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Assessing Public Acceptance of Autonomous Vehicles for Smart and Sustainable Public Transportation in Urban Areas: A Case Study of Jakarta, Indonesia

Charli Sitinjak [1,2], Zurinah Tahir [3,*], Mohd Ekhwan Toriman [3], Novel Lyndon [3], Vladimir Simic [4], Charles Musselwhite [5], Wiyanti Fransisca Simanullang [6,7] and Firdaus Mohamad Hamzah [8]

1 Faculty of Psychology, Esa Unggul University, Jakarta 11510, Indonesia
2 Centre for Research in Psychology and Human Well-Being (PSiTra), Faculty of Social Sciences and Humanities, Universiti Kebangsaan Malaysia, Bangi 43600, Selangor, Malaysia
3 Research Centre for Development, Social, and Environment, Faculty of Social Sciences and Humanities, Universiti Kebangsaan Malaysia, Bangi 43600, Selangor, Malaysia
4 Faculty of Transport and Traffic Engineering, University of Belgrade, 110110 Belgrade, Serbia
5 Transport and Health Integrated Research Network (THINK) and Psychology Department, Aberystwyth University, Aberystwyth SY23 3FL, UK
6 Research Center for Chemistry, National Research and Innovation Agency (BRIN), Jakarta Pusat 10340, Indonesia
7 Department of Chemical Engineering, Faculty of Engineering, Widya Mandala Surabaya Catholic University, Pakuwon 60112, Indonesia
8 Department of Mathematics, Centre for Defence Foundation Studies, Universiti Pertahanan Nasional Malaysia, Kem Sungai Besi, Kuala Lumpur 57000, Selangor, Malaysia
* Correspondence: zurinahtahir@ukm.edu.my

Abstract: This study examines the benefits and drawbacks of autonomous public transit vehicles among 210 Indonesians. Some 25% of respondents knew nothing about driverless vehicles, whereas 14% did. The average 5-point Likert scale response was 3.12 (SD = 1.05), indicating intermediate expertise. Some 42% of respondents used autonomous vehicle sources such as public transport, 47% had no experience, and 11% were doubtful. The survey items' Cronbach's alpha score is 0.873, indicating strong internal consistency and reliability. Most respondents supported the deployment of autonomous road vehicles for public transportation and said they would improve public transportation quality and accessibility. Technical issues and legal liabilities worried responders. The mean scores for the seven autonomous car benefits were similar, showing that respondents did not strongly prefer any benefit. After assessing the socioeconomic status and concerns, the study indicated that people who saw greater benefits were more tolerant of autonomous vehicles. Most respondents also wanted a clearer explanation of their legal responsibilities in case of an accident, thought human operators should play a major role in the future, and supported government trials of autonomous vehicles before their widespread usage. The study's findings can help policymakers and stakeholders increase public acceptance of new transportation solutions such as autonomous vehicles, and improve future mobility safety and sustainability.

Keywords: autonomous vehicles; public transportation; public perception; cross-sectional study; social acceptance

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1. Introduction

In urban areas, in which population density is highest, space is limited, and daily commuting and traffic congestion are common issues, public transportation plays an especially important role in society [1,2]. The field of autonomous vehicles (AVs) is advancing rapidly, with prototype development and on-road testing of AVs frequently occurring, suggesting that AV deployment for public transportation may soon become a reality. The Gateway

Project in Greenwich, England, and the La Rochelle Automated Road Transportation System in France are examples of places in which autonomous vehicles have been tested on public roads [3,4]. If this materializes, it will have far-reaching implications for how we move around the world and use public transportation in the years to come.

Recent years have seen a proliferation of research into how AVs could change the face of urban transportation [5]. Additionally, a growing body of research is devoted to learning how people feel about and react to AVs in the personal transportation and shuttle service sectors [6,7]. According to these reports, AVs are generally well-received by the scientific community. Nonetheless, significant issues remain regarding their quickness, effectiveness, and security. Furthermore, while informative, these studies are narrow in scope, exploring only a few specific AV uses [1,3]. Therefore, in cities in which public transportation is heavily utilized, there is a knowledge gap regarding how the public views and accepts the incorporation of AVs into the public transportation system. In order to fill this void, this research investigates the potential for broader use of AVs in public transportation, especially in highly populated areas that rely heavily on public transportation [8–11].

AVs in public transportation are not new; driverless trains in subway and metro systems are just one example [12]. However, particular difficulties are associated with using AVs as public road transportation. These vehicles must coexist with other traffic on public roads and spaces, and interact with the public in natural settings rather than artificially created environments [13–15].

Despite these challenges, autonomous road public transport could transform public transportation systems by introducing safer and more efficient shared mobility [16–18]. Improving public transport's appeal and use could reduce city traffic congestion and transportation's environmental impact due to fuel economy and emissions [19–21]. Autonomous road public transport can also provide reliable, safe, on-demand public transport in low-demand or underserved areas. In addition, automation reduces human errors and resource constraints [22,23]. AVs could also free up workers for jobs and services requiring more people [24–26].

Despite these potential benefits, a few challenges must be addressed, counting security, framework security, vehicle control, morals, legitimate liability, and integration with other transport modes [27–29]. Moreover, these impediments directly affect the public's discernment of autonomous vehicles and their acknowledgement and appropriation of public transportation [30,31]. Subsequently, it is vital to address these impediments to guarantee the effective delivery of autonomous public transport within public transportation frameworks.

1.1. Aims of the Study

The public perception of AVs as a mode of transportation in Jakarta, Indonesia, is an essential factor in determining the success of their adoption. With the growing traffic congestion and demand for transportation solutions in Jakarta, AVs offer a potential solution to address these challenges [32]. First, it is crucial to understand how the public views this technology, and what factors drive its adoption. By uncovering the public's perception of AVs in Jakarta, this research aims to provide insights into the driving factors that will shape the future of autonomous road transportation in Indonesia [33,34].

The findings of this research are expected to play a significant role in shaping the future of AV adoption in Jakarta and beyond [35]. By gaining a deeper understanding of the public's perception of AVs, this research will provide a valuable resource for policymakers and stakeholders as they work to promote and regulate the use of this technology [36,37]. It will also provide important insights for companies and organizations developing AVs as they work to create products and services that meet the needs and expectations of the public. Overall, this research is a crucial step towards a future of safe, convenient, and accessible autonomous road transportation in Jakarta and beyond [37,38].

1.2. Research Question

- What are the public's main concerns regarding implementing autonomous public transportation on roads?
- What factors influence people's preferences for implementing autonomous public transportation on roads, such as the type of vehicle, the level of automation, and the degree of human involvement?
- How do people's concerns, expectations, and preferences regarding autonomous public transportation on roads vary across demographic characteristics?

