Public perceptions and support for policies enhancing safety and justice in connected and automated vehicles and vulnerable road users interactions

Martínez-Buelvas, Laura; Rakotonirainy, Andry; Grant-Smith, Deanna; Haque, Md Mazharul; Oviedo-Trespalacios, Oscar

DOI
10.1016/j.cstp.2025.101571

Publication date
2025

Document Version
Final published version

Published in
Case Studies on Transport Policy

Case Studies on Transport Policy 22 (2025) 101571

Contents lists available at ScienceDirect

Case Studies on Transport Policy

journal homepage: www.elsevier.com/locate/cstp

Public perceptions and support for policies enhancing safety and justice in connected and automated vehicles and vulnerable road users interactions

Laura Martínez-Buelvas [a,*], Andry Rakotonirainy [a], Deanna Grant-Smith [b], Md Mazharul Haque [c], Oscar Oviedo-Trespalacios [d]

[a] Queensland University of Technology (QUT), Centre for Accident Research and Road Safety – Queensland (CARRS-Q), 130 Victoria Park Rd, Kelvin Grove, QLD 4059, Australia
[b] University of the Sunshine Coast, Moreton Bay Campus, School of Business and Creative Industries, 1 Moreton Parade, Petrie QLD 4502, Australia
[c] Queensland University of Technology (QUT), School of Civil and Environmental Engineering, Faculty of Engineering, Brisbane, QLD 4001, Australia
[d] Delft University of Technology, Faculty of Technology, Policy and Management, Section of Safety and Security Science, Jaffalaan 5, 2628 BX Delft, The Netherlands

ARTICLE INFO

Keywords:
Connected and automated vehicles
Transport policy
Policy acceptance
Governance
Safety
Justice

ABSTRACT

Despite the anticipated benefits, the rollout of Connected and Automated Vehicles (CAVs) is likely to encounter numerous challenges, including public readiness to adopt and coexist with these vehicles. This study utilised a cross-sectional survey of 384 Australian residents aged 18 to 82 (M = 42.93, SD = 15.48) to assess public perceptions and support for policies designed to enhance safety and justice in interactions between CAVs and vulnerable road users (VRUs) such as pedestrians, cyclists and people with disabilities. Participants evaluated 15 policies (identified through a structured, expert-informed process as a preliminary stage) across five evaluation dimensions: acceptability for improving safety within the transport system, acceptability for improving justice within the transport system, perceived improvement of safety for all VRUs, perceived improvement of justice for all VRUs, and willingness to support each policy. Data were analysed using descriptive statistics, cluster analysis, and hierarchical regression models. Policies focusing on systemic improvements, such as VRU-focused infrastructure and technology enhancements, received strong public support. Public preferences align with policies promoting fairness and inclusivity, while punitive measures and VRU-burdening policies were resisted. Cluster analysis identified three groups: VRU-burdening policies (low support), VRU-centric safety policies (moderate support), and VRU-focused infrastructure and technology policies (high support). Regression analyses revealed that factors such as age, transport accessibility, and disability influenced policy support. A content analysis revealed a strong preference for prioritising public transport investment, implementing inclusive urban designs, and establishing robust ethical frameworks. The findings highlight the need for policies that prioritise VRU safety and justice in CAV deployment. Support for inclusive, non-punitive measures points to the importance of fairness and system-wide reforms. To transition toward a safer, more equitable transport system, the study suggests the potential for more radical, community-driven policies and increased transparency in CAV development.

1. Introduction

Cities are dynamic systems that continually evolve in response to challenges such as congestion, inequitable access to resources, environmental degradation, and population pressures. Despite these issues, cities also provide opportunities for innovation by leveraging dense networks of people, resources, and ideas to foster collaboration (Bettencourt, 2015). Technological advancements are central to this transformation, reshaping urban structures and redefining transport systems (Bibri & Krogstie, 2017). The deployment of Connected and Automated Vehicles (CAVs) exemplifies these changes, as related technologies integrate automated operation with real-time connectivity to address critical urban challenges (Cohen et al., 2020; Matin & Dia, 2022). Their potential benefits include enhanced mobility, congestion reduction, and the promotion of sustainable urban design (Kim et al., 2019; Sundararajan et al., 2019; Faber & Lierop, 2020; Riggs et al., 2020). However, integrating CAVs into urban environments also raises significant concerns related to safety, equity, and justice, particularly for

* Corresponding author at: Queensland University of Technology (QUT), K Block, 130 Victoria Park Road, Kelvin Grove, QLD 4059, Australia.
E-mail addresses: laurapatricia.martinezbuelvas@qut.edu.au, laumartinez89@gmail.com (L. Martínez-Buelvas).

https://doi.org/10.1016/j.cstp.2025.101571
Received 22 April 2025; Received in revised form 25 July 2025; Accepted 17 August 2025
Available online 19 August 2025

vulnerable road users (VRUs) (Martínez-Buelvas et al., 2022). Addressing these concerns requires robust policy-oriented research to establish effective regulatory frameworks that support a sustainable and equitable deployment of CAV technologies.

Governments worldwide have developed policies and regulatory frameworks to support the integration of CAVs on public roads, aiming to unlock their potential benefits, including improved safety, operational efficiency, and environmental sustainability. Notable advancements in this area have been made in regions such as the United States, Europe, the United Kingdom, and Australia. For example, the European Union (EU) has taken a proactive approach by standardising policies and regulations to advance CAV deployment across member states. The European Commission, in particular, has worked to harmonise legal requirements and promote cross-border cooperation (European Commission, 2018). By eliminating regulatory barriers, the Commission aims to foster innovation, encourage investment, and simplify compliance for manufacturers and developers. This standardisation also seeks to build public trust in CAV technologies by ensuring consistent safety and performance standards across the region.

In the United States, the National Highway Traffic Safety Administration (NHTSA) has introduced comprehensive federal and state-level guidelines to govern CAV deployment. These frameworks include safety standards, testing procedures, and data-sharing protocols to ensure a unified and transparent approach (U.S. Department of Transportation, 2018). Similarly, the United Kingdom has implemented robust measures to support CAV development through the Centre for Connected and Autonomous Vehicles (CCAV). The Code of Practice for Testing outlines guidelines for safe and responsible trials, including pre-trial assessments at closed facilities, human safety drivers for on-road tests, and comprehensive safety management plans (Department for Transport, 2023). Australia has also made significant strides in its approach to CAV regulation. The National Transport Commission (NTC) has developed federal guidelines emphasising safety, liability, and public accountability. Trial organisations are required to conduct thorough safety assessments, consider the needs of vulnerable road users, and mitigate potential impacts on existing infrastructure (National Transport Commission, 2017; 2019). Moreover, the NTC mandates that appropriate insurance and compensation mechanisms be in place for injuries caused by CAV operations, reinforcing a safety-first approach to deployment.

Academic research also plays a vital role in shaping these regulatory frameworks by providing technical recommendations that enhance the performance and safety of CAVs. Some studies have focused on infrastructure design to facilitate the seamless integration of CAVs into urban road networks. For example, Chatziioannou et al. (2024) explored the relationship between CAV infrastructure and urban road design, highlighting the benefits, challenges, and strategies for seamless integration. The authors propose short-term measures, such as upgrading boulevards and designating CAV-specific routes, to support deployment with minimal disruption. For long-term implementation, they advocate adapting arterial and collector roads to integrate CAVs into transport networks while preserving neighbourhood accessibility and liveability.

Other scholars, such as Milakis, Van Arem, & Van Wee (2017), introduced a framework to evaluate the societal and spatial impacts of CAVs, highlighting the importance of proactive urban planning to address potential inequities and mitigate unintended consequences. Building on their ripple effect framework, this review categorised the impacts of CAVs into three interconnected levels: first-order (traffic, travel cost, and travel choices), second-order (vehicle ownership and sharing, land use, and infrastructure), and third-order (energy consumption, air pollution, safety, social equity, economy, and public health). Fagnant & Kockelman (2015) identify several significant barriers to the full implementation and widespread adoption of Connected and Automated Vehicles (CAVs). High initial costs may limit accessibility, while the lack of a unified federal regulatory framework risks creating a fragmented landscape of state policies, complicating deployment. Additionally, unresolved legal and liability issues, cybersecurity threats, and privacy concerns pose critical challenges that must be addressed to ensure a safe and equitable transition. To mitigate risks such as congestion and increased vehicle kilometres travelled, they propose strategies such as dynamic pricing models and prioritising shared CAV use, which could help optimise road network efficiency and minimise negative externalities. Advancing this discussion, Atakishiyev et al. (2021) introduce a design framework incorporating automated control, explainable artificial intelligence (AI), and regulatory compliance to enhance the safety and reliability of automated driving systems.

Policy development for CAVs must address key challenges, including safety standards, liability frameworks, infrastructure adaptation, and ethical decision-making in complex scenarios. Li et al. (2018) emphasise the importance of flexible and collaborative policymaking that involves government agencies, industry leaders, and academia to navigate the rapid pace of technological change. By fostering cross-sector collaboration, they argue that policymakers can better address evolving societal needs and the challenges posed by automation in transport. Similarly, Lee & Hess (2020) analyse global CAV testing regulations, highlighting regional disparities in safety standards, testing protocols, and data-sharing. The authors emphasise the potential benefits of harmonisation, such as consistent safety practices and reduced costs, while addressing challenges like political and cultural differences that hinder international collaboration and regulatory alignment. In addition, Sohrabi, Khreis, & Lord (2020) explore the public health implications of CAV deployment, proposing targeted policies to promote electric CAVs, regulate urban development, and manage traffic demand to maximise health benefits and minimise risks.

Alongside these regulatory and technical considerations, recent research highlights the critical importance of public perception in shaping the success and equity of CAV deployment. For instance, Dennis, Paz & Yigitcanlar (2021) conducted a comparative study in Las Vegas, revealing that younger, male, and highly educated individuals, particularly those with direct experience using a shuttle CAV, expressed more positive attitudes toward CAV adoption. In a similar vein, Gazder & Algherbal (2025) applied statistical and machine learning models in Bahrain to identify key predictors of acceptance, such as tech-savviness, age, gender, and familiarity with traditional vehicles, and found meaningful contrasts when compared with attitudes in Saudi Arabia. Ahmed et al. (2022) further demonstrated that machine learning models can accurately predict user adoption levels, with major concerns centring on the fear of relinquishing control to autonomous systems. Expanding on these insights, Martínez-Buelvas et al. (2024a) investigated CAV acceptance through the dual lenses of safety and justice. Their study found that although both drivers and pedestrians supported CAV adoption in principle, they remained deeply concerned about system reliability, potential economic barriers, and disproportionate risks to VRUs.

Despite these valuable contributions, critical gaps remain in embedding safety and justice into the design and implementation of CAV policy and regulation, particularly when it comes to the needs of VRUs. Existing frameworks continue to focus heavily on technological innovation and basic safety compliance (Milakis, van Arem & van Wee, 2017), while the equitable distribution of benefits and burdens is often overlooked (Tan & Taeihagh, 2021; Emory et al., 2022). Addressing these gaps requires integrating public values, especially those shaped by lived experiences and social disparities, into the foundation of policy design. Justice in transport systems involves three key dimensions: distributive justice, which concerns the fair allocation of benefits and burdens; procedural justice, which ensures inclusivity in decision-making; and recognition justice, which upholds the rights of all road users, particularly marginalised groups (Fraser, 1995; Kymlicka, 2002; Young, 1990).

Transport justice frameworks advocate for policies that prevent vulnerable communities from disproportionately bearing the burdens of new transport technologies (Pereira et al., 2017; Martens, 2017; 2020).

Recent research has introduced structured frameworks to address justice concerns in CAV integration, proposing inclusive policies that explicitly account for safety and equity issues. For instance, Martínez-Buelvas et al. (2022) present a structured transport justice framework to address the challenges of integrating CAVs with VRUs, advocating for inclusive policy frameworks that explicitly tackle safety and justice concerns. Similarly, Acheampong & Cugurullo (2019) highlight the ethical and governance challenges of CAV technologies, emphasising a people-centred approach that ensures equitable access and addresses VRUs' diverse needs. Fatima, Lee & Dannenberg (2024) further underscore equity concerns in CAV adoption, highlighting disparities in access, infrastructure, and job impacts. They recommend policies such as subsidies for low-income users, inclusive service distribution, and diverse data integration to mitigate inequities and foster fairness in CAV deployment. Despite these contributions, the intersection of CAV policy and transport justice remains underexplored, as much research continues to prioritise technological advancements over the safety and justice implications for VRUs.

