are less likely to express intentions to use these technologies if they perceive them as less relevant. Therefore, strategies to enhance the perceived relevance and benefits of AVs and SAVs can be crucial in increasing individuals' intentions to adopt them.

The negative influence of perceived relevance on intentions (H_{2d}: $INT \leftarrow PR$) supports previous research by Useche *et al.* [60], as well as emphasizes the need to address perceived relevance to foster positive intentions toward AVs and SAVs. This finding suggests that individuals are less likely to express intentions to use these technologies if they perceive them as less relevant. Therefore, strategies to enhance the perceived relevance and benefits of AVs and SAVs can be crucial in increasing individuals' intentions to adopt them. Studies have shown that behavioral intentions are a crucial predictor of individuals' actual use of AVs and SAVs [61,62]. Therefore, addressing perceived relevance through targeted education and awareness campaigns, which provide accurate and comprehensive information about AVs and SAVs as well as emphasize these technologies' potential relevance and benefits, is essential. Additionally, the present findings suggest that perceived relevance is a critical factor in shaping individuals' intentions towards AVs and SAVs, highlighting the need to address potential barriers and obstacles that may affect individuals' perceptions of the relevance of these technologies.

Additionally, the positive influences of attitudes (H_3: $INT \leftarrow ATT$), subjective norms (H_{4a}: $INT \leftarrow SN$), and perceived behavioral control (H_{5a}: $INT \leftarrow PBC$) on intentions align with the research conducted by Reid *et al.* [63]. These studies have highlighted the significant role of attitudes, subjective norms, and perceived control in shaping individuals' intentions to use AVs and SAVs. The present findings emphasize the importance of addressing these factors to promote positive intentions and facilitate the adoption of autonomous transportation options.

The present findings show that attitudes, subjective norms, and perceived behavioral control have positive influences on intentions (H_3: $INT \leftarrow ATT$, H_{4a}: $INT \leftarrow SN$, H_{5a}: $INT \leftarrow PBC$), which aligns with the research conducted by Tan *et al.* [44] and Obrenovic *et al.* [57]. These studies highlighted the significant role of attitudes, subjective norms, and perceived control in shaping individuals' intentions to use AVs and SAVs. The present findings emphasize the importance of addressing these factors to promote positive intentions and facilitate the adoption of autonomous transportation options.

To summarize, the following factors have been found to influence individuals' intentions to use AVs and SAVs:

i. knowledge (H_{1b}: $INT \leftarrow KN$);
ii. perceived relevance (H_{2d}: $INT \leftarrow PR$);
iii. attitudes (H_3: $INT \leftarrow ATT$);

iv. subjective norms (H_{4a}: $INT \leftarrow SN$);
v. perceived behavioral control (H_{5a}: $INT \leftarrow PBC$).

6. Conclusions and Implications

The study contributed to the existing research on factors influencing individuals' intentions in adopting AVs and SAVs. It investigated the relationships between knowledge, attitudes, perceived relevance, subjective norms, perceived behavioral control, and intentions in AVs and SAVs. The study found that knowledge negatively influenced perceived relevance and positively influenced attitudes, subjective norms, perceived behavioral control, and intentions. Additionally, the study found that perceived relevance negatively influenced attitudes, subjective norms, perceived behavioral control, and intentions. Attitudes, subjective norms, and perceived behavioral control positively influenced intentions. These findings highlight the need for targeted education and awareness campaigns:

i. to provide accurate and comprehensive information about AVs and SAVs;
ii. to emphasize the potential benefits and capabilities of these technologies;
iii. to address potential barriers and obstacles that may affect individuals' perceptions and attitudes towards these technologies.

The findings of this study have the following implications for policymakers, transportation planners, and researchers:

i. the study highlighted the importance of education and awareness campaigns to increase familiarity and understanding of AVs and SAVs, which might lead to greater acceptance and adoption of these technologies;
ii. the study emphasized the need to address perceived relevance to foster positive attitudes and enhance the acceptance of AVs and SAVs;
iii. the study underscored the importance of addressing attitudes, subjective norms, and perceived behavioral control to promote positive intentions and facilitate the adoption of autonomous transportation options;
iv. the study suggested that social influence played a significant role in shaping individuals' attitudes and intentions toward AVs and SAVs, highlighting the importance of social norms in promoting the adoption of these technologies.