1.3. Organization of the Study

The remaining part of the paper is organized as follows. The literature review is in the second section, and the Materials and Methods section is provided in Section 3. Section 4 presents a descriptive analysis and the results regarding the concerns, benefits, and preferences. Section 5 interprets the findings. The last section summarizes the study's main conclusions.

2. Literature Review

2.1. Autonomous Vehicles in Public Transportation

Public transportation is crucial in densely populated cities, in which parking is at a premium and gridlock is the norm. Prototype development and on-road testing of AVs are frequently happening, suggesting that AV deployment for public transit may soon become a reality [39,40]. Despite their usefulness, prior studies have only covered a small subset of possible applications for autonomous vehicles (AVs); thus, we still do not know how the general public feels about AVs being integrated into the public transit system [41,42]. Therefore, this study explores the potential for increased AV deployment in public transit, particularly in densely populated places in which such deployment is particularly important.

Public transportation utilizing Avs is not without challenges; while autonomous trains in subway and metro systems are one example, employing Avs as public road transportation brings unique challenges [42–44]. These vehicles must interact with humans in their natural environs rather than in a controlled laboratory setting [45]. Public transportation networks could be revolutionized by introducing safer and more efficient shared mobility made possible by autonomous road public transport, notwithstanding these challenges [46,47]. Further, Avs can free up personnel for jobs and services that require more people by providing dependable, safe, on-demand public transport in low-demand or underserved locations [48,49].

Recent years have seen a proliferation of studies examining the potential impact of Avs on urban transportation, and there is also a growing number of studies examining how people feel about and react to Avs in the personal transportation and shuttle service sectors [50,51]. These studies show that Avs have widespread support among researchers. Concerns about their speed, efficiency, and safety are still major obstacles. Security, framework security, vehicle control, morals, legitimate liability, and integration with other transport modes all affect how the public views Avs, and whether or not they will adopt them as viable means of public transit [11,21,52].

Congestion in urban areas and pollution from vehicle emissions can be mitigated by promoting public transit usage [53]. AVs can lessen the likelihood of mistakes and free up resources so that more humans can be allocated to tasks and services that need them. However, security, framework security, vehicle control, morality, legitimate liability, and integration with other modes of transportation must all be addressed to ensure the efficient deployment of autonomous road public transport in public transportation networks [54,55]. In achieving universal adoption and transforming public transportation networks, autonomous road public transport can provide safer, more efficient, and environmentally friendly shared mobility if certain barriers are removed.

2.2. General Problem to Optimizing General Public Transportation

Public transportation design has become a topic of significant interest and research in recent years, owing to its critical importance in modern urban environments. One of the most pressing challenges facing public transport systems is the potential impact of autonomous vehicles, as noted in a previous study by Owais [56]. The advent of autonomous vehicles could significantly disrupt traditional public transport systems and necessitate rethinking their design to accommodate changing travel patterns and preferences.

Another critical challenge in public transportation design is optimizing transit assignment models, which allocate transit resources such as buses and trains to meet passenger demand effectively. This task is particularly challenging as it necessitates balancing numerous factors such as transit frequency, passenger demand, and network connectivity. Several studies by Owais and Shaim [57] have attempted to address this problem.

The placement of traffic sensors is yet another critical design issue affecting public transport systems. Proper placement of these sensors is essential for detecting traffic congestion and predicting transit travel times accurately. This problem has been the subject of extensive research over the past few decades, as discussed in several research [57–59]. Various optimization techniques have been proposed to address this problem, and the accurate placement of sensors can lead to improved travel times and reduced congestion.

Overall, designing public transportation systems is a multifaceted problem that demands careful consideration of various factors, such as the impact of autonomous vehicles, optimization of transit assignment models, and placement of traffic sensors. Addressing these challenges is crucial for ensuring effective management of public transport systems, meeting the demands of passengers, and keeping pace with the ever-changing urban landscape.

2.3. Public Acceptance of AVs in Public Transportation

The rise of autonomous vehicles (AV) has sparked considerable interest and discussion regarding their potential use in public transportation. AV has the potential to revolutionize public transportation, but there are concerns and uncertainties about its adoption and implementation [54,55]. This literature review focuses on three main variables associated with AV in public transportation: attention, benefits, and implementation preferences, proposed by researchers to describe Indonesian public acceptance of autonomous vehicles.

The public's worries about the safety and security of autonomous cars must be addressed as they become increasingly common in public transit [60]. Accidents involving AVs in the past have raised issues about the reliability of the technology, so these worries are not unwarranted [60,61]. In addition, passengers' security and privacy are at risk because of the possibility of hacking. As a result, scientists are investigating potential solutions, such as improving cybersecurity measures to foil hacking efforts and creating more foolproof communication networks for AVs [62,63].

AVs' threat to the job market is another big issue, especially for the transportation industry [64]. Introducing AVs may potentially displace these workers, which would have severe societal and economic repercussions. However, many believe that introducing AVs would create new employment prospects, particularly in technological research, development, and transportation service providers [65]. However, these worries must be addressed, and solutions developed to reduce the negative impacts of AVs on employment, such as training and re-skilling programs for affected workers [64,65].

Despite these worries, people nevertheless have high hopes for the benefits of adopting autonomous buses and taxis. Increased safety is a major perk, as AVs have the potential to cut down on mishaps prompted by human mistakes. In addition, AVs have the potential to make life easier for persons who have trouble getting around, such as the elderly or people with disabilities [66]. Possible benefits of AVs include faster and more efficient transportation and less traffic congestion [67]. Therefore, the development and deployment of AVs in public transit networks must consider and embrace these potential benefits.

People also have opinions on the best way to introduce driverless buses and trains to city streets. Others may choose a mixed traffic environment to imitate real-world driving circumstances [68,69], while others may favour dedicated AV lanes to avoid contact with other vehicles. While some prefer on-demand AV services, others feel more secure with predetermined itineraries. Acknowledging and responding to these preferences during AVs' design, testing, and rollout can boost public acceptability and adoption of these technologies. Public policy and legislation should also address liability and legal responsibility in the event of accidents or other issues [70] before AVs are introduced.

The preference for autonomous vehicles in public transportation depends on their autonomy. Others prefer vehicles with a human backup driver for safety [67], while some prefer completely autonomous vehicles without human intervention. Comfort and confidence in technology also influence preferences. According to research, people more familiar with AV technology are more likely to prefer completely autonomous vehicles [65,71].

Frequently cited advantages of autonomous vehicles in public transportation include enhanced safety, reduced traffic congestion, and increased accessibility for marginalized populations. Autonomous vehicles are anticipated to reduce human error and enhance traffic flow, resulting in fewer accidents and smoother traffic. Additionally, AVs can be tailored to the requirements of the disabled and elderly, making transportation more accessible for these populations [72]. In addition, using autonomous vehicles can reduce transportation's [67] environmental impact by reducing both the number of automobiles on the road and emissions.