Understanding public perceptions of CAVs is crucial to shaping equitable and effective policies, particularly regarding interactions between CAVs and VRUs. A lack of public consultation on CAV policies risks undermining acceptance and adoption, potentially delaying implementation and limiting the benefits these technologies can offer, such as enhanced safety, efficiency, and accessibility in transport systems. Rather than focusing on specific road user or stakeholder groups, this study addresses a key gap by identifying groups of policy measures that are most likely to gain public support during the transition to integrating CAVs and VRUs. The ultimate goal is to inform the development of widely accepted policy frameworks that prioritise safety, promote justice, and improve the experiences of VRUs within the broader transport system.

2. Method

The study utilised an online survey targeting Australian residents aged 18 and older. Designed as a cross-sectional study, the survey aimed to capture a snapshot of participants' attitudes, perceptions, and preferences regarding policies designed to enhance safety and justice in CAV-VRU interactions. The cross-sectional approach was chosen to maximise the sample size within a limited data collection timeframe. The survey sought to gather public insights on policies intended to improve safety and justice in CAV-VRU interactions, as well as to identify the policy groups most likely to gain public support during the transition to safer and more equitable transport systems.

2.1. Participants

A total of 384 road users from across Australia participated in the online survey, with representation from every state. The age of the participants ranged from 18 to 82 (M = 42.93, SD = 15.48). Males accounted for 52.9 % of the sample, females 43 %, and nonbinary 3.6 %. In the study, 30.2 % of participants (116 out of 384) reported having a disability. Among those who identified as having a disability, the types most commonly reported included hearing impairment, physical disability, and vision impairment. Refer to Table 1 for a detailed breakdown of the demographic responses.

The survey data also reveals diverse patterns in car ownership, walking/driving habits, and access to public transport. A majority (71.9 %) of respondents own a car, while 13.3 % rely on household access to a car, and 9.4 % do not have access to a car at all. Most participants (68 %) hold an open Australian driver's license, and a significant portion (61.7 %) drive conventional vehicles, with 15.9 % opting for hybrid cars and 9.4 % using electric vehicles. Regarding vehicle usage, most respondents (22.7 %) reported driving every day, followed by those who drove 5 days a week (17.4 %) and 3 days a week (13 %). A notable portion of the participants either drive less frequently (5.7 % use a car less than once a

Table 1
Sample characteristics.

Characteristic	Category	Sample %
Age group	18–30	24.2 %
	31–45	38.5 %
	Above 45	37.2 %
Gender	Male	52.9 %
	Female	43.0 %
	Nonbinary	3.6 %
	Other	0.5 %
Disability Types	Hearing impairment	8.3 %
	Physical disability	11.7 %
	Vision impairment	4.7 %
	Intellectual disability	3.9 %
Car ownership	I am a car owner	71.9 %
	I only have access to a car in the household	13.3 %
	I rent/hire a car	3.1 %
	I have access to a work vehicle	2.3 %
	I do not have access to a car	9.4 %
Driver's license status	I do not have a driver's license	6.0 %
	Learner's permit	8.9 %
	Provisional 1 / Provisional 2	5.7 %
	Open Australian License	68.1 %
	Restricted Australian license (e.g., for work only)	3.1 %
	International valid in Australia to drive	8.1 %
Type of vehicle	Conventional non-electric or non-hybrid vehicle	61.7 %
	Electric vehicle	9.4 %
	Hybrid vehicle	15.9 %
	I do not drive regularly	13.0 %
Age of the vehicle	Less than 1 year old	6.3 %
	1–3 years old	24.9 %
	4–6 years old	23.4 %
	7–10 years old	22.8 %
	More than 10 years old	22.8 %
Vehicle technology	Little to no technology	3.3 %
	Basic technology	8.7 %
	Somewhat advanced technology	52.4 %
	Advanced technology	32.0 %
	Very advanced technology	3.6 %
Days per week do you drive	1 day	2.9 %
	2 days	7.3 %
	3 days	13.0 %
	4 days	10.9 %
	5 days	17.4 %
	6 days	9.6 %
	Everyday	22.7 %
	I use a car less than once a week	5.7 %
	I do not drive a car	10.4 %
Days per week do you walk 30 mins	1 day	6.3 %
	2 days	11.0 %
	3 days	18.3 %
	4 days	12.8 %
	5 days	11.5 %
	6 days	4.5 %
	Everyday	21.2 %
	I walk less than once a week	10.2 %
	I do not walk	4.2 %
Use public transport	1 day	6.8 %
	2 days	11.2 %
	3 days	12.0 %
	4 days	6.0 %
	5 days	8.6 %
	6 days	2.3 %
	Everyday	3.6 %
	I use public transport less than once a week	15.4 %
	I do not use any form of public transport	19.3 %
	I use public transport for certain events	14.8 %
Access public transport	Very difficult	11.2 %
	Difficult	14.6 %
	Neutral	18.8 %
	Easy	37.0 %
	Very Easy	18.5 %

(*continued on next page*)

Table 1 (*continued*)

Characteristic	Category	Sample %
Distance public transport from home	Public transport is less than 10 min away	57.3 %
	Public transport is 10–19 min away	29.1 %
	Public transport is 20–29 min away	7.1 %
	Public transport is more than 30 min away	6.5 %
Income (AUD) before taxes	$3,500 or more per week ($182,000 or more per year)	6.3 %
	$3,000 – $3,499 per week ($156,000 – $181,999 per year)	5.8 %
	$2,000 – $2,999 per week ($104,000 – $155,999 per year)	11.3 %
	$1,750 – $1,999 per week ($91,000 – $103,999 per year)	7.9 %
	$1,500 – $1,749 per week ($78,000 – $90,999 per year)	12.6 %
	$1,250 – $1,499 per week ($65,000 – $77,999 per year)	10.5 %
	$1,000 – $1,249 per week ($52,000 – $64,999 per year)	7.1 %
	$800 – $999 per week ($41,600 – $51,999 per year)	6.5 %
	$650 – $799 per week ($33,800 – $41,599 per year)	6.5 %
	$500 – $649 per week ($26,000 – $33,799 per year)	6.8 %
	$400 – $499 per week ($20,800 – $25,999 per year)	3.7 %
	$300 – $399 per week ($15,600 – $20,799 per year)	5.8 %
	$150 – $299 per week ($7,800 – $15,599 per year)	2.6 %
	$1 – $149 per week ($1 – $7,799 per year)	1.4 %
	$0 or nil income	4.2 %
	Negative income	1.0 %

week) or do not drive at all (10.4 %).

In terms of walking, a significant number of participants (21.2 %) reported walking every day for more than 30 min, with 18.3 % walking 3 days a week. A substantial portion, however, reported walking infrequently, with 10.2 % walking less than once a week and 4.2 % not walking at all. When considering the purpose of walking, the majority of participants indicated they walk for exercise or jogging (47.7 %) and for leisure or strolling (47.9 %). These findings suggest that walking is primarily viewed as a recreational or health-promoting activity rather than a necessity for commuting or running errands. Additionally, the survey shows that public transport accessibility varies, with 57 % of respondents living within 10 min of a transport stop and 37 % finding access easy. However, a notable 19.3 % report not using public transport at all, highlighting reliance on personal vehicles despite varying levels of transport access. Lastly, the income data indicates a wide income distribution, with a substantial portion earning between $1,500 and $3,499 per week, suggesting a middle to upper-middle-class demographic for the survey population.

2.2. Survey design

The survey was designed to comprehensively examine public perceptions, preferences, and attitudes toward fully connected and automated vehicles (CAVs), with a specific focus on safety and justice considerations in their interactions with vulnerable road users (VRUs). It began with a demographic section to collect essential participant information, such as age, gender, disability status, and walking/driving habits, which provided a foundation for understanding how different groups perceive CAVs.

The survey introduced CAVs through a clear definition and visual explanation, ensuring all participants had a consistent understanding of the concept. It expressly referred to fully connected and automated vehicles, defined as Level 5 of automation. A Level 5 CAV is a fully automated vehicle capable of operating without any human involvement in all environments and conditions. These vehicles are equipped with advanced connectivity features, enabling communication with other vehicles, infrastructure, and external systems to improve safety, efficiency, and navigation (Society of Automotive Engineers, 2021).

To guide participants' understanding of key evaluative concepts, the survey included brief definitions of *safety* and *justice* before the policy evaluation section. Participants were prompted with the following message: *"Please keep in mind the information presented above and then answer the questions below. We want to know how you perceive safety and justice if a fully connected and automated vehicle is available on the roads today."*.

The definitions provided were:

- *Safety*: *the condition of being protected from or unlikely to cause danger, risk, or injury.*
- *Justice means creating a fair situation where no one is held back because they can't access what they need to live a good and respectful life. It also focuses on ensuring everyone gets their fair share of the benefits and responsibilities of transport.*

These definitions ensured a shared conceptual foundation and minimised ambiguity in how participants interpreted the justice and safety dimensions used in the policy ratings.

Participants were then invited to assess proposed policies aimed at improving CAV-VRU interactions, considering their acceptability, effectiveness, willingness to support and potential impact on safety and justice within the transport system, using 1–7 Likert-type questions. The 15 policies analysed in this study were developed through a structured, expert-informed process as a preliminary stage. Interviews were conducted with international, national, and local key informants from academic, policy, and operational domains involved in CAV deployment. These experts contributed to identifying policies that promote safe and just CAV-VRU interactions, ensuring that the proposed measures address real-world challenges and equity concerns in transport systems. To ensure comprehension and facilitate meaningful engagement with the policy content, all policies were deliberately articulated in clear, non-technical language. Instead of outlining specific implementation mechanisms or regulatory procedures, the policies were designed to capture broad public expectations regarding safety and justice outcomes, particularly those affecting vulnerable road users.

As outlined in Table 2, respondents were presented with these policies to facilitate their assessments and enhance their understanding of CAV-VRU interactions. Finally, the survey concluded with open-ended questions, offering participants the chance to share additional insights on safety, justice, and other considerations regarding CAV implementation in Australia.

2.3. Procedure

The online survey was created using the Qualtrics platform (http://www.qualtrics.com) and distributed via social media (e.g., Facebook, Twitter, LinkedIn) and email through the university mailing lists. Participants were required to be over 18 years old and residing in Australia. To ensure broad geographic representation across all Australian states and territories, the survey was disseminated through targeted paid advertisements on Facebook, Instagram and X, which were used to reach underrepresented areas and demographics, including rural and remote regions. The survey took approximately 30 min to complete, and respondents were informed that participation was voluntary. The survey was administered following approval from the Research Ethics Committee (ethics number 7586). Data collection took place between July 2024 and January 2025. All participants were required to provide their consent before commencing the survey. To encourage

Table 2
Evaluated transport policies in the survey aimed at improving interactions between VRUs-CAVs.

Policy #	Definition	Description
Policy #1	Speed reduction in shared zones	***Before fully connected and automated vehicles are allowed on our roads,*** these vehicles must automatically reduce their speed by 20 km/hr in areas where they share the road with vulnerable users, such as pedestrians and cyclists.
Policy #2	Accurate VRU detection sensors	***Before fully connected and automated vehicles are allowed on our roads,*** these vehicles must have sensors that can detect pedestrians, cyclists, children, the elderly, and people with disabilities with 100 % accuracy at all times.
Policy #3	Priority at signalised crossings	***Before fully connected and automated vehicles are allowed on our roads,*** these vehicles must let pedestrians, cyclists, children, the elderly, or people with disabilities cross first, including signalised intersections where these road users already have priority.
Policy #4	Priority at unsignaled intersections	***Before fully connected and automated vehicles are allowed on our roads,*** these vehicles must let pedestrians, cyclists, children, the elderly, or people with disabilities cross first, including unsignalised intersections where currently these road users have no priority.
Policy #5	Priority at zebra crossings	***Before fully connected and automated vehicles are allowed on our roads,*** these vehicles must let pedestrians, cyclists, children, the elderly or people with disabilities cross first, including zebra crossing where these road users already have priority.
Policy #6	Priority at mid-block crossings	***Before fully connected and automated vehicles are allowed on our roads,*** these vehicles must let pedestrians, cyclists, children, the elderly, or people with disabilities cross first, including mid-block crossings where currently these road users have no priority.
Policy #7	Mandatory VRU wearables for detection	***Before fully connected and automated vehicles are allowed on our roads,*** pedestrians, cyclists, children, the elderly, and people with disabilities must be required to use wearables or bio attachments to communicate with these vehicles. For example, these road users must use smartphone apps to signal their presence, helping the vehicle detect them more effectively.
Policy #8	Fines for blocking private CAVs	***Before fully connected and automated vehicles are allowed on our roads,*** penalties and fines must be enacted for pedestrians, cyclists, children, the elderly, or people with disabilities who block the path of a private fully connected and automated vehicle.
Policy #9	Fines for blocking public CAVs	***Before fully connected and automated vehicles are allowed on our roads,*** penalties and fines must be enacted for pedestrians, cyclists, children, the elderly, or people with disabilities who block the path of a public fully connected and automated vehicle.
Policy #10	Traffic light coordination for VRUs	***Before fully connected and automated vehicles are allowed on our roads,*** these vehicles and traffic lights must coordinate to prioritise active pedestrians or cyclists over conventional car drivers.
Policy #11	Proving safety on all roads	***Before fully connected and automated vehicles are allowed on our roads,*** they need to prove they can drive safely where there are pedestrians, cyclists, children, elderly people, or those with disabilities.
Policy #12	Effective communication with VRUs	***Before fully connected and automated vehicles are allowed on our roads,*** these vehicles must effectively communicate with pedestrians, cyclists, children, the elderly, and people with disabilities through signage and other means.
Policy #13	Mandatory reflective materials for VRUs	***Before fully connected and automated vehicles are allowed on our roads,*** pedestrians, cyclists, children, the elderly, and people with disabilities must use materials such as reflective clothing that makes them more visible to these vehicles.
Policy #14	CAVs sharing lanes with buses	***Before fully connected and automated vehicles are allowed on our roads,*** these vehicles should be allowed to share lanes with buses, particularly in areas where dedicated lanes for them are not feasible to enhance safety and traffic flow.
Policy #15	Prioritising public transport investment	***Before fully connected and automated vehicles are allowed on our roads,*** it is essential to prioritise and allocate funding for public transport infrastructure instead of investing in these vehicles.

participation, respondents were offered to enter a prize draw to receive 1 of 10 $100 e-gift Australia cards upon completion of the survey and the option to receive a summary of the study findings. Invalid samples were excluded if the survey contained incomplete responses or if it took an unusually short or long time (i.e., less than 5 min or more than 50 min) for a participant to complete.