The present study has several limitations that should be addressed in future research. First, the study was conducted in a specific geographic location and may not be generalizable to other contexts. Second, the study relied on self-reported data, possibly subject to social desirability bias. Third, the study did not examine the potential moderating effects of age, gender, and prior experience with AVs and SAVs, which may influence the relationships between the variables studied. Fourth, the study did not examine the potential interactions between the variables studied, which may provide additional insights into the factors influencing individuals' intentions to use AVs and SAVs.

Future research should address the limitations of the present study and explore the specific aspects of knowledge that influence individuals' perceptions and acceptance of AVs and SAVs. Additionallyfuture research should also examine the potential interactions between the variables studied to provide additional insights into the factors influencing individuals' intentions to use AVs and SAVs. Finally, future research should explore the potential cultural and societal differences in the factors influencing individuals' intentions to use AVs and SAVs.

Appendix

Table A1
Results of the statistical analysis and the confirmatory factor analysis

Constructs	Items	Means	SDs	α	SFLs	CRs	AVEs
Attitudes towards AVs/SAVs	I believe using AVs/SAVs for travel is favorable	3.45	0.8	0.87	0.74	0.9	0.6
	I have a positive perception of AVs/SAVs	3.67	0.8				
	I find the idea of using AVs/SAVs desirable	3.23	0.9				
Subjective norms	People who are vital to me expect me to use	3.78	0.7	0.89	0.81	0.9	0.7
	The individuals significant to me support me	3.55	0.8				
	If people around me use AVs/SAVs, I am more likely to use them too	3.41	0.9				
Perceived behavioral control	I feel I have sufficient opportunities to use AVs/SAVs when traveling	3.62	0.7	0.83	0.72	0.9	0.6
	The decision to use AVs/SAVs when traveling is entirely up to me	3.28	0.9				
	I have the necessary resources (financial means) to use AVs/SAVs when traveling	3.49	0.8				
Knowledge about AVs/SAVs	I am familiar with the operational procedures, driving comfort, and distance capabilities	3.71	0.7	0.88	0.78	0.9	0.6
	I am knowledgeable about the associated cost	3.39	0.8				
	I understand the advantages of AVs/SAVs	3.57	0.8				
Perceived risk associated with AVs/SAVs	I am concerned about potential risks to myself and my family when using AVs/SAVs	2.92	0.9	0.75	0.65	0.8	0.5
	I fear experiencing financial and time losses when using AVs/SAVs	2.84	1				
	I worry that the functionality and system of AVs/SAVs may cause me trouble	3.12	0.9				
Travelers' choice intention to use AVs/SAVs	I firmly intend to use AVs/SAVs	3.54	0.8	0.86	0.75	0.9	0.6
	I will likely choose AVs/SAVs for my travel needs in the future	3.39	0.8				
	I am actively considering using AVs/SAVs as my preferred mode of transportation	3.26	0.9				
	I would prioritize using AVs/SAVs over other transportation options	3.48	0.8				
Trust in AVs/SAVs	I believe that AVs/SAVs will protect the well-being of passengers and pedestrians	3.62	0.7	0.82	0.7	0.8	0.6
	I have confidence in the technology	3.57	0.8				
	I trust that AVs/SAVs will make informed and rational decisions while driving	3.41	0.8				
Sustainability of AVs/SAVs	Adopting AVs/SAVs can decrease fuel consumption and dependence on fossil fuels	3.58	0.8	0.88	0.79	0.9	0.6
	I perceive AVs/SAVs as a sustainable solution for urban mobility	3.47	0.8				
	I believe that AVs/SAVs can promote a shift toward cleaner and greener transportation	3.35	0.8				
	I think that AVs/SAVs have the potential to contribute to an eco-friendly future	3.72	0.7				
Enjoyment of driving AVs/SAVs	I find driving AVs/SAVs to be a pleasurable and enjoyable experience	3.67	0.7	0.85	0.73	0.9	0.6
	I enjoy the freedom and control that comes with driving AVs/SAVs	3.53	0.8				
	I find the experience of operating AVs/SAVs engaging and entertaining	3.58	0.8				
	I feel a sense of excitement and enjoyment when driving AVs/SAVs	3.43	0.8				

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