However, there are potential drawbacks to implementing autonomous vehicles in public transportation. One concern is the possibility of exacerbating existing inequalities, particularly in low-income and minority communities in which AV services may be limited [53,54]. In addition, implementing AV technology in public transportation systems can be expensive, and the benefits may not always outweigh the costs [17]. Lastly, there is the possibility of technical difficulties and unanticipated outcomes, which could result in system failures and accidents.

The implementation cost of autonomous vehicles in public transportation is important for governments and consumers. Although developing and deploying AVs is costly, proponents argue that long-term labor cost savings and increased efficiency will offset these costs. Concerns exist regarding the affordability of AV-based public transportation, particularly for low-income communities that rely heavily on public transportation [15,20,55,60].

Another factor that influences preferences for AV implementation in public transportation is efficiency. AVs can reduce congestion and travel times by optimizing routes and reducing the required stops for each journey [61] This increased efficacy could result in improved accessibility and mobility for passengers, especially those with disabilities or limited mobility. However, concerns exist that AVs may exacerbate existing disparities in access to transportation, as autonomous transit and ride-sharing services may not reach all areas or communities.

Another significant factor in implementing autonomous vehicles in public transportation is convenience. Autonomous vehicles have the potential to provide passengers with greater flexibility and convenience by facilitating on-demand services and reducing delay times [62]. In addition, the ability to perform other duties, such as work or leisure activities, during the commute could make public transportation more appealing to some passengers. Concerns exist, however, that these conveniences may jeopardize safety and security, as passengers may be less vigilant and attentive during journeys [53].

Preferences for implementing autonomous vehicles in public transportation are complex and multifaceted, considering safety, cost, efficiency, and convenience, among other factors. As AV technology continues to advance, it will be crucial for policymakers and transportation authorities to carefully consider these factors and develop a sustainable and equitable strategy for AV integration into public transportation systems.

3. Materials and Methods

In this study, we aimed to provide information about transportation technology and its development in Indonesia through literature reviews. We then conducted an online survey of 49 items to investigate the concerns, benefits, and preferences of implementing public transportation on Jakarta's autonomous roads, and the intention to adopt autonomous vehicles (AV) (please see Appendix A, Figure A1 for the research framework).

3.1. Population

Participants were recruited through open calls to participate in research via WhatsApp messages and snowball sampling techniques. The study lasted from January 2022 to August 2022, and all participants participated voluntarily (i.e., they did not receive a fee).

3.2. Sampling

Our survey was completed by 210 individuals, with 62.86% identifying as male. The ages of the participants ranged from 17 to 61 years and above. The sample of participants in our study tended to be younger and more highly educated, partially due to the high proportion of undergraduate students (45.24%) among them. Despite this, a significant portion of the participants (87%) reported using public transportation daily, which is relatively close to the Land Transport Authority (LTA)'s goal of achieving a 75% public transport mode share (see Table 1).

Table 1. Sample demographics.

Variable	Total	% of Sample	Variable	Total	% of Sample
Age			Labor status		
17–24	32	15.24%	Civil servant	95	45.24%
25–30	55	26.19%	Private employee	56	26.67%
31–40	35	16.67%	Unemployed	20	9.52%
41–50	62	29.52%	Student	39	18.57%
51–60	16	7.62%	Education status		
61 and above	10	4.76%	Postgraduate	64	30.48%
Marital status			Undergraduate	95	45.24%
Married	117	55.71%	Diploma	43	20.48%
Separated/divorced	28	13.33%	Senior high school	8	3.81%
Single	65	30.95%	Junior high school	0	0.00%
Physical disability			Gender		
Yes	37	17.62%	Male	132	62.86%
No	173	82.38%	Female	78	37.14%

3.3. Survey Questions

In this study, we developed our questionnaire to explore the efficacy, benefits, and preferences around implementation of public transportation in the capital city of Jakarta. We have proposed 5 items to uncover "concerns", 7 items to find "benefits", and 11 items aimed at finding "implementation preferences". The questions were formed using a Likert scale, with five answer choices ranging from 'strongly agree' to 'strongly disagree'. The items created have been tested to produce good alpha Cronbach values for this study (see Tables 2–4).

Table 2. Concerns about autonomous public transportation on the road.

Item		Cronbach's α = 0.873	Mean (SD)
1	Autonomous vehicles may not be able to drive as well as human drivers.	0.88	4.00 (0.76)
2	Introduction of autonomous vehicles may be rejected because there is no proof of their safety systems when employed on the capital's roads.	0.86	4.15 (0.68)
3	The implementation of autonomous vehicles will cause many job closures.	0.87	4.17 (0.66)
4	Autonomous vehicles may be hacked by others, making them unsafe. Public transport rates will increase when autonomous vehicles are applied.	0.87	4.17 (0.61)
5	Legal problems will arise when autonomous vehicles are implemented.	0.86	4.00 (0.76)

Table 3. Benefits that people expect to receive from using driverless buses and taxis.

Item		Cronbach's α = 0.856	Mean (SD)
1	Automatic vehicles are a mode of public transportation that is more common than other types of manual transportation.	0.84	3.60 (1.05)
2	Introducing automated vehicles as a mode of public transportation will help reduce traffic congestion on the capital's roads.	0.84	3.70 (1.04)
3	Automated vehicles will help solve the problem of public vehicle drivers without driving licenses.	0.85	3.55 (1.01)
4	Introducing automated vehicles will increase efficiency in travelling in the capital.	0.86	3.25 (1.06)
5	In addition, introducing automated vehicles will improve the reliability of public transportation in the capital.	0.86	3.40 (1.11)
6	Automatic vehicles will help shorten travel time.	0.86	3.50 (1.15)
7	Using an automatic mode of transportation will help provide vehicle solutions for disabled parents.	0.87	3.80 (1.08)

We utilized a three-item, 5-point Likert scale to evaluate the respondents' expectations of receiving autonomous public transportation. This degree was educated by the Unified Hypothesis of Acknowledgment and Utilize of Innovation 2 (UTAUT2) show, a broadly adopted system for analyzing client acknowledgement of innovation. The UTAUT2 show in-corporates four key developments affecting innovation acknowledgement: execution expectancy, exertion anticipation, social impact, and encouraging conditions. After adapting them to the particular setting of autonomous public transportation, we developed three statements to represent these developments [73,74].

"I expect to utilize autonomous public transportation when it becomes available", "I accept that utilizing autonomous public transportation will upgrade my commuting involvement", and "I accept that utilizing autonomous public transportation could be a great thing" were the three stetements utilized in our overview. On a 5-point Likert scale extending from 1 (I unequivocally oppose this idea) to 5 (I unequivocally concur), respondents were inquired to rank each statement.

Table 4. Preferences for how to implement autonomous public transportation on roads.