2.4. Data analysis

The data analysis was conducted using IBM SPSS Statistics version 29 to perform quantitative analyses, including descriptive statistics, cluster analysis, and hierarchical regression models. Descriptive statistics provided an overview of participant demographics and policy preferences. At the same time, Ward's cluster analysis grouped the 15 evaluated policies into three categories: VRU-burdening policies (low support), VRU-centric safety policies (moderate support), and VRU-focused infrastructure and technology policies (high support). The Ward method was chosen for its ability to minimise within-cluster variance, ensuring that policies were grouped based on clear, distinct patterns in public perceptions. Its hierarchical structure facilitated the visualisation of relationships between policies through dendrograms, offering interpretable and empirically grounded insights into public preferences (Mooi & Sarstedt, 2011). Scatterplots complemented the cluster analysis by visually mapping policy acceptability across safety and justice dimensions.

Hierarchical multiple regression models were used to examine the factors influencing public support for policies within each cluster. This approach allowed us to explore the incremental contribution of different groups of user characteristics, vehicle attributes, driving behaviour, demographics, and accessibility, by entering them in conceptual blocks. The method was chosen not only for its analytical flexibility, but also for its alignment with theory-driven modelling practices in social and transport research, where predictors are structured to reflect layered influences on attitudes and behaviours (Bozovic et al., 2021; Harrison & Raudenbush, 2012; Raudenbush & Bryk, 2002). Rather than relying on bivariate correlations or automatic selection procedures, this structure enabled a more nuanced understanding of how various factors collectively shape support for different policy types (Gelman & Hill, 2007). For the open-ended question, *"Besides the presented policies, which would you propose to improve safety and justice in the transport system when a fully* *connected and automated vehicle and pedestrians/cyclists/children/elderly/people with disabilities interact soon? Is there something you would like to tell the government about?"* the first author undertook a deductive content analysis. Participants' written comments were compiled into a Microsoft Excel document and reviewed to identify recurring themes by analysing the frequency of content mentioned in each response. The co-authors reviewed, refined the themes and provided feedback.

3. Results

3.1. Descriptive data for CAVs- related knowledge

A significant majority of participants (95.3 %) had heard of fully connected and automated vehicles before the survey, with only a small proportion (3.9 %) unaware of these vehicles. This suggests that CAVs have already garnered widespread recognition, likely due to media coverage or emerging technologies. The media was the most frequently cited source of information, with 317 participants reporting exposure to CAVs through television, the internet, or other online platforms. Personal networks, including friends, family, and colleagues, were the second most common source, cited by 155 participants. Awareness through other channels was less common, with 39 participants learning about CAVs through public trials and 27 encountering them in driving simulators. Notably, a small group mentioned *"other"* sources, providing examples such as professional work settings, personal interest, or involvement in related technological fields, including Tesla ownership or employment in the automotive or tech industries. (See Fig. 1).

3.2. Descriptive data for public support of policies

As shown in Table 3, the findings highlight clear public preferences for policies that promote safety and justice in the transport system, especially in the context of VRUs interacting with CAVs. These preferences were evident across the five evaluation dimensions: acceptability for improving safety within the transport system, acceptability for improving justice within the transport system, perceived improvement of safety for all VRUs, perceived improvement of justice for all VRUs, and willingness to support each policy. For instance, policies prioritising systemic improvements, such as Policy #11 (proving safety on all roads), received the highest support across all dimensions, with mean scores consistently above 5.5. This highlights strong public endorsement for measures that ensure pedestrian safety in dedicated spaces. Similarly, Policy #5 (priority at zebra crossings) and Policy #2 (accurate VRU detection sensors) were highly rated, reflecting widespread approval of visible, practical, and technologically advanced solutions to improve VRU safety and justice. These results indicate that the public strongly favours policies that reduce risks and promote fairness without placing additional burdens on vulnerable or marginalised groups.

Moderately supported policies, such as Policy #10 (traffic light coordination for VRUs) and Policy #6 (priority at mid-block crossings), scored around 4.7–4.8 on average across dimensions. While these policies are perceived as beneficial, they may face slight resistance due to concerns about their feasibility or implementation. Conversely, policies that shift responsibility onto VRUs, such as Policy #7 (mandatory VRU wearables for detection) and Policy #13 (mandatory reflective materials for VRUs), were rated significantly lower, with means around 3.3–3.5. This reflects public concerns about equity, as these measures may be seen as disproportionately burdening VRUs rather than addressing systemic challenges. Similarly, punitive measures like Policies #8 and #9 (Fines for blocking private or public CAVs) also received low ratings, with mean scores around 3.7–3.8. These findings suggest strong resistance to policies perceived as unjust, particularly those that penalise vulnerable groups without addressing the root causes of safety and justice issues.

To conclude, the analysis highlights a clear preference for policies that focus on systemic improvements, fairness, and inclusivity. Public support is most substantial for measures that reduce risks and prioritise VRU safety, mainly when these measures are framed as equitable and non-punitive. In contrast, interventions that rely on individual responsibility or introduce penalties are less likely to gain widespread acceptance. These insights provide valuable guidance for policymakers seeking to balance safety and justice in the transport system during the deployment of CAVs.

3.3. Cluster analysis to identify policy groups

In this study, we employed Ward's cluster analysis to classify policies aimed at improving the acceptance of CAVs as tools for advancing safety and justice within the transport system, as well as for VRUs. This method was chosen for its ability to generate hierarchical groupings of data and display multiple cluster solutions, which enhanced the robustness and interpretability of our findings. Ward's method minimises within-cluster variance, ensuring the formation of distinct, meaningful policy groupings based on participant perceptions (Mooi & Sarstedt, 2011).

We visualised policy evaluations across two scatterplots. The first scatterplot (Fig. 2a) mapped the acceptability of policies for improving justice (x-axis) and safety (y-axis) within the overall transport system. The second scatterplot (Fig. 3a) focused explicitly on VRUs, with the x-axis showing perceived improvements in justice and the y-axis representing perceived improvements in safety. Across both scatterplots and

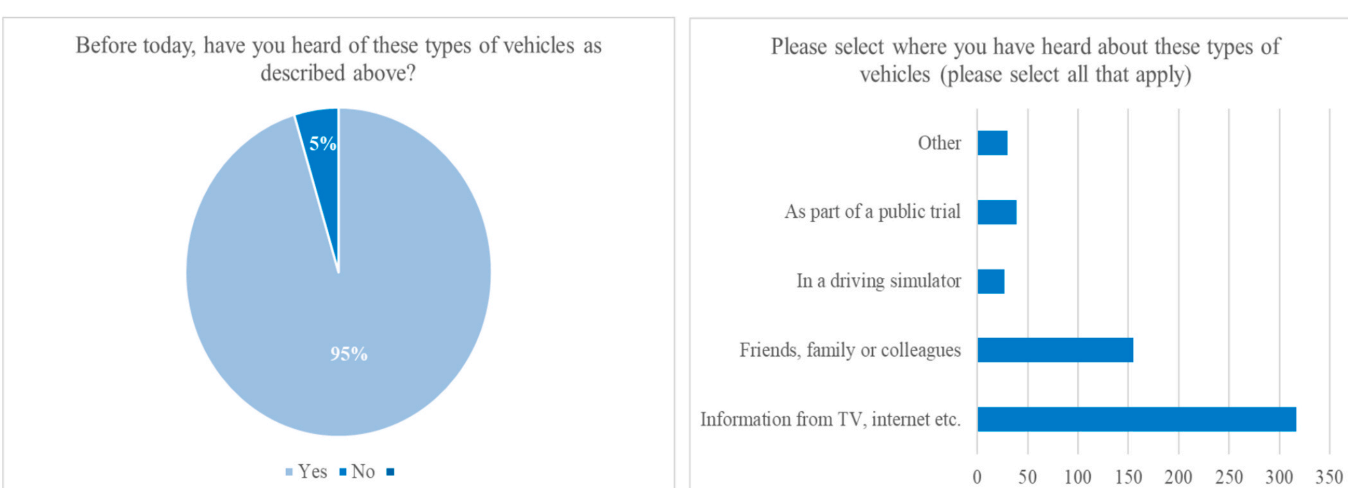
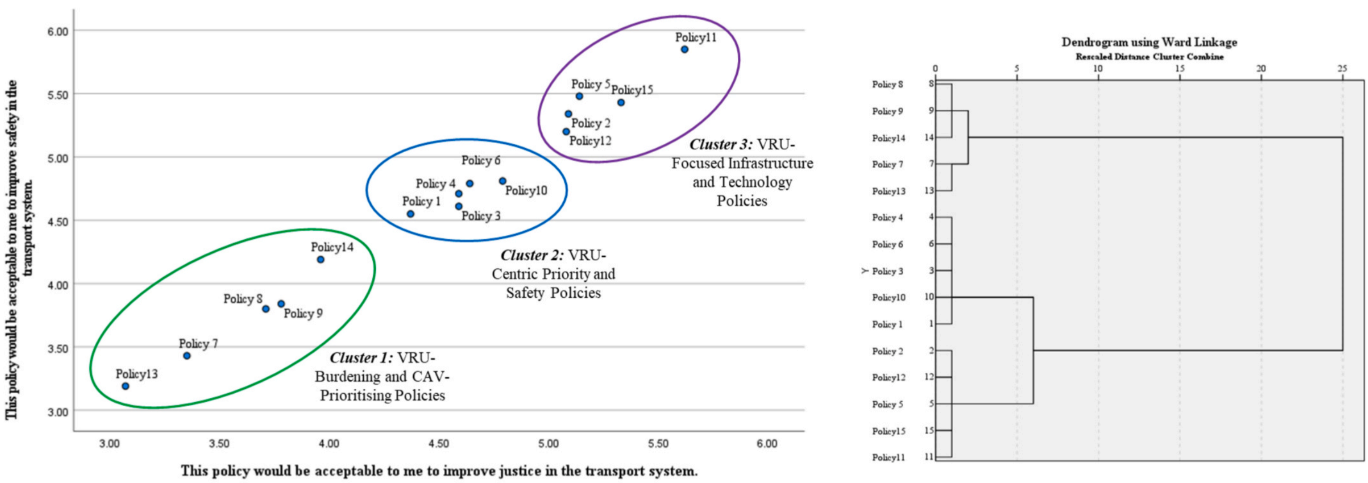


Fig. 1. Responses CAVs- related knowledge.