Item		Cronbach's α = 0.879	Mean (SD)
1	A trial must be conducted free-of-charge to provide a personal experience for the community before implementing automated vehicles.	0.864	4.90 (0.45)
2	A clear law must be established before implementing automated vehicles so that they are held responsible for any accidents that may occur.	0.867	3.75 (1.16)
3	Advertisements related to automated vehicles must be published immediately, especially those regarding automated vehicle technology works, in order to provide the public with knowledge.	0.884	3.50 (1.17)
4	Automated vehicles must provide more comfort than older public vehicles.	0.875	3.65 (1.08)
5	Automated vehicles must have special lanes created to avoid congestion and road accidents.	0.880	3.60 (1.21)
6	Human operators still have to be there to play a role in monitoring automated vehicle systems.	0.868	3.65 (1.13)
7	The government is obliged to provide greater incentives and lower tariffs for automated vehicles.	0.885	3.95 (0.98)
8	I will wait for the environment to support automated vehicles before I provide my support.	0.888	4.00 (0.98)
9	The human operator still has to be there to take over the wheel in case of a system failure.	0.882	3.80 (1.08)
10	The provision of an emergency button to turn off/stop the automatic vehicle engine must be provided.	0.881	2.90 (1.32)
11	Detailed automated vehicle testing is mandatory before implementation.	0.890	3.55 (1.01)

We calculated the Cronbach's alpha to guarantee the measure's legitimacy and inner consistency. In our study, the measure's inside consistency was commendable, with a Cronbach's alpha coefficient of more than 0.70. Subsequently, the ultimate statements and measures created for the study are displayed in Tables 2–4. These tables display the three statements utilized to determine the public's desire to have access to autonomous road public transport, alongside their individual errors and standard deviations.

3.4. Analysis

We utilized IBM SPSS 26 software to analyze the results of our study. Our initial analysis used descriptive statistics to examine the frequency of social concerns and benefits reported by respondents regarding autonomous vehicles. We then conducted a *t*-test analysis to determine the demographic factors influencing public acceptance of AV technology. Finally, we performed a path analysis to investigate the relationship between variables that can predict public acceptance of AVs from a social perspective.

4. Results

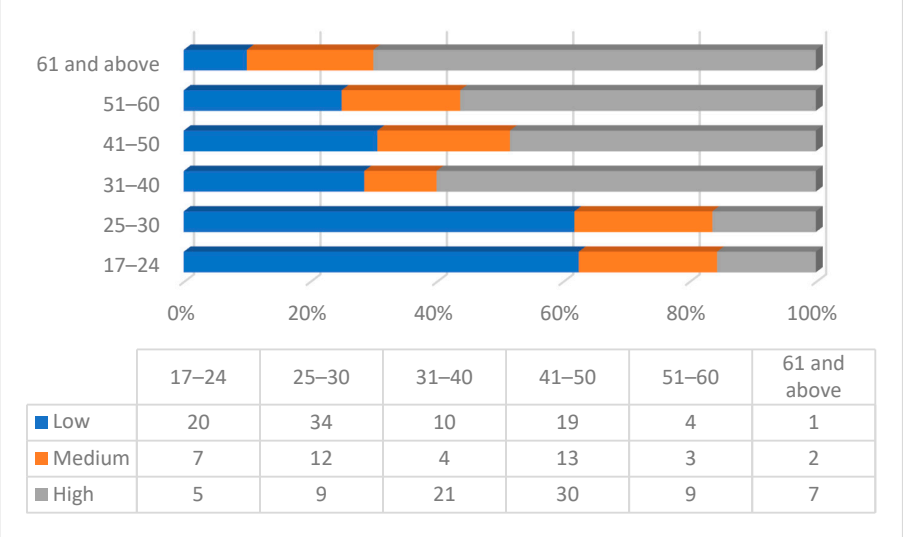
Before participating in the survey, respondents were asked to self-report their knowledge about autonomous vehicles in general. The data indicate that 25% of respondents had no prior knowledge of autonomous vehicles, while 14% reported having a good understanding of the subject. Most respondents (61%) indicated that their knowledge of

autonomous vehicles fell between these extremes. The average response on the 5-point Likert scale was 3.12 (SD = 1.05), indicating a moderate level of knowledge about autonomous vehicles among the respondents.

When asked about their previous experience with autonomous vehicles, 42% of respondents reported using autonomous vehicle sources, such as public transport (bus). In contrast, 47% reported having no previous experience with autonomous vehicles, while 11% were unsure whether they had. These findings suggest that while some individuals have had direct experience with autonomous vehicle sources, others remain relatively unfamiliar.

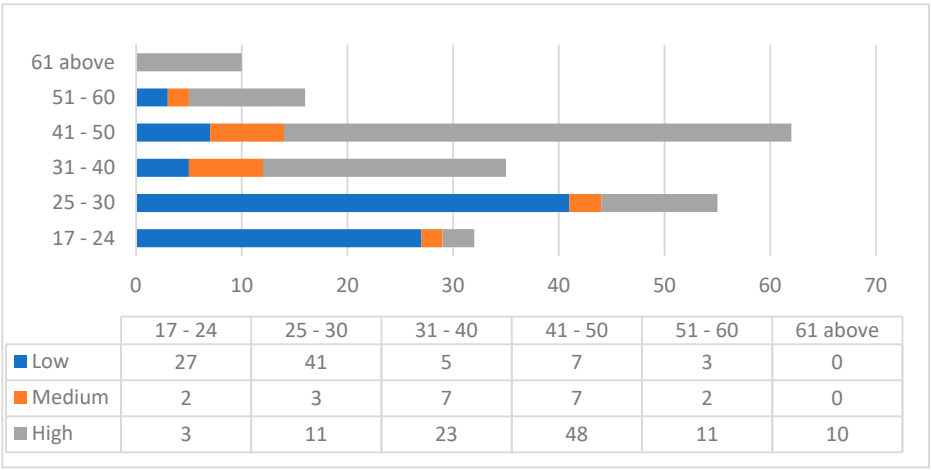
4.1. Descriptive Analysis

The first analysis is related to the frequency of respondents concerned about autonomous public transportation on the road, based on age and employment status (see Figures 1 and 2).



	17–24	25–30	31–40	41–50	51–60	61 and above
Low	20	34	10	19	4	1
Medium	7	12	4	13	3	2
High	5	9	21	30	9	7

Figure 1. Age-related concerns about autonomous public transportation on the road.



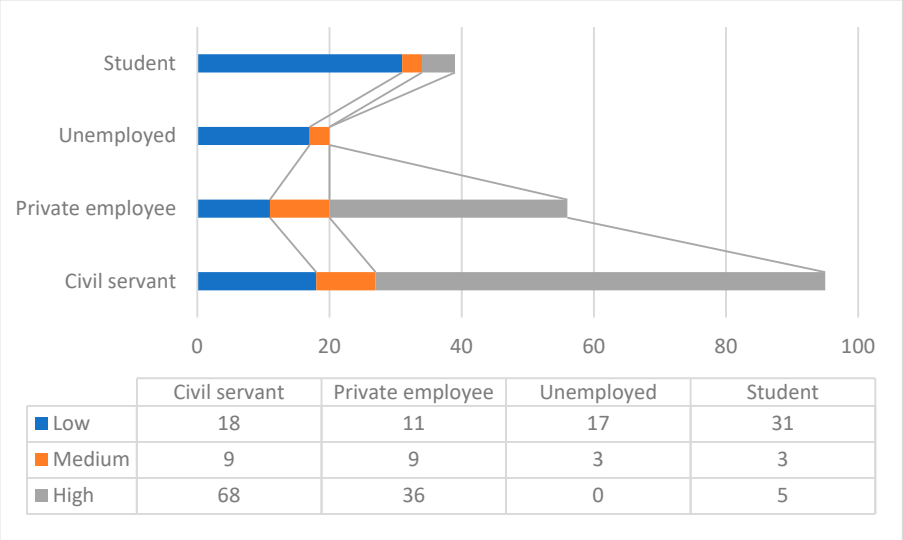
	17 - 24	25 - 30	31 - 40	41 - 50	51 - 60	61 above
Low	27	41	5	7	3	0
Medium	2	3	7	7	2	0
High	3	11	23	48	11	10

Figure 2. Age-related benefits that people expect to receive from using driverless buses and taxis.

From Figure 1, it can be observed that as people get older, they tend to express more concerns regarding public transportation. Additionally, Figure 2 shows that as people's age increases, they tend to have higher expectations for the benefits they can derive from using public transportation.

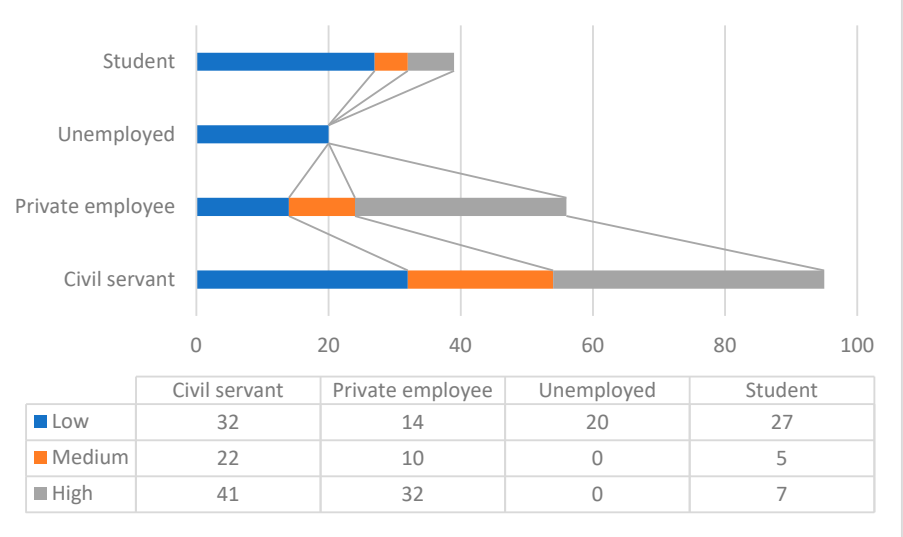
Data from the survey suggest a correlation between age and public transportation concerns. As people age, they may become more aware of potential issues and challenges associated with using public transportation, such as crowdedness, delays, and safety concerns. This heightened awareness may result in greater expression of concerns regarding public transportation. Similarly, the data also indicate that older individuals tend to have higher expectations for the benefits they can derive from using public transportation. This may be due to a greater reliance on public transportation for daily activities, such as commuting and running errands. Older individuals may also have more public transportation experience, leading to a greater understanding of its potential benefits and drawbacks.

The following figures (Figures 3 and 4) depict the frequency of concerns and expected benefits regarding autonomous public transportation on the road, as seen from the perspective of different occupations.



	Civil servant	Private employee	Unemployed	Student
Low	18	11	17	31
Medium	9	9	3	3
High	68	36	0	5

Figure 3. Type of occupation-related concerns about autonomous public transportation on the road.



	Civil servant	Private employee	Unemployed	Student
Low	32	14	20	27
Medium	22	10	0	5
High	41	32	0	7

Figure 4. Type of occupation-related benefits that people expect to receive from using driverless buses and taxis.

Figure 3 shows that individuals in transportation and logistics occupations express higher levels of concern regarding the safety and reliability of autonomous public trans-

portation. In comparison, individuals in managerial or administrative occupations express relatively lower levels of concern.

One possible explanation for this finding is that individuals in transportation and logistics occupations may have greater experience and expertise in the field, which makes them more aware of the potential challenges and limitations of autonomous public transportation. In contrast, individuals in managerial or administrative occupations may have less direct experience with transportation and may therefore be less aware of the potential concerns.

Figure 4, on the other hand, shows that individuals in higher-status occupations tend to place greater emphasis on the benefits of using driverless buses and taxis. For example, individuals in service occupations expect greater convenience and time savings from using autonomous public transportation, while individuals in professional or technical occupations expect greater comfort and flexibility.

4.2. Concerns about Autonomous Public Transportation on the Road

The data presented in Table 2 show the results of a survey conducted to investigate the public's perception of automated vehicles concerning their ability to drive as well as humans, safety concerns, job loss, the potential for hacking, legal issues, and impact on public transport fares. The Cronbach's alpha score of 0.873 indicates the survey items' high internal consistency and reliability.

Each item's mean score and standard deviation (SD) are also provided. Item 1 received a mean score of 4.00 with an SD of 0.76, indicating that respondents generally agreed that automated vehicles might not be able to drive as well as human drivers. Item 2 received a mean score of 4.15 with an SD of 0.68, suggesting that respondents are concerned about the safety of implementing automated vehicles on the roads of Jakarta without sufficient proof of their safety.

Item 3 received a mean score of 4.17 with an SD of 0.66, indicating that respondents believe implementing automated vehicles will cause many job closures. Item 4 received a mean score of 4.17 with an SD of 0.61, indicating that respondents perceive automated vehicles to be vulnerable to hacking, and that public transport rates will increase if they are implemented. Finally, item 5 received a mean score of 4.00 with an SD of 0.76, suggesting that respondents believe that legal problems will arise when automated vehicles are implemented. Overall, the data suggest that the public have several concerns and reservations about implementing automated vehicles in public transport, including safety, job loss, the potential for hacking, legal issues, and increased public transport fares.