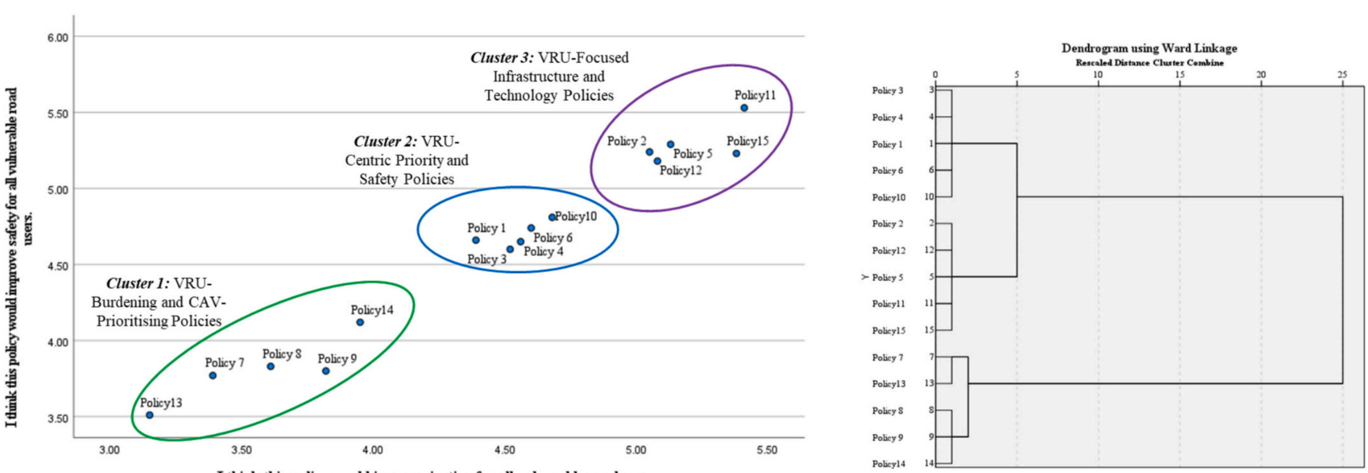
Table 3
Descriptive statistics for each policy.

Policy	This policy would be acceptable to me to improve safety in the transport system. *(Safety_T)*		This policy would be acceptable to me to improve justice in the transport system. *(Justice_T)*		I think this policy would improve safety for all vulnerable road users. *(Safety_V)*		I think this policy would improve justice for all vulnerable road users. *(Justice_V)*		I am willing to support this policy. *(Willingness)*	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Policy 1: Speed reduction in shared zones	4.546	1.961	4.370	1.901	4.660	1.841	4.390	1.909	4.470	2.025
Policy 2: Accurate VRU detection sensors	5.336	1.842	5.090	1.867	5.240	1.762	5.050	1.808	5.150	1.832
Policy 3: Priority at signalised crossings	4.607	1.989	4.590	1.962	4.600	1.991	4.520	1.941	4.480	2.056
Policy 4: Priority at unsignaled intersections	4.711	1.938	4.590	1.900	4.650	1.953	4.560	1.922	4.590	1.913
Policy 5: Priority at zebra crossings	5.479	1.674	5.140	1.782	5.290	1.736	5.130	1.791	5.250	1.824
Policy 6: Priority at mid-block crossings	4.791	1.850	4.640	1.847	4.740	1.867	4.600	1.866	4.710	1.893
Policy 7: Mandatory VRU wearables for detection	3.426	2.118	3.350	2.139	3.770	2.063	3.390	2.156	3.320	2.150
Policy 8: Fines for blocking private CAVs	3.799	2.064	3.710	2.060	3.830	2.102	3.610	2.046	3.710	2.133
Policy 9: Fines for blocking public CAVs	3.843	2.066	3.780	2.006	3.800	2.023	3.820	2.058	3.780	2.070
Policy 10: Traffic light coordination for VRUs	4.809	1.800	4.790	1.825	4.810	1.832	4.680	1.841	4.700	1.859
Policy 11: Proving safety on all roads	5.846	1.479	5.620	1.597	5.530	1.710	5.410	1.649	5.690	1.649
Policy 12: Effective communication with VRUs	5.204	1.680	5.080	1.737	5.180	1.647	5.080	1.641	5.070	1.771
Policy 13: Mandatory reflective materials for VRUs	3.193	2.037	3.070	2.011	3.510	2.128	3.150	2.074	3.160	2.104
Policy 14: CAVs sharing lanes with buses	4.185	1.985	3.960	1.980	4.120	1.953	3.950	1.969	4.100	2.031
Policy 15: Prioritising public transport investment	5.435	1.702	5.330	1.818	5.230	1.773	5.380	1.710	5.350	1.767



a) b)

Fig. 2. (a) Cluster pertinence by policies deemed acceptable for enhancing safety and justice within the transport system, (b) dendrogram.



a) b)

Fig. 3. (a) Cluster pertinence by policies deemed acceptable for enhancing safety and justice for all vulnerable road users, (b) dendrogram.

dendrograms, we identified three distinct clusters of policies that reflected public perceptions of their acceptability in terms of safety and justice, both system-wide and for VRUs. *Cluster 1, "VRU-Burdening and CAV-Prioritising Policies,"* included policies #7, #8, #9, #13, and #14. These policies scored the lowest on both justice and safety acceptability, indicating widespread public disapproval. This cluster likely represented policies that prioritised CAV deployment at the expense of VRU needs, shifting the burden disproportionately onto vulnerable or marginalised groups. *Cluster 2, "VRU-Centric Priority and Safety Policies,"* consisted of policies #1, #3, #4, #6, and #10. These policies demonstrated moderate acceptability, reflecting a balanced approach that considered VRU needs while addressing broader transport system requirements. *Cluster 3, "VRU-Focused Infrastructure and Technology Policies,"* included policies #2, #5, #11, #12, and #15. These policies received the highest scores for both justice and safety acceptability and were strongly preferred by participants. These policies prioritised infrastructure and technological solutions tailored to VRU needs, aligning closely with public expectations for a safe and equitable transport system. This cluster represented the most promising direction for policy development, as it highlighted the potential of equitable and inclusive infrastructure to address safety and justice goals simultaneously.

A comparison of Fig. 2(a) and 3(a) revealed subtle yet significant differences in public perceptions depending on the framing of justice concerns. Fig. 2(a) presented a general justice perspective, while Fig. 3 (a) introduced a VRU-specific justice lens. The latter resulted in more compact groupings within Cluster 2, suggesting that participants evaluated policies more consistently when their impacts on VRUs were explicitly highlighted. The dendrograms (Fig. 2b and 3b) confirmed the presence of three primary clusters in both analyses. However, differences in the linkage distances at which clusters merged were observed. For instance, the dendrogram in Fig. 3(b) displayed tighter groupings within Cluster 2, reinforcing the importance of VRU-specific considerations in enhancing the consistency of policy evaluations.

By aggregating the data for the policies within each cluster, the mean scores for each dimension, safety within the transport system (Safety_T), safety for VRUs (Safety_V), justice within the transport system (Justice_T), justice for VRUs (Justice_V), and willingness, were calculated and compared across clusters. Descriptive statistics and ANOVA analyses were performed to identify and evaluate significant differences between clusters (Tables 4 and 5).

The results indicated significant differences across the three clusters for all dimensions. Cluster 1 scored the lowest across all variables, reflecting widespread disapproval. For example, Safety_T (M = 3.689, SD = 0.386) and Safety_V (M = 3.806, SD = 0.217) scores indicated low confidence in the ability of these policies to ensure safety, both within the transport system and for VRUs. Similarly, Justice_T (M = 3.574, SD = 0.359) and Justice_V (M = 3.584, SD = 0.323) suggested perceptions of inequity, with these policies prioritising CAV deployment over VRU needs. Participants expressed the lowest willingness to accept these policies (M = 3.614, SD = 0.376), aligning with their negative safety and justice ratings. Cluster 2 achieved moderate scores, reflecting a more balanced approach to CAV deployment that considered both VRU needs and broader transport system requirements. Safety_T (M = 4.693, SD = 0.114) and Safety_V (M = 4.692, SD = 0.083) scores suggested moderate confidence in safety outcomes, while Justice_T (M = 4.596, SD = 0.151) and Justice_V (M = 4.550, SD = 0.107) indicated perceptions of fairness. Willingness to accept these policies was also moderate (M = 4.590, SD = 0.115), suggesting they were viewed more positively than those in Cluster 1 but less favourably than those in Cluster 3. On the other hand,

Table 5
ANOVA results.

Variable		Sum of Squares	df	Mean Square	F	Sig.
Safety_T	Between Groups	7.886	2	3.943	53.749	<.001
	Within Groups	0.88	12	0.073		
	Total	8.766	14			
Justice_T	Between Groups	7.151	2	3.575	52.662	<.001
	Within Groups	0.815	12	0.068		
	Total	7.966	14			
Safety_V	Between Groups	5.603	2	2.801	115.39	<.001
	Within Groups	0.291	12	0.024		
	Total	5.894	14			
Justice_V	Between Groups	6.688	2	3.344	69.169	<.001
	Within Groups	0.58	12	0.048		
	Total	7.268	14			
Willingness	Between Groups	7.181	2	3.591	50.633	<.001
	Within Groups	0.851	12	0.071		
	Total	8.032	14			

Table 4
Cluster descriptives.

Dimension	Cluster	N	Mean	SD	SE	95 % Confidence Interval for Mean		Min	Max
						Lower Bound	Upper Bound		
Safety_T	Cluster1	5	3.689	0.386	0.173	3.210	4.169	3.19	4.18
	Cluster2	5	4.693	0.114	0.051	4.551	4.835	4.55	4.81
	Cluster3	5	5.460	0.240	0.107	5.162	5.758	5.2	5.85
	Total	15	4.614	0.791	0.204	4.176	5.052	3.19	5.85
Justice_T	Cluster1	5	3.574	0.359	0.160	3.129	4.019	3.07	3.96
	Cluster2	5	4.596	0.151	0.067	4.409	4.783	4.37	4.79
	Cluster3	5	5.252	0.229	0.102	4.968	5.536	5.08	5.62
	Total	15	4.474	0.754	0.195	4.056	4.892	3.07	5.62
Safety_V	Cluster1	5	3.806	0.217	0.097	3.537	4.075	3.51	4.12
	Cluster2	5	4.692	0.083	0.037	4.589	4.795	4.6	4.81
	Cluster3	5	5.294	0.138	0.062	5.123	5.465	5.18	5.53
	Total	15	4.597	0.649	0.168	4.238	4.957	3.51	5.53
Justice_V	Cluster1	5	3.584	0.323	0.144	3.183	3.985	3.15	3.95
	Cluster2	5	4.550	0.107	0.048	4.417	4.683	4.39	4.68
	Cluster3	5	5.210	0.172	0.077	4.997	5.423	5.05	5.41
	Total	15	4.448	0.721	0.186	4.049	4.847	3.15	5.41
Willingness	Cluster1	5	3.614	0.376	0.168	3.147	4.081	3.16	4.1
	Cluster2	5	4.590	0.115	0.051	4.447	4.733	4.47	4.71
	Cluster3	5	5.302	0.241	0.108	5.003	5.601	5.07	5.69
	Total	15	4.502	0.757	0.196	4.083	4.922	3.16	5.69

Cluster 3 received the highest ratings across all variables, highlighting strong public approval for policies that prioritised VRU safety and justice through infrastructure and technology solutions. Safety_T (M = 5.460, SD = 0.240) and Safety_V (M = 5.294, SD = 0.138) demonstrated high confidence in safety outcomes for both the transport system and VRUs. Similarly, Justice_T (M = 5.252, SD = 0.229) and Justice_V (M = 5.210, SD = 0.172) reflected strong perceptions of justice. Willingness to accept these policies was also the highest (M = 5.302, SD = 0.241), with low standard deviations indicating a high level of agreement among participants.

ANOVA results confirmed statistically significant differences between clusters across all measures. For each dimension, the F-statistics were large and highly significant ($p < 0.001$), indicating that the variation between the clusters was much more significant than the variation within the clusters. For Safety_T, the ANOVA yielded an F-statistic of 53.749 ($p < 0.001$), showing that participants perceived significant differences in how well policies ensured safety within the transport system. Similarly, for Safety_V, the F-statistic was even higher (F = 115.390, $p < 0.001$), highlighting that the safety of VRUs differed substantially across the clusters. These results confirmed that Cluster 1 policies were perceived as least safe, while Cluster 3 policies were perceived as most effective in ensuring safety for both the system and VRUs. In terms of justice, the ANOVA for Justice_T (F = 52.662, $p < 0.001$) and Justice_V (F = 69.169, $p < 0.001$) indicated strong differences in perceived fairness within the transport system and specifically for VRUs. Policies in Cluster 1 were seen as prioritising CAVs at the expense of equity, while Cluster 3 policies were perceived as the most just, particularly in addressing the needs of vulnerable road users. Finally, for willingness to accept the policies, the ANOVA yielded an F-statistic of 50.633 ($p < 0.001$), confirming significant differences in public acceptance of the policies across clusters. Participants expressed the least willingness to accept Cluster 1 policies, moderate willingness for Cluster 2, and the highest willingness for Cluster 3.

To conclude, the findings underscore the importance of prioritising VRU-centric infrastructure and technology policies (Cluster 3) to achieve safety and justice within the transport system and for all VRUs. These policies are the most acceptable to the public, demonstrating the potential for equitable and multidimensional approaches to garner widespread support. Moreover, the strong correlation between justice and safety acceptability suggests that these goals can be pursued simultaneously without significant trade-offs. Conversely, the persistently low ratings of VRU-burdening and CAV-prioritising policies (Cluster 1) highlight widespread public resistance to approaches that shift burdens onto VRUs, regardless of the justice framework applied. This resistance underlines the need to avoid policies that exacerbate existing inequities.

3.4. Hierarchical regression analysis

3.4.1. Cluster 1: VRU-Burdening and CAV-Prioritising policies

The regression analysis examined factors that influenced the willingness to support the policies included in this cluster, which aimed to improve safety and justice in CAV-VRU interactions. In step 1, *"What type of vehicle do you drive regularly?"* was entered into the model. A significant regression equation was found ($F(1,325) = 29.70$, $p < 0.001$), with an R^2 of 0.08, indicating that the type of vehicle explained 8.4 % of the variance. In step 2, *"Age of the vehicle"* was added to the model, and a significant improvement was observed ($F(2,324) = 19.60$, $p < 0.001$) with an R^2 of 0.11. Both variables were significant predictors, with the age of the vehicle showing a negative association with the dependent variable.

In step 3, *"How advanced is the technology in your vehicle?"* was included. This addition yielded a significant regression equation ($F(3,323) = 15.99$, $p < 0.001$) with an R2 of 0.13, indicating that 12.9 % of the variance was explained. The technology level showed a negative and significant effect on the model. In step 4, the inclusion of "What is your current driver's licence status?" improved the model further ($F(4,322) = 13.62$, $p < 0.001$) with an R2 of 0.15. Driver's licence status was positively associated with the dependent variable.

Steps 5 and 6 introduced *"Approximately how many days per week do you drive a vehicle?"* and *"What is your current age?"* respectively, resulting in significant equations ($F(6,320) = 11.07$, $p < 0.001$) with an R2 of 0.17. While driving frequency was positively associated, age showed a small but significant negative effect. Together, the predictors in the final model explained 17.2 % of the variance in the dependent variable, demonstrating that vehicle characteristics, driver demographics, and driving behaviours all contribute significantly to the model's explanatory power. The results of the hierarchical regression model for cluster 1 are presented in Table 6.

3.4.2. Cluster 2: VRU-Centric priority and safety policies

The results of the hierarchical regression model for cluster 2 are presented in Table 7. The model explains up to 9.3 % of the variance in support ($R^2 = 0.093$) with two predictors: current age and ease of access to public transport. In step 1, *"What is your current age?"* was included in the model. The results indicated a significant regression equation ($F(1,325) = 27.20$, $p < 0.001$) with an R^2 of 0.077, meaning that age explained 7.7 % of the variance. The coefficient for age was negative and statistically significant ($B = -0.029$, $p < 0.001$), suggesting that older age is associated with lower scores on the dependent variable.

In step 2, *"How easily can you access public transport?"* was added to the model. The inclusion of this predictor significantly improved the model ($F(2,324) = 16.55$, $p < 0.001$), with the R^2 increasing to 0.093, indicating that the two predictors together explained 9.3 % of the variance in the cluster. Ease of access to public transport was positively associated with the dependent variable ($B = 0.161$, $p = 0.019$), suggesting that better access to public transport correlates with higher values of willingness to support the policies in this cluster, even when controlling for age.

3.4.3. Cluster 3: VRU-Focused infrastructure and technology policies

The results of the hierarchical regression model for cluster 3 are presented in Table 8. In step 1, *"How accessible is public transport from your home?"* was included in the model. A significant regression equation was found ($F(1,325) = 5.46$, $p = 0.020$), with an R^2 of 0.017, indicating that accessibility to public transport explained 1.7 % of the variance. The coefficient for accessibility was negative and significant ($B = -0.188$, $p = 0.020$), suggesting that greater accessibility is associated with lower values of the dependent variable.

In step 2, *"What is your current age?"* was added to the model. This addition significantly improved the model ($F(2,324) = 5.20$, $p = 0.006$), with an R^2 of 0.031, indicating that age and public transport accessibility together explained 3.1 % of the variance. Age showed a small but significant negative association with the cluster ($B = -0.010$, $p = 0.028$), suggesting that older individuals tend to report lower values for the dependent variable, even after accounting for transport accessibility.

In the final step, *"Do you have a disability?"* was introduced as a predictor, leading to a significant improvement in the model ($F(3,323) = 5.68$, $p < 0.001$) with an R^2 of 0.050. The inclusion of disability status increased the explained variance to 5 %, and the variable was positively associated with the dependent variable ($B = 0.413$, $p = 0.011$), indicating that individuals with disabilities reported higher values for the willingness to support the policies in this cluster.

3.5. Other proposed policies and government recommendations

To explore additional policy proposals and gather recommendations for government action regarding CAV deployment and future interactions with VRUs, we performed a detailed manual content analysis of participant feedback. Among the 243 participants, 44 indicated they had no further comments on the topic, leaving 199 comments for analysis. Participants' comments closely aligned with the 15 policies

Table 6
Hierarchical multiple linear regression cluster 1.

Model		B	Std. Error	SB	95.0 % Confidence Interval Lower Bound	Upper Bound	p
1	(Constant)	2.855	0.188		2.485	3.224	<.001
	What type of vehicle do you drive regularly?	0.613	0.112	0.289	0.392	0.834	<.001
	R^2: 0.084						
2	(Constant)	3.819	0.375		3.082	4.556	<.001
	What type of vehicle do you drive regularly?	0.469	0.121	0.222	0.231	0.708	<.001
	Age of the vehicle:	−0.227	0.077	−0.17	−0.378	−0.076	.003
	R^2: 0.108						
3	(Constant)	5.357	0.66		4.058	6.656	<.001
	What type of vehicle do you drive regularly?	0.455	0.12	0.215	0.218	0.691	<.001
	Age of the vehicle:	−0.341	0.086	−0.254	−0.51	−0.172	<.001
	How advanced is the technology in your vehicle?	−0.352	0.125	−0.168	−0.599	−0.106	.005
	R^2: 0.129						
4	(Constant)	4.61	0.725		3.184	6.036	<.001
	What type of vehicle do you drive regularly?	0.411	0.121	0.194	0.174	0.649	<.001
	Age of the vehicle:	−0.36	0.086	−0.269	−0.529	−0.192	<.001
	How advanced is the technology in your vehicle?	−0.378	0.125	−0.18	−0.623	−0.132	.003
	What is your current driver's license status?	0.241	0.1	0.126	0.044	0.438	.017
	R^2: 0.1545						
5	(Constant)	4.054	0.758		2.563	5.545	<.001
	What type of vehicle do you drive regularly?	0.416	0.12	0.196	0.18	0.651	<.001
	Age of the vehicle:	−0.357	0.085	−0.267	−0.524	−0.19	<.001
	How advanced is the technology in your vehicle?	−0.383	0.124	−0.182	−0.627	−0.14	.002
	What is your current driver's license status?	0.249	0.099	0.13	0.053	0.445	.013
	Approximately how many days per week do you drive a vehicle?	0.106	0.045	0.12	0.017	0.194	.019
	R^2: 0.159						
6	(Constant)	4.368	0.766		2.86	5.875	<.001
	What type of vehicle do you drive regularly?	0.37	0.121	0.174	0.132	0.607	.002
	Age of the vehicle:	−0.342	0.085	−0.255	−0.509	−0.175	<.001
	How advanced is the technology in your vehicle?	−0.33	0.125	−0.157	−0.576	−0.083	.009
	What is your current driver's license status?	0.276	0.1	0.144	0.08	0.472	.006
	Approximately how many days per week do you drive a vehicle?	0.101	0.045	0.115	0.013	0.189	.025
	What is your current age?	−0.013	0.006	−0.118	−0.024	−0.001	.027
	R^2: 0.172						

Table 7
Hierarchical multiple linear regression cluster 2.

Model		B	Std. Error	SB	95.0 % Confidence Interval Lower Bound	Upper Bound	p
1	(Constant)	5.824	0.259		5.313	6.334	<.001
	What is your current age?	−0.029	0.006	−0.278	−0.04	−0.018	<.001
	R^2: 0.077						
2	(Constant)	5.232	0.36		4.524	5.941	<.001
	What is your current age?	−0.028	0.006	−0.265	−0.039	−0.017	<.001
	How easily can you access public transport (e.g., to catch public transport to/from work)?	0.161	0.069	0.125	0.026	0.296	.019
	R^2: 0.093						

Table 8
Hierarchical multiple linear regression cluster 3.

Model		B	Std. Error	SB	95.0 % Confidence Interval Lower Bound	Upper Bound	p
1	(Constant)	5.578	0.154		5.276	5.88	<.001
	How accessible is public transport from your home?	−0.188	0.081	−0.129	−0.347	−0.03	.02
	R^2: 0.017						
2	(Constant)	6.025	0.253		5.526	6.523	<.001
	How accessible is public transport from your home?	−0.186	0.08	−0.127	−0.343	−0.028	.021
	What is your current age?	−0.01	0.005	−0.121	−0.02	−0.001	.028
	R^2: 0.031						
3	(Constant)	5.4	0.351		4.709	6.091	<.001
	How accessible is public transport from your home?	−0.176	0.08	−0.12	−0.332	−0.019	.028
	What is your current age?	−0.013	0.005	−0.147	−0.022	−0.003	.008
	Do you have a disability?	0.413	0.162	0.141	0.093	0.732	.011
	R^2: 0.050						

presented in this study, reinforcing key themes such as equity, safety, and technological readiness. The analysis revealed five central themes: prioritisation of public transport, infrastructure improvements for VRUs, inclusivity and accessibility, ethical and legal frameworks, and community engagement and education. These themes represent participants' priorities for a transport system that is safe, just, and inclusive. The findings underscore the importance of prioritising public welfare over technological advancement and ensuring that the benefits of CAVs are equitably distributed. Table 9 summarises the identified themes, providing a detailed description of each. It also quantifies the findings by

Table 9
Themes from open-ended qualitative responses.

Theme	Description of the theme	Frequency (n)	Percentage (%)
Prioritisation of public transport	Advocating for investment in public transport as a sustainable, equitable alternative to CAVs.	70	35 %
Infrastructure improvements for VRUs	Enhancing safety infrastructure for pedestrians, cyclists, and other vulnerable road users (VRUs).	50	25 %
Inclusivity and accessibility	Emphasising equitable access to transport systems, particularly for individuals with disabilities and those without access to technology.	30	15 %
Ethical and legal frameworks	Addressing liability, data privacy, cybersecurity, and ethical decision-making for CAV-related issues.	40	20 %
Community engagement and education	Advocating for inclusive policymaking and raising public awareness about CAV technologies to foster trust and informed discourse.	40	20 %

displaying the total number of comments per theme and their corresponding percentages.

3.5.1. *Prioritisation of public transport*

During coding, a significant number of comments highlighted participants' preference for improving public transport rather than investing heavily in private CAVs. Codes such as "public transport accessibility," "free or reduced-cost public transport," and "government responsibility for transit" frequently appeared. For this reason, public transport emerged as a dominant theme, with participants advocating for its improvement over the introduction of CAVs. Comments consistently emphasised the critical role of public transport in reducing congestion, promoting equity, and offering sustainable mobility solutions.

Many participants called for substantial investments to make public transit affordable, reliable, and accessible, particularly for disadvantaged communities. As one participant put it, *"Public transport should always be the priority. No more roads, please" (F, 56)*. Several respondents argued that prioritising public transport aligns with broader goals of equity and sustainability, urging governments to integrate CAVs into public transport systems rather than allowing them to exacerbate car dependency. One participant highlighted, *"Instead of automated private vehicles, the only automated vehicles should be public. Why invest in something that would elevate the lives of a few who can afford this technology?" (F, 33)*. This concern was echoed by another, who stated, *"I would greatly prefer investment in public transportation, and it would be entirely unjust if pedestrians and other members of the public had to adapt to privately owned autonomous vehicles at a cost to themselves" (M, 27)*. The responses reflect a collective belief that enhancing public transport is not only a practical solution for urban mobility but also a moral imperative for ensuring equitable access to the transport system for all.

3.5.2. *Infrastructure improvements for vulnerable road users*

This theme emerged from codes such as "dedicated pedestrian/cyclist lanes," "improve pedestrian crossings," and" retrofit infrastructure in rural areas." Participants consistently highlighted the gaps in existing infrastructure that fail to protect VRUs, making this a priority area for safety. For instance, one participant expressed their priorities clearly: "*I just want safe and protected bike lanes, safe pedestrian crossings, wider and shaded footpaths, and raised crossings at intersections, so cars have to go over the raised area instead of pedestrians having to go down onto the road" (M, 36)*. The need for broader changes to address these issues was repeatedly highlighted, as another participant noted: *"Footpaths are too narrow and poorly maintained, there are not enough safe crossings with islands, cyclists should always have permanent, dedicated lanes wherever there is a road, and they should really fix the train bridges so there are no at-road level crossings. More pedestrian refuge islands is also a brilliant opportunity to plant more trees" (F, 31)*. These suggestions underline the interconnected benefits of safety improvements and environmental enhancements.