4.3. Benefits That People Expect to Receive from Using Autonomous Buses and Taxis

The study examines seven benefits: (1) automatic vehicles being more prevalent than manual modes of transportation; (2) a reduction in traffic congestion in the capital city; (3) automated vehicles resolving the issue of public vehicle drivers without driving licenses; (4) an increase in travel efficiency in the capital city; (5) improved reliability of public transportation in the capital city; (6) decreased travel time due to the use of automatic vehicles; and (7) provision of transportation options for disabled parents.

The mean scores for all seven benefits suggest that the respondents perceived the advantages of introducing autonomous road public transport. However, the mean scores were relatively close to the 'neutral' option in the questionnaire, which is 3. Furthermore, one-sample *t*-tests showed that the mean scores for all benefits were significantly different from the scale mean, with all *p*-values below 0.05.

Regarding demographic factors, there were no significant differences in responses based on gender, age, marital status, and occupation, with *p*-values ranging from 0.12 to 0.95. However, two exceptions were observed: (1) male respondents had a higher perception of the safety of autonomous road public transport than their female counterparts, and (2) participants with a high school education or lower reported a lower perception of the

benefits of automated public transportation in terms of travel efficiency compared to those with a college education or higher.

4.4. Significant Differences Found in Concern, Benefit, and Preference Scores across Demographic Characteristics

Furthermore, a *t*-test analysis was conducted to determine which demographic factors significantly influence concern, benefit, and preference. The survey data analysis revealed several interesting findings. Significant differences were found in the concern, benefit, and preference scores across various demographic characteristics of the respondents. Table 5 will provide a detailed overview of these findings.

Table 5. Differences in concern, benefit, and preference scores across demographic characteristics: results of *t*-test analysis.

Group	Sample Size	Concern (Mean)	Benefit (Mean)	Preference (Mean)	Pooled Standard Deviation	*t*-Test Statistic	Critical Value (Alpha = 0.05)	Result
AGE								
17–24	32	2.60	3.40	2.80	0.90	1.80	2.042	Not significant
25–30	55	3.20	4.10	2.50	0.60	4.40	2.002	Significant
31–40	35	2.90	3.80	2.90	0.80	2.70	2.03	Not significant
41–50	62	3.10	3.70	2.60	0.70	2.90	2.002	Significant
51–60	16	3.50	3.30	3.00	0.50	5.70	2.947	Significant
61 and above	10	3.30	3.50	2.80	0.90	1.70	2.718	Not significant
Labor status								
Civil Servant	95	3.00	4.00	2.70	0.70	3.00	2.002	Significant
Private Employee	56	2.80	3.90	2.80	0.90	1.90	2.101	Not significant
Unemployed	20	3.30	3.50	2.50	0.70	2.20	2.086	Not significant
Student	39	3.10	4.20	2.90	0.60	4.10	2.002	Significant
Education status								
Postgraduate	64	2.90	4.10	2.60	0.80	3.30	2.002	Significant
Undergraduate	95	3.20	3.60	2.80	0.60	4.70	2.002	Significant
Diploma	43	2.80	3.90	2.70	0.70	3.10	2.01	Not significant
Senior High School	8	3.50	3.30	3.00	0.50	5.70	2.306	Not significant
Marital status								
Married	117	2.90	3.90	2.50	0.70	3.80	1.983	Significant
Separated/Divorced	28	3.00	4.00	2.40	0.60	4.20	2.048	Significant
Single	65	3.10	3.90	2.60	0.60	4.00	2.023	Significant
Physical disability								
Yes	37	2.80	3.70	2.30	0.60	4.10	2.032	Significant
No	173	3.00	3.90	2.50	0.70	3.80	1.985	Significant
Gender								
Male	132	2.80	3.80	2.40	0.60	4.30	1.985	Significant
Female	78	3.10	3.90	2.60	0.60	4.00	2.023	Significant

The results of the *t*-test analysis revealed significant differences in the respondents' concern, benefit, and preference scores based on their demographic characteristics. Each group's sample size ranged from 8 to 132, with an aggregated standard deviation between 0.50 and 0.90. At a significance level of 5%, the *t*-test statistic ranged from 1.70 to 5.70, with critical values ranging from 1.983 to 2.947.

The analysis revealed that the mean scores for concern, benefit, and preference varied significantly across age categories, employment status, education status, marital status, physical disability, and gender. Specifically, the 25- to 30-year-old age group, students, postgraduates, and singles, exhibited significant differences in the three scores. In contrast, only the concern and benefit scores demonstrated substantial differences between civil servants and separated/divorced respondents. In contrast, there were no significant distinctions between the scores of private-sector employees, unemployed people, those with a high school diploma, and those without a diploma.

4.5. Preferences for How to Implement Autonomous Public Transportation on Roads

The survey explored 11 opinions about the execution of autonomous public transport, and Table 4 shows the results. The participants showed their preferences for having human

operators on board. Mean inclination scores for all alternatives, apart from those specified over, were over 4, showing a solid assertion on the 5-point Likert scale. In any case, one-sample *t*-tests affirmed that the mean scores for all usage alternatives were altogether different from the mean of the scale, with all *p*-values below 0.05.

There were no noteworthy contrasts in inclinations based on sex, age, conjugal status, work status, or physical inability status (*p*-values extended from 0.07 to 0.86). In any case, there were noteworthy contrasts based on education levels. For example, participants with a postgraduate degree had a lesser inclination to encourage others to utilize autonomous street public transport. They were more likely to attempt it themselves compared to other participants. Their mean score was 2.59 (SD = 1.21), whereas the scores of other participants ranged from 3.29 to 3.74, with a *p*-value of 0.001.

4.6. Exploring the Link between Perceived Concerns and Benefits and Acceptance of Autonomous Road Public Transport

The relationship between states of mind concerning benefits and concerns and the acceptance of independent public transportation on streets was explored utilizing correlation and straight regression analyses. As a marker of general attitudes toward benefits and concerns, the mean score of eight things related to concerns (mean (SD) = 3.87 (0.72)) and seven things related to benefits (mean (SD) = 4.05 (0.68)) was utilized. As anticipated, there was a solid negative relationship between worry-based attitudes and endorsement of autonomous public transportation ($r = -0.23$, $p = 0.01$). On the other hand, worry-based, benefits-based states of mind were emphatically related to approval ($r = 0.56$, $p = 0.001$). Isolated direct regression models were conducted for attitudes toward concerns (Model 1) and states of mind towards benefits (Model 2), and after that with both attitudes (Model 3), and with sociodemographic factors (Model 4).

Attitudes toward benefits altogether anticipated acknowledgement of autonomous public transportation (Model 2), whereas concerns-focused attitudes (Model 1) did not. Displaying both states of mind, (Model 3) uncovered that benefits-focused attitudes were the critical acknowledgement indicator. This shows that benefits-focused attitudes may clarify a few concerns about autonomous public transportation. The acceptance score increased only somewhat, from 0.38 to 0.40. The results were invariant after considering socioeconomics (Show 4). Information from the regression analysis is summarized in Table 6.