Participants consistently linked infrastructure upgrades to safety and justice, reflecting a belief that physical changes to the transport system are foundational for achieving equity. One participant succinctly summarised this perspective: *"The government desperately needs to improve the pedestrian and cyclist safety situations. Footpaths are too narrow and poorly maintained, and there are not enough safe crossings with islands" (F, 33)*. Another added, *"Prioritise infrastructure for vulnerable road users so we don't have to share with any motor vehicles" (M, 52)*. Collectively, these responses reflect a strong consensus that redesigning infrastructure is essential for creating a safer and fairer transport system that can effectively integrate CAVs.

3.5.3. *Inclusivity and accessibility*

Codes such as "inclusive design," "accessible vehicles," and "no burden on VRUs" reflected participants' concerns about marginalised groups, particularly people with disabilities, the elderly, and those without access to wearable technology. Concerns around inclusivity and accessibility were prominent, with participants firmly rejecting policies that placed the burden of adaptation on VRUs. Many criticised proposals requiring VRUs to use reflective clothing, specific apps, or wearable devices to ensure their visibility to CAVs. One participant voiced their frustration: *"Pedestrians should NOT have to wear something so that these cars can see them… If the robot can't see pedestrians, then it should not be allowed on the road" (NB, 18)*. Another participant echoed this sentiment: *"There is no way you can insist that all people walking around roads must have a smartphone with a specific app or wear hi-vis clothing; that is silly. The onus is on the automated car companies to find a way to detect pedestrians" (F, 47)*.

Participants also highlighted how deployment strategies for CAVs could exacerbate existing inequities. Concerns were raised about low-income and marginalised communities being left behind in infrastructure and technology upgrades. As one participant stated, *"Low-income and marginalised communities might not have the same access to the benefits of CAVs. Wealthier neighbourhoods might receive the necessary infrastructure and technology upgrades first, leaving lower-income areas with outdated systems that do not offer the same level of protection for pedestrians and cyclists. Further, as cities will adapt, there might be a tendency to prioritise the needs of automated vehicles over pedestrians and cyclists" (F, 29)*. These concerns reinforced the need for a transport system that prioritises equity and does not disproportionately disadvantage certain groups. Participants also called for universally accessible CAVs, emphasising that affordability and inclusive design should be central to their development and deployment. One participant highlighted the challenges faced by people with disabilities, stating, "*It's not feasible to expect people with disabilities to wear special clothing or use devices. Please think of other ways to make it easy for me to stay alive as a pedestrian" (F,43)*.

3.5.4. *Ethical and legal framework*

This theme developed from codes related to "liability," "data privacy," and "safety standards." Participants' responses revealed a cautious and critical outlook, demanding that ethical considerations, public safety, and accountability frameworks take precedence over the rapid deployment of CAVs. These concerns reflect a broader call for a transport system that is not only technologically advanced but also just, transparent, and protective of all road users. A central issue raised was liability, with many participants questioning who would be held accountable in the event of accidents involving CAVs.

As one participant articulated, *"Liability must be clear. Who is responsible when a CAV causes harm, the manufacturer, the operator, or the government?" (M, 38)*. Another participant emphasised the gravity of the issue, stating, *"Justice requires someone to go to jail for a considerable time when one of these machines kills someone" (M, 49)*. In addition to liability, participants expressed a strong demand for stringent safety standards and rigorous testing of CAV technologies before deployment. Many comments reflected scepticism about the readiness of CAVs and called for comprehensive regulatory frameworks to ensure their performance and reliability. One participant summarised this sentiment: *"Governments should develop and enforce more stringent safety standards to ensure the performance and reliability of autonomous vehicles" (M, 45)*. Concerns about data privacy and cybersecurity also emerged as a critical issue, with participants emphasising the importance of transparency and accountability to maintain public trust. As one participant noted, *"Stringent laws are needed to ensure data privacy and prevent misuse of personal information" (M, 44)*. This perspective underscores the participants' worries about how personal data might be managed and protected in a transport system that heavily relies on connected technologies.

3.5.5. Community engagement and education

Comments were coded for themes such as "public consultation," "awareness campaigns," and "education for VRUs and CAV manufacturers," reflecting participants' emphasis on the need for meaningful community engagement and the dissemination of accessible information. Participants consistently stressed the importance of involving communities in policymaking and ensuring that public education campaigns address diverse needs while fostering trust in CAV technologies. One participant succinctly captured this sentiment: *"Community voices must be heard. Education campaigns are critical for building understanding and trust in this technology" (M, 63)*.

Many participants highlighted the value of participatory approaches to ensure policies reflect the realities and challenges faced by different road users, particularly vulnerable groups. As one participant put it, *"Campaigns and awareness to educate vulnerable road users on the capabilities and limitations… Involve marginalised and vulnerable communities in the decision-making process" (F, 29)*. Public education campaigns were also seen as crucial for ensuring safe interactions between VRUs and CAVs. One participant emphasised, *"Launch extensive public education campaigns to increase awareness of the capabilities and limitations of automated vehicles among all road users. This helps vulnerable road users understand how to interact safely with these vehicles, such as knowing when and how to cross the road in the presence of autonomous cars, and what behaviours to avoid" (M, 36)*. The call for clear and accessible information was a recurring concern, with participants stressing the need for educational resources tailored to all demographics. As one participant suggested, "I'd like to see a really clear and simple explainer of these vehicles and the laws made available to everyone… so that all people can be educated and informed" (F, 48). These responses reflect a belief that successful CAV integration depends on a collaborative and informed approach, where public trust is built through transparency, inclusion, and robust education initiatives.

4. Discussion

The present study investigated public perceptions and support for policies designed to enhance safety and justice in interactions between CAVs and VRUs. This research offers a comprehensive analysis by integrating quantitative methods, such as cluster analysis and hierarchical regression, with qualitative content analysis to provide a multidimensional understanding of public preferences. A key innovation of this study lies in its explicit focus on justice-oriented policies, an area often overlooked in CAV research while addressing the specific needs of VRUs. Furthermore, it is one of the first studies to systematically assess the public acceptability of policy interventions across safety and justice dimensions, capturing nuanced public preferences for equitable and inclusive transport solutions.

4.1. Implications for CAV policies

Using Ward's cluster analysis, three distinct policy clusters were identified: VRU-burdening policies (low public support), VRU-centric safety policies (moderate support), and VRU-focused infrastructure and technology policies (high support). These clusters provide critical insights into public perceptions of safety, justice, and the acceptability of CAVs. The findings deepen our understanding of transport justice and provide valuable guidance for developing equitable policymaking frameworks to enhance global transport systems, particularly by addressing interactions between CAVs and VRUs.

The study revealed a clear public preference for policies prioritising VRU-focused infrastructure and technology, reflecting a demand for equitable solutions that balanced innovation with inclusivity. Policies improving road safety across networks or prioritising VRUs at crossings were particularly well-received, demonstrating a public desire for measures that addressed systemic risks and ensured fair access to safe transport systems. These results align with Reyes-Muñoz & Guerrero-Ibáñez (2022), highlighting the role of advanced sensing and communication technologies in enhancing VRU safety and supporting equitable, innovation-driven solutions. Similarly, Sadaf et al. (2023) highlighted the necessity of vehicle-to-everything (V2X) communication and VRU-centred infrastructure to ensure safety, reflecting public support for innovative solutions that integrate VRU considerations. Collectively, these studies reinforce the critical importance of prioritising VRU safety through dedicated infrastructure and advanced technologies to foster equitable and inclusive transport systems.

This research also pointed out significant public disapproval of policies that place an undue burden on VRUs. For example, policies requiring VRUs to wear reflective materials or other safety gear were widely rejected as they shifted the responsibility for safety onto vulnerable individuals rather than addressing systemic shortcomings in the transport system. This resistance highlights public concern over the equity implications of such measures and the pressing need for policies that hold systemic actors, such as planners and policymakers, accountable for creating safer and just transport environments. Martínez-Buelvas et al. (2024b) explored how CAV deployment could exacerbate existing transport injustices, particularly for VRUs, emphasising the importance of addressing systemic issues rather than transferring safety responsibilities to individuals. Their findings advocate for justice-oriented approaches and inclusive decision-making in the design of transport systems, ensuring that accountability rests with systemic actors rather than individuals. Similarly, the *Ethics of Connected and Automated Vehicles Report* contends that VRUs, given their heightened vulnerability, require distinct protections to ensure they achieve the same level of safety as other road users (Horizon 2020 Commission Expert Group, 2020). While specific measures, such as equipping VRUs with transponder beacons for automatic detection by sensors (Reid, 2021), aim to enhance safety, they risk unintended consequences by further shifting responsibility onto VRUs. This perpetuates systemic inequities within the transport system and fails to address the root causes of safety concerns. Furthermore, the study revealed minimal public support for punitive measures targeting VRUs, such as fines or penalties. This finding further emphasises the need for justice-oriented policies that tackle the structural causes of transport inequities. Approaches that prioritise inclusive design, equitable infrastructure, and innovative technologies to enhance VRU safety directly are more likely to resonate with public sentiment and advance broader goals of fairness and justice within the transport system.

Key demographic factors, including age, transport accessibility, and disability status, emerged as significant predictors of policy acceptance.

Older participants showed lower levels of support for advanced technological policies, consistent with findings by Payre et al. (2014) and Schoettle & Sivak (2014), which attribute this hesitancy to reduced familiarity with emerging technologies. Conversely, younger individuals demonstrated greater receptivity to innovative transport solutions, as highlighted by Deb et al. (2017), pointing to a generational divide in technology adoption and acceptance. Participants with disabilities expressed notably stronger support for policies prioritising safety and accessibility. This is consistent with findings by Kacperski et al. (2024), who compared attitudes toward automated vehicles among German residents with and without visual impairments. Their study found that individuals with visual impairments had significantly more positive perceptions of CAVs, largely driven by heightened expectations of greater independence and improvements in safety and sustainability.

The content analysis revealed five key themes, prioritisation of public transport, infrastructure improvements for VRUs, inclusivity and accessibility, ethical and legal frameworks, and community engagement and education, emphasising public demands for justice and safety in the deployment of CAVs. These themes closely align with the cluster analysis findings, particularly the strong public support for VRU-focused infrastructure and technology policies in Cluster 3. For instance, the prioritisation of public transport aligns with the high acceptability of policies such as prioritising public transport investment, reflecting a clear public preference for systemic reforms over car-centric solutions. This supports Fagnant & Kockelma's (2015) argument that sustainable, shared mobility solutions are essential for equitable transport systems. Additionally, Buehler (2018) highlighted that to remain competitive with private cars, public transport agencies and governments must harness emerging automated and connected technologies, integrate public transport with other mobility services, coordinate regional offerings, and ensure alignment with land-use planning.

The demand for infrastructure improvements for VRUs, such as dedicated lanes and safer crossings, further aligns with Cluster 3 policies like accurate VRU detection sensors and priority at zebra crossings, which were strongly supported by their focus on safety and justice. These findings resonate with Milakis, van Arem, & van Wee's (2017) assertion that proactive urban design is vital to address the safety risks posed by CAVs. Conversely, the rejection of Cluster 1 policies, such as mandatory wearables and fines for blocking CAVs, aligns with the content analysis theme of inclusivity, as participants criticised policies that disproportionately shifted the burden of adaptation onto VRUs. Martínez-Buelvas et al. (2022) argue that such imbalances in shared responsibility undermine transport justice by unfairly requiring VRUs to avoid harm while assuming they have access to or can afford advanced technology. These preferences underscore the public's alignment with principles of recognition justice (Young, 1990), highlighting the demand for systemic rather than individualised solutions to transport inequities.

Participants highlighted the critical importance of ethical and legal frameworks, including clear accountability and robust safety standards. This emphasis aligns with the moderate support observed for Cluster 2 policies, such as traffic light coordination for VRUs. While these policies were generally viewed as beneficial, their lower ratings indicated a need for additional safeguards and greater transparency in governance. Chng, Anowar, & Cheah (2021) underscored public preferences for clear liability in CAV-related accidents, comprehensive education campaigns, and authority-led road testing to build trust in the technology.

Finally, the theme of community engagement further emphasised the importance of participatory justice, where policies are shaped through inclusive and informed public consultation, as advocated by Pereira et al. (2017). Similarly, Emory et al. (2022) categorised equity-focused policies into three key areas: access and inclusion, multimodal transportation, and community wellbeing. These categories reflect participants' calls for holistic, community-driven policymaking approaches that address diverse needs. In conclusion, a justice-oriented approach to transport system design is essential, one that prioritises equity, dismantles systemic barriers, and ensures the fair distribution of CAV technology benefits across all road users, particularly those who are most vulnerable.