Table 6. Relationship between attitudes towards concerns and benefits and acceptance of autonomous road public transport: a linear regression analysis.

Variables	Model 1	Model 2	Model 3	Model 4
Attitudes towards concerns	−0.23 *		−0.05	−0.08
Attitudes towards benefits		0.56 **	0.57 **	0.62 **
R-Square	0.053	0.316	0.329	0.642

* $p < 0.05$, ** $p < 0.001$; **1**: with concerns as the sole independent variable; **2**: with benefits as the sole independent variable; **3**: with both concerns and benefits as independent variables; **4**: with both concerns and benefits as independent variables, and socioeconomics as a covariant.

The table shows the outcomes of four regression models, indicating that attitudes towards benefits exhibit a more robust positive correlation with the dependent variable compared to attitudes towards concerns. The results of Model 2 indicate that the coefficient for attitudes towards benefits, as the only independent variable, was statistically significant at the $p < 0.001$ level. Additionally, the R-squared value of 0.316 suggests that attitudes towards benefits explain a substantial proportion of the variance in the dependent variable. Upon inclusion of attitudes towards concerns in Model 3, there was an observed increase in the coefficient for attitudes towards benefits, resulting in an increase in the R-squared value to 0.329. This implies that the impact of attitudes towards benefits on the dependent variable persists even after accounting for attitudes towards concerns.

The fourth model analysis revealed that including socioeconomic factors as a covariate did not have a statistically significant effect on the association between attitudes towards concerns and benefits and the dependent variable. The study found that attitudes towards concerns and benefits significantly influenced the dependent variable. Additionally, including socioeconomics as a covariate improved the model's fit, as evidenced by the increase in the R-squared value to 0.642.

We first performed a linear regression analysis to see if there was a correlation between safety perception and autonomous vehicle adoption intentions. Then, we performed a mediator analysis to see if safety perception would influence those intentions if convenience was a positive factor. We estimated 95% CIs for each regression coefficient using conditional process modelling [27] and bootstrap resampling (with 5000 iterations). Figure 5 presents the data analysis results. According to the results, the perception of ease of use plays a mediating role in the relationship between safety concerns and the likelihood that a person will choose to ride an autonomous vehicle. Further, a Sobel test was conducted, and the results supported the conclusion of partial mediation in the model tested ($z = 1.75$, $p = 0.08$).

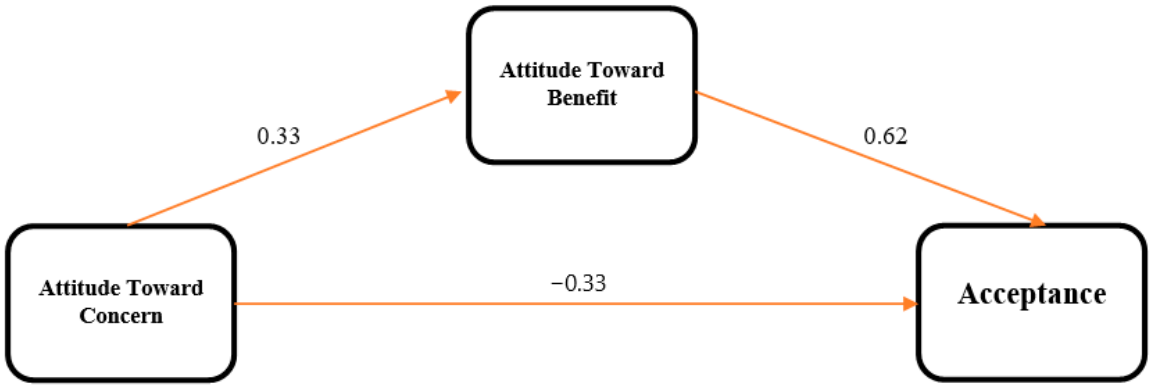


Figure 5. Final model relationship between attitudes toward concerns, benefits and acceptance.

5. Discussion

There is growing interest in using self-driving vehicles in public transportation. However, while some studies have looked at how people feel about self-driving cars when they are used privately, there has been some research into how people feel about self-driving cars when they are used on public roads. Unfortunately, very few studies have investigated this [2–4,18,75]. This study examines public acceptance of AV in public transport, the concerns and benefits associated with its implementation, and implementation preferences in Indonesia.

Consistent with previous studies conducted in other cities worldwide, our results demonstrate a general acceptance of AVs as a mode of public transport in Indonesia [9,76,77]. There are reduced implementation concerns and greater public awareness of the benefits, which act to increase acceptance. Perceptions of individual utility partially mediated the relationship between concern and acceptance. Despite the concerns, people who felt they could benefit more from AV were more likely to accept its implementation. This finding reflects a moral norm system assessment between potential benefits and risks in cognitive processes that precede Avs' acceptance.

Concerns around AVs being susceptible to errors and worries about responding to unanticipated circumstances were among the main concerns that our participants communicated. Avs' responsibility for mishaps was a significant concern [78]. Participants felt that it would be best for the government to conduct comprehensive tests of AVs before implementing them. Moreover, participants believed that AVs would progress the quality and availability of public transport [79]. Finally, participants accepted that AVs would make transportation more available, particularly for people who did not have driver's licenses. This is of specific interest to the nation of Indonesia.

The analysis in this study provides interesting insights, as it reveals that not all age groups significantly impact public acceptance of AVs. The analysis shows that the age groups of 17–24 and 31–40 do not significantly influence the acceptance of AVs. This may be because individuals within the 17–24 age range are mostly school-aged and use private transportation, while those within the 31–40 age range tend to use their vehicles for commuting to work. This differs from developed countries such as Japan and China, in which public transportation is more commonly used for mobility [80,81]. This may be because some developed countries have successfully created public transportation systems that are well-liked by the public, which is difficult for developing countries such as Indonesia to replicate.

Regarding occupation, private sector workers and those unemployed do not significantly impact the acceptance of AVs. This may be because private sector workers prefer private transportation due to their high mobility requirements. This is supported by the culture in Indonesia, in which individuals who work in Jakarta tend to live far away from their workplaces and are constrained by the lack of public transportation options. This is different from civil servants and students, who usually rely on public transportation, as they have limited options for transportation. Civil servants have limited transportation funds, while students prefer public transportation as it is more affordable.

Another interesting finding of this study is that marital status (married, separated/divorced, single) and disability status significantly impact public acceptance of Avs; these factors are not commonly associated with public acceptance in some countries. These results provide a new perspective for stakeholders to target respondents more effectively to improve public acceptance of AVs.

Participants were less concerned about reasonableness, with a conceivable increase in the acceptance of public transport after presenting AVs among their concerns. This shows that participants expectations stay the same to a great extent, particularly with regard to expectations of financial incentives to use AVs in public transport.