4.2. Alignment with Australian policies

The integration of CAVs into the Australian transport system offers a transformative opportunity to improve mobility, safety, equity and justice. However, the realisation of these benefits depends on the alignment between public expectations and national strategies, as outlined in key documents such as the National Connected and Automated Vehicle Action Plan: 2024–27 (Australian Government, 2023), the New South Wales Connected and Automated Vehicles Plan (Transport for NSW, 2022), and the Transport Technology Strategy (Transport for NSW, 2024). The findings of this study reveal areas of both alignment and misalignment, highlighting the opportunities and challenges in aligning policies with public preferences.

Public support for VRU-centric infrastructure and safety policies, such as accurate VRU detection systems, reduced CAV speeds in shared zones, and comprehensive safety testing, strongly align with Australian policy priorities. The *NSW CAV Readiness Strategy* and the *Transport Technology Strategy* emphasise advancing technologies to enhance VRU safety. For example, one priority in NSW involves testing and deploying CAVs through trials and pilot projects to engage users, build a local ecosystem, support infrastructure development, and improve understanding of the technical requirements and performance of CAV technologies (Transport for NSW, 2022). Additionally, strong public support for integrating CAVs into public transport aligns with the *National Road Transport Technology Strategy*, which aims to leverage CAVs to enhance accessibility and efficiency. The strategy explicitly outlines the importance of policies that ensure CAVs optimise transport networks, such as aligning road use and parking policies with regional development plans and incorporating CAVs into public transport service guidelines. Similarly, Australian policies' focus on ethical and legal standards aligns with public demand for robust accountability measures. The *National Connected and Automated Vehicle Action Plan* addresses critical issues such as liability, data privacy, and cybersecurity, reflecting public concerns for transparency and safety in CAV deployment.

Despite notable areas of alignment, several significant points of misalignment between public expectations and existing policies were identified in this study. One key divergence concerns policies that shift responsibility onto VRUs, such as mandatory wearables or reflective materials. While not central to Australian frameworks, such measures have surfaced in broader discussions and are widely rejected by the public. Participants overwhelmingly emphasised that the responsibility for safety should lie with systemic actors, such as policymakers and developers, rather than with individuals. Another critical area of contention relates to resource allocation. While Australian policies advocate integrating CAVs into public transport systems, public concerns persist regarding the potential for excessive investment in private CAV infrastructure at the expense of public transit. Participants consistently expressed a preference for prioritising investments in public transport to prevent further entrenching car dependency. This tension reveals a gap between innovation-driven approaches and the equity-focused principles emphasised in initiatives like the Cooperative and Automated Vehicle Initiative (CAVI) by the Queensland Department of Transport and Main Roads.

Public resistance to punitive measures, such as fines for VRUs blocking CAVs, further highlights a disconnect between public expectations and potential enforcement-focused strategies. While such measures are not explicitly outlined in Australian frameworks, they conflict with public demands for justice-oriented policies that address systemic issues rather than penalising vulnerable groups. Similarly, concerns about spatial and socio-economic inequities in CAV infrastructure upgrades also highlight a critical area for improvement. Participants raised concerns that investments could disproportionately benefit wealthier areas, exacerbating existing inequities and leaving low-income or marginalised communities behind. Additionally, public feedback revealed gaps in community engagement and transparency. While Australian policies stress the importance of stakeholder consultation, participants called for more meaningful and inclusive engagement mechanisms that prioritise the perspectives of VRUs and other vulnerable groups. This includes public education campaigns to raise awareness of CAV capabilities and limitations, fostering trust in these technologies. Participants also expressed concerns about the lack of transparency in CAV safety validation processes, advocating for more transparent communication about testing outcomes, technological readiness, and how public input is incorporated into policy development.

In summary, the findings of this study reveal partial alignment between public perceptions and the evolving policy landscape for CAV deployment in Australia. The National Transport Commission (NTC) and Austroads have developed foundational frameworks that emphasise safe integration of automated vehicles, including consideration of VRUs through safety assessments, insurance mechanisms, and trial governance (National Transport Commission, 2017; 2019; Austroads, 2023). The most recent *Guidelines for the Evaluation and Reporting of Automated Vehicle Trials* highlight the importance of ethical conduct, community engagement, and transparent performance reporting, signalling growing institutional recognition of the broader social and equity implications of CAV adoption.

While these frameworks currently avoid explicitly penalising VRUs, this study found strong public opposition to policies that shift responsibility onto vulnerable users. Rather than supporting punitive or burden-shifting approaches, respondents showed greater support for measures grounded in systemic improvements, such as inclusive infrastructure and advanced detection technologies. This public orientation aligns more closely with policies that foreground fairness and accessibility than with those narrowly focused on technological performance. These preferences reinforce broader calls in the literature to embed transport justice principles into the governance of automated mobility (Fatima et al., 2024; Martínez-Buelvas et al., 2022; 2024a; 2024b). As Australia advances its regulatory and infrastructure agenda, policymakers should prioritise equity, systemic accountability, and inclusive engagement to ensure public legitimacy and socially sustainable CAV deployment.

4.3. Policy implications

The findings of this research provide critical guidance for policymakers striving to balance safety and justice in the transport system during the deployment of CAVs. Policymakers should focus on measures that enhance infrastructure and leverage technology to protect VRUs while avoiding interventions that disproportionately burden or penalise this vulnerable group. Policymakers should also prioritise equitable and inclusive policies that reflect public support for measures integrating VRU needs into infrastructure and technology development. Initiatives such as upgrading infrastructure for pedestrians and cyclists or implementing advanced VRU detection technologies can build trust and promote equitable safety outcomes. At the same time, resistance to specific policy clusters highlights the risks of neglecting VRU needs or introducing inequitable measures. It is crucial for policymakers to critically assess potential inequities and adopt participatory approaches that engage VRUs in the decision-making process. Moreover, embedding justice considerations explicitly in policy frameworks is essential. Public preferences for VRU-specific justice lenses demonstrate the importance of targeted strategies that address the unique challenges faced by VRUs. By embracing these approaches, policymakers can navigate the complexities of CAV deployment, ensuring that safety and justice remain central to the transport system while fostering a fair and sustainable transition to emerging technologies.

5. Limitations and Future research suggestions

The study has several limitations. First, it considered only fifteen CAV-VRU policies to gauge public preferences. While this approach provided broad insights, it lacked the granularity needed for detailed policy development and may have overlooked context-specific nuances. Future research should explore a wider range of policies, incorporating variations in implementation and potential trade-offs to generate more equitable and actionable recommendations for CAV deployment and VRU interactions. Second, the cross-sectional design captured public attitudes at a single point in time, limiting its ability to track how perceptions evolve as CAV technologies become more integrated into society (Kesmodel, 2018). Longitudinal studies are recommended to examine shifts in public opinion over time, providing a deeper understanding of how familiarity with CAVs influences policy acceptance and attitudes toward safety and justice for VRUs.

Third, while the sample was somewhat diverse, it may not fully represent the broader population (Sousa et al., 2004). The study focused on Australian residents and relied on online surveys, which may have introduced biases by favouring participants with internet access or those particularly interested in technology. Future research should adopt more inclusive sampling strategies to better capture underrepresented groups, including individuals from rural areas, lower socio-economic backgrounds, and marginalised communities. Importantly, given Australia's high car dependency, it is also important to include individuals who experience structural transport disadvantage, such as those without access to a private vehicle or those with mobility challenges due to age, disability, or geography. This context makes the present findings particularly significant. Australia is among the most car-dependent nations globally: over 91 % of households own at least one vehicle, more than 55 % own two or more, and the national average is 1.8 vehicles per household (Australian Bureau of Statistics, 2021). Nearly 19.4 million Australians hold a driver's licence, and 69.7 % of employed people commute by car, underscoring the centrality of driving for work, social participation, and daily life (Australian Broadcasting Corporation, 2023). In such a system, where motorists dominate public road space and shape infrastructure priorities (Flatt & Odinsman, 2015; Saeidizand et al., 2022), it is striking that participants, many of whom are active drivers, strongly rejected punitive or VRU-burdening policies. This suggests a growing recognition that advancing justice and safety in the context of CAVs demands systemic, fairness-oriented reforms rather than approaches that place responsibility on vulnerable groups. Notably, the sample also included a substantial proportion of individuals who may themselves be classified as VRUs, such as older adults and people with disabilities. While this reflects the study's commitment to transport justice, it may also have amplified sensitivity to measures perceived as inequitable. Future research should compare attitudes across user groups to explore these differences.

Fourth, the study relied on self-reported data, which may have been influenced by cognitive biases such as social desirability, confirmation bias, or framing effects. These factors could have shaped participants' responses to CAV policies. Future studies should integrate mixed-methods approaches, such as qualitative interviews or experimental designs, to validate findings and mitigate the impact of these biases. Fifth, while the study did not include large-scale statistical analysis to validate findings across broader populations, the cross-sectional survey provided valuable insights into public attitudes. The sample was small but aligned with quantitative research norms and was not intended to generate nationally representative conclusions. Although efforts were made to include participants from all states, the sample may not fully reflect Australia's national population. Despite these limitations, the survey findings offer a useful foundation for future large-scale studies that could examine population-level trends and inform policy, infrastructure planning, and vehicle design to improve pedestrian safety and equity. Also, the use of hierarchical regressions in this exploratory study simplified the analysis but had limitations in addressing complex relationships or predicting outcomes.

Furthermore, the policy items in the survey were designed to reflect VRU perspectives on safety and justice. While this aligns with the study's focus on transport justice, the wording may have influenced participant responses, particularly in how responsibility was perceived. Future research could explore alternative phrasings to assess how different framings affect public support for these policies. Additionally, although the survey captured a range of sociodemographic characteristics and transport experiences, Question 9.6.4 ("What type of vehicle do you drive regularly?") may have been interpreted as referring primarily to cars, potentially overlooking responses from participants who regularly use bicycles, e-scooters, or motorcycles. While this does not invalidate the findings, future studies should refine this question to explicitly capture the diversity of transport modes and examine potential differences in responses across various user groups.

6. Conclusion

This study explored public perceptions and preferences regarding policies aimed at enhancing safety and justice in interactions between CAVs and VRUs. The findings revealed strong public support for systemic and inclusive policies, such as infrastructure improvements and advanced technologies prioritising VRU safety and equity. Conversely, policies that placed undue burdens on VRUs, such as mandatory wearables or punitive penalties, faced significant resistance, underscoring the need for fairness in policy design. Key factors influencing public support included demographic characteristics, accessibility to public transport, and disability status. Public attitudes demonstrated a clear preference for policies that simultaneously address safety and justice, highlighting the interconnected nature of these values. This calls for holistic policymaking that integrates ethical, social, and technical considerations to ensure fair and sustainable CAV deployment strategies. Finally, the research underscores the importance of involving diverse communities in the policymaking process to address equity concerns and foster inclusivity effectively. Transparent communication and targeted education campaigns are essential to build public trust and enhance the acceptance of policies. By prioritising collaborative approaches, policymakers can create a safer, more equitable transport system that benefits all road users.

It is important to note that this study focused specifically on public perceptions of policies governing CAV-VRU interactions and did not address broader ethical concerns related to decision-making algorithms in CAVs or the implications of algorithmic fairness in automated driving systems. Future research should explore these areas to provide a more comprehensive understanding of the ethical and technological dimensions of CAV deployment. Addressing these challenges is essential for ensuring a transport system that is not only technologically advanced but also safe and just, prioritising the needs of all road users, particularly vulnerable ones.

CRediT authorship contribution statement

Laura Martínez-Buelvas: Writing – review & editing, Writing – original draft, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Andry Rakotonirainy:** Writing – review & editing, Supervision, Formal analysis. **Deanna Grant-Smith:** Writing – review & editing, Supervision, Formal analysis. **Md Mazharul Haque:** Writing – review & editing, Supervision, Formal analysis. **Oscar Oviedo-Trespalacios:** Writing – review & editing, Supervision, Methodology, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Ahmed, M.L., Iqbal, R., Karyotis, C., Palade, V., Amin, S.A., 2021. Predicting the public adoption of connected and autonomous vehicles. IEEE Trans. Intell. Transp. Syst. 23 (2), 1680–1688. https://doi.org/10.1109/TITS.2021.3109846.

Atakishiyev, S., Salameh, M., Yao, H., Goebel, R., 2021. Towards safe, explainable, and regulated autonomous driving. In: Explainable Artificial Intelligence for Intelligent Transportation Systems. CRC Press, pp. 32–52. https://doi.org/10.48550/arXiv.2111.10518.

Australian Bureau of Statistics. (2021). Motor vehicle census, Australia (Catalogue No. 9309.0). https://www.abs.gov.au/statistics/industry/tourism-and-transport/motor-vehicle-census-australia/latest-release.