One limit of our study is the demographic of the survey, which included a greater proportion of undergraduates and more young people than are found within the general populace. Our findings give valuable early insight into perceptions of AVs as public transport, and acknowledgement of Avs among Indonesian public transport clientele, highlighting potential center zones in which public transport administrators and authorities may arrange the implementation of AVs. Studies employing a comparative system and taking into account sections of the population with particular transport necessities ought to be conducted to ascertain broader acceptance of AVs. This will be especially valuable in cities that are arranging to use AVs in public transport, as a way to inform usage procedures.

6. Conclusions

This study on public acceptance of autonomous vehicles (AVs) in Indonesia provides important insight into the factors influencing the relationship between concerns and acceptance of AVs, especially in public transportation. The methodology employed in this study is unique and sheds light on specific concerns that need to be addressed before the widespread implementation of AVs in public transport.

The numerical results presented in the study show that a significant percentage of respondents have a positive attitude towards AVs, while others express concerns about their safety and legal liability. These results provide useful information for policymakers and public transport operators in Indonesia, and for other cities considering implementing AVs in public transportation. Efforts to improve the perceived benefits of AVs, such as increased safety and efficiency, could improve public acceptance of AVs, even among those concerned about their implementation. Therefore, policymakers and public transport operators should prioritize addressing these concerns to ensure the successful implementation of AVs in public transportation.

This study discovered a unique fact: not all demographic characteristics and criteria significantly influence public acceptance. For example, employment status, education

status, marital status, physical disability, and gender did not show significant differences in the three scores. However, the 25 to 30-year-old age group, students, postgraduates, and singles exhibited significant differences in the three scores. Additionally, only the concern and benefit scores showed substantial differences between civil servants and separated/divorced respondents. In contrast, no significant differences were found between the scores of private sector employees, unemployed people, those with a high school diploma, and those without a diploma. Therefore, this study provides unique and interesting results that warrant further discussion, particularly in developing countries such as Indonesia.

Furthermore, this study provides valuable insights for stakeholders, highlighting the importance of considering an individual's social factors, such as their concerns and perceived benefits, when implementing AV regulations. Policymakers can utilize this information to improve public acceptance and ease implementation. The study's findings have important implications, especially in developing countries such as Indonesia.

Overall, this study provides a foundation for future research on the use of AVs as public transport in Indonesia and other developing countries, with implications for policymakers, public transport operators, and the wider public. Despite the valuable insights that this study provides on public acceptance of autonomous vehicles (AVs) in Indonesia, there are several limitations to consider:

- A small sample size limited the study and may not fully represent Indonesia's general population.
- The study was conducted in a single urban area in Indonesia, and may not reflect the attitudes and behaviors of individuals in rural areas.
- The study only focused on public acceptance of Avs, and did not investigate the factors that may influence the adoption of AV technology.

In future research, several points could be explored to advance our understanding of public acceptance of AVs in Indonesia. Firstly, future studies could delve deeper into the factors that may influence the adoption of AV technology, such as cost, safety, and reliability. By examining these factors, stakeholders can better tailor their strategies to increase public acceptance of AVs in the country.

Secondly, future studies could investigate AVs' potential benefits and drawbacks for Indonesia's environment, traffic, and public health. This information may help policymakers and researchers identify the most promising use cases for AVs in their country and develop policies that maximize their benefits while minimizing their negative impacts.

Third, future research could utilize various statistical approaches to comprehensively understand the factors influencing public acceptance of AV technology. It is important to use various statistical techniques to obtain more interesting results, such as:

- Using cluster analysis to investigate the differences in social concerns and benefits reported by different population segments. This could help to identify population subgroups with different attitudes towards AV technology, and inform targeted policymaking.
- Use factor analysis to identify the factors contributing to public acceptance of AV technology, such as safety, convenience, or environmental concerns. This could help policymakers to design interventions that address the specific factors that are most important to the public.
- Conduct structural equation modelling to investigate the complex relationships between factors influencing public acceptance of AVs. This could help identify the key drivers of public acceptance and inform policies promoting AV technology's adoption.

Finally, future studies could expand the sample size and include individuals from diverse demographic backgrounds and regions to increase the generalizability of the findings. In doing so, researchers can ensure that the findings represent the broader population in Indonesia, and stakeholders can use the results to develop more effective strategies for promoting the adoption of AVs in the country. Overall, these future research directions can help shed more light on the complex factors that influence public acceptance

of AVs in Indonesia, and can guide policymakers and stakeholders towards more effective strategies for promoting the adoption of this promising technology.

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Appendix A

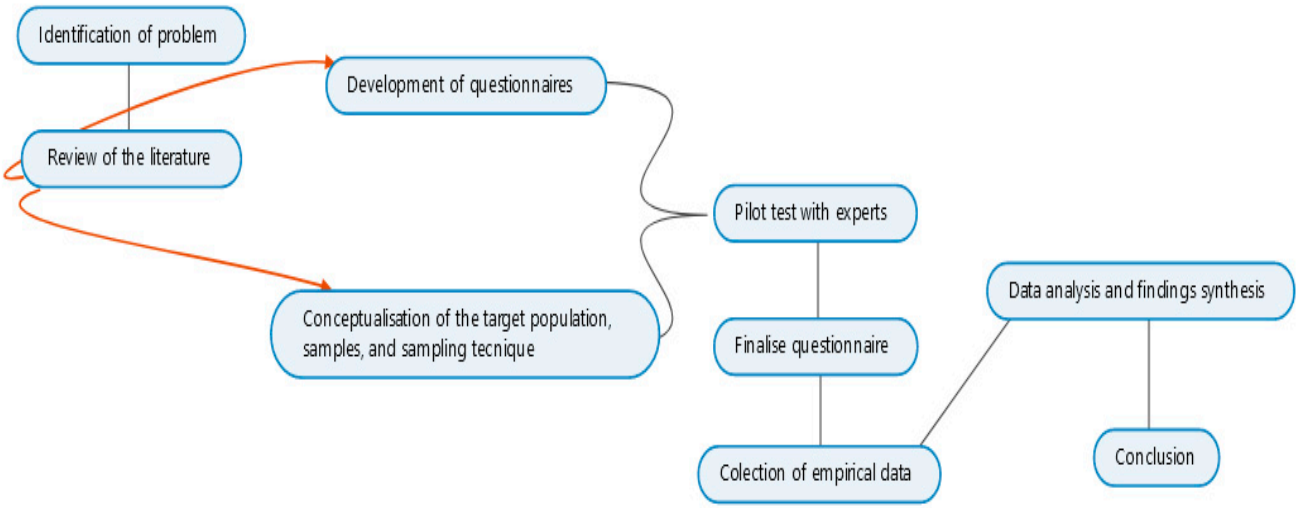

Figure A1. Research flow chart.

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