Australian Broadcasting Corporation. (2023). What is it like not driving as an adult? https://www.abc.net.au/news/2023-01-18/adults-who-do-not-drive/101767786.

Australian Government. (2023). Draft National Road Transport Technology Strategy and 2024–27 National Connected and Automated Vehicle (CAV) Action Plan. Retrieved from https://www.infrastructure.gov.au/have-your-say/draft-national-road-transport-technology-strategy-and-2024-27-national-connected-and-automated.

Austroads. (2023). Guidelines for the evaluation and reporting of automated vehicle trials (AP-G102-23). https://austroads.com.au/publications/connected-and-automated-vehicles/ap-g102-23.

Bettencourt, L. M. (2015). Cities as complex systems. Modeling complex systems for public policies, 217-236.

Bibri, S.E., Krogstie, J., 2017. On the social shaping dimensions of smart sustainable cities: A study in science, technology, and society. Sustain. Cities Soc. 29, 219–246. https://doi.org/10.1016/j.scs.2016.11.004.

Bozovic, T., Stewart, T., Hinckson, E., Smith, M., 2021. Clearing the path to transcend barriers to walking: Analysis of associations between perceptions and walking behaviour. Transport. Res. F: Traffic Psychol. Behav. 77, 197–208. https://doi.org/10.1016/j.trf.2021.01.003.

Buehler, R., 2018. Can public transportation compete with automated and connected cars? J. Public Transp. 21 (1), 7–18. https://doi.org/10.5038/2375-0901.21.1.2.

Chatziioannou, I., Tsigdinos, S., Tzouras, P.G., Nikitas, A., Bakogiannis, E., 2024. Connected and Autonomous Vehicles and Infrastructure Needs: Exploring Road Network Changes and Policy Interventions. In: Deception in Autonomous Transport Systems: Threats, Impacts and Mitigation Policies. Springer International Publishing, Cham, pp. 65–83. https://doi.org/10.1007/978-3-031-55044-7_5.

Chng, S., Anowar, S., Cheah, L., 2021. To embrace or not to embrace? Understanding public's dilemma about autonomous mobility services: A case study of Singapore. Case Studies on Transport Policy 9 (4), 1542–1552. https://doi.org/10.1016/j.cstp.2021.08.004.

Cohen, T., Stilgoe, J., Stares, S., Akyelken, N., Cavoli, C., Day, J., Wigley, E., 2020. A constructive role for social science in the development of automated vehicles. Transp. Res. Interdiscip. Perspect. 6, 100133. https://doi.org/10.1016/j.trip.2020.100133.

Deb, S., Strawderman, L., Carruth, D.W., DuBien, J., Smith, B., Garrison, T.M., 2017. Development and validation of a questionnaire to assess pedestrian receptivity toward fully autonomous vehicles. Transp. Res. Part C Emerging Technol. 84, 178–195. https://doi.org/10.1016/j.trc.2017.08.029.

Dennis, S., Paz, A., Yigitcanlar, T., 2021. Perceptions and attitudes towards the deployment of autonomous and connected vehicles: Insights from Las Vegas. Nevada. Journal of Urban Technology 28 (3–4), 75–95. https://doi.org/10.1080/10630732.2021.1879606.

Department for Transport. (2023). Code of Practice: automated vehicle trialling. https://www.gov.uk/government/publications/trialling-automated-vehicle-technologies-in-public/code-of-practice-automated-vehicle-trialling.

Emory, K., Douma, F., Cao, J., 2022. Autonomous vehicle policies with equity implications: Patterns and gaps. Transp. Res. Interdiscip. Perspect. 13, 100521. https://doi.org/10.1016/j.trip.2021.100521.

European Commission. (2018). On the Road to Automated Mobility: An EU Strategy for Mobility of the Future. Communication from the Commission to the European Parliament, The Council, and the European Economic and Social Committee, The Committee of the Regions. European Commission. https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2018:0283:FIN:EN:PDF.

Faber, K., Van Lierop, D., 2020. How will older adults use automated vehicles? Assessing the role of AVs in overcoming perceived mobility barriers. Transportation Research Part A: Policy & Practice 133, 353–363. https://doi.org/10.1016/j.tra.2020.01.022.

Fagnant, D.J., Kockelman, K., 2015. Preparing a nation for autonomous vehicles: opportunities, barriers and policy recommendations. Transp. Res. A Policy Pract. 77, 167–181. https://doi.org/10.1016/j.tra.2015.04.003.

Fatima, S., Hsiu Lee, C., Dannenberg, A.L., 2024. Equity issues associated with the widespread implementation of autonomous vehicles. Oxford Open Infrastruct. Health 2, ouae002. https://doi.org/10.1093/ooih/ouae002.

Flatt, L., Odinsman, J., 2015. The institutionalisation of cycling – A case study of Sydney and Melbourne. Lund University. Master's Thesis.

Fraser, N., 1995. Recognition or redistribution? A critical reading of Iris Young's Justice and the Politics of Difference. J Polit Philos 3 (2), 166–180. https://doi.org/10.1111/j.1467-9760.1995.tb00033.x.

Gazder, U., Algherbal, E., 2025. Determining Factors Affecting Acceptance of Autonomous Vehicles using Statistical and Machine Learning Models. Eur. J. Geogr. 16 (2), 225–240. https://doi.org/10.48088/ejg.u.gaz.16.2.225.240.

Gelman, A., Hill, J., 2007. Data analysis using regression and multilevel/hierarchical models. Cambridge University Press.

Harrison, D.M., Raudenbush, S.W., 2012. Linear regression and hierarchical linear models. In: Handbook of Complementary Methods in Education Research. Routledge, pp. 411–426.

Horizon 2020 Commission Expert Group to Advise on Specific Ethical Issues Raised by Driverless Mobility. (2020). Ethics of Connected and Automated Vehicles: Recommendations on road safety, privacy, fairness, explainability and responsibility.
Kacperski, C., Kutzner, F., Vogel, T., 2024. Comparing autonomous vehicle acceptance of German residents with and without visual impairments. Disabil. Rehabil. Assist. Technol. 1–11. https://doi.org/10.1080/17483107.2024.2317930.
Kesmodel, U.S., 2018. Cross-sectional studies–what are they good for? Acta Obstet. Gynecol. Scand. 97 (4), 388–393. https://doi.org/10.1111/aogs.13331.
Kim, M.K., Park, J.H., Oh, J., Lee, W.S., Chung, D., 2019. Identifying and prioritising the benefits and concerns of connected and autonomous vehicles: A comparison of individual and expert perceptions. Res. Transp. Bus. Manag. 32, 100438. https://doi.org/10.1016/j.rtbm.2020.100438.
Kymlicka, W., 2002. Contemporary political philosophy: An introduction, 2nd ed. Oxford University Press, Oxford.
Lee, D., Hess, D.J., 2020. Regulations for on-road testing of connected and automated vehicles: Assessing the potential for global safety harmonisation. Transportation Research Part A - Policy and Practice 136, 85–98. https://doi.org/10.1016/j.tra.2020.03.026.
Li, S., Sui, P.C., Xiao, J., Chahine, R., 2019. Policy formulation for highly automated vehicles: Emerging importance, research frontiers and insights. Transp. Res. A Policy Pract. 124, 573–586. https://doi.org/10.1016/j.tra.2018.05.010.
Martens, K., 2017. Transport Justice: Designing fair transportation systems. Routledge, New York, NY.
Martens, K., 2020. How just is transportation justice theory? The issues of paternalism and production: A comment. Transp. Res. A Policy Pract. 133, 383–386. https://doi.org/10.1016/j.tra.2020.01.012.
Martínez-Buelvas, L., Rakotonirainy, A., Grant-Smith, D., Oviedo-Trespalacios, O., 2022. A transport justice approach to integrating vulnerable road users with automated vehicles. Transportation Research Part D: Transport & Environment 113, 103499. https://doi.org/10.1016/j.trd.2022.103499.
Martínez-Buelvas, L., Rakotonirainy, A., Grant-Smith, D., Oviedo-Trespalacios, O., 2024. A multi-road user evaluation of the acceptance of connected and automated vehicles through the lenses of safety and justice. Transport. Res. F: Traffic Psychol. Behav. 107, 521–536. https://doi.org/10.1016/j.trf.2024.09.011.
Martínez-Buelvas, L., Rakotonirainy, A., Grant-Smith, D., Oviedo-Trespalacios, O. (2024b). Impact of Connected and Automated Vehicles on Transport Injustices. 2024 IEEE Intelligent Vehicles Symposium (IV), Jeju Island, Korea, Republic of, 1609-1614. doi: 10.1109/iv55156.2024.10588552.
Matin, A., Dia, H., 2022. Impacts of connected and automated vehicles on road safety and efficiency: A systematic literature review. IEEE Trans. Intell. Transp. Syst. 24 (3), 2705–2736. https://doi.org/10.1109/TITS.2022.3227176.
Milakis, D., Van Arem, B., Van Wee, B., 2017. Policy and society related implications of automated driving: A review of literature and directions for future research. J. Intell. Transp. Syst. 21 (4), 324–348. https://doi.org/10.1080/15472450.2017.1291351.
Mooi, E., Sarstedt, M., 2011. Chapter 9: Cluster Analysis. In: Mooi, E., Sarstedt, M. (Eds.), A Concise Guide to Market Research. Springer-Verlag, Berlin, pp. 273–324.
National Transport Commission, 2017. Guidelines for Trials of Automated Vehicles in Australia. National Transport Commission. https://www.ntc.gov.au/sites/default/files/assets/files/AV_trial_guidelines.pdf.
National Transport Commission, 2019. Motor Accident Injury Insurance and Automated Vehicles. Aug. National Transport Commission. https://www.ntc.gov.au/sites/default/files/assets/files/Motor-accident-injury-insurance-and-automated-vehicles-August-2019.pdf.
Payre, W., Cestac, J., Delhomme, P., 2014. Intention to use a fully automated car: Attitudes and a priori acceptability. Transport. Res. F: Traffic Psychol. Behav. 27, 252–263. https://doi.org/10.1016/j.trf.2014.04.009.
Pereira, R.H., Schwanen, T., Banister, D., 2017. Distributive justice and equity in transportation. Transp. Rev. 37 (2), 170–191. https://doi.org/10.1080/01441647.2016.1257660.
Queensland Government. (2017). Cooperative and Automated Vehicle Initiative. Online at: https://www.qld.gov.au/transport/projects/cavi/cavi-project [30.07.2024].
Raudenbush, S. W., & Bryk, A. S. (2002). Hierarchical linear models: Applications and data analysis methods (Vol. 1). Sage.
Reid, C. (2021). Biden's $1.2 Trillion Infrastructure Bill Hastens Beacons For Bicyclists And Pedestrians Enabling Detection By Connected Cars. Forbes. Online at: https://www.forbes.com/sites/carltonreid/2021/11/06/bidens-12-trillion-infrastructure-bill-hastens-beacon-wearing-for-bicyclists-and-pedestrians-to-enable-detection-by-connected-cars/?sh=236328385a3d [31.03.2022].
Reyes-Muñoz, A., Guerrero-Ibáñez, J., 2022. Vulnerable road users and connected autonomous vehicles interaction: A survey. Sensors 22 (12), 4614. https://doi.org/10.3390/s22124614.
Riggs, W., Appleyard, B., Johnson, M., 2020. A design framework for livable streets in the era of autonomous vehicles. Urban, Planning & Transport Research 8 (1), 125–137. https://doi.org/10.1080/21650020.2020.1749123.
Sadaf, M., Iqbal, Z., Javed, A.R., Saba, I., Krichen, M., Majeed, S., Raza, A., 2023. Connected and automated vehicles: Infrastructure, applications, security, critical challenges, and future aspects. Technologies 11 (5), 117. https://doi.org/10.3390/technologies11050117.
Saeidizand, P., Fransen, K., Boussauw, K., 2022. Revisiting car dependency: A worldwide analysis of car travel in global metropolitan areas. Cities 120, 103467. https://doi.org/10.1016/j.cities.2021.103467.
Schoettle, B., & Sivak, M. (2014). A survey of public opinion about autonomous and self-driving vehicles in the U.S., the UK, and Australia. University of Michigan, Ann Arbor, Transportation Research Institute.
Sheller, M. (2018). Theorising mobility justice. Tempo Social, 30(2), 17-34. doi: 10.11606/0103-2070.ts.2018.142763.
Society of Automotive Engineers. (2021). SAE Levels of Driving Automation™ Refined for Clarity and International Audience. Online at: https://www.sae.org/blog/sae-j3016-update [31.11.2023].
Sohrabi, S., Khreis, H., Lord, D., 2020. Impacts of autonomous vehicles on public health: A conceptual model and policy recommendations. Sustain. Cities Soc. 63, 102457. https://doi.org/10.1016/j.scs.2020.102457.
Sousa, V.D., Zauszniewski, J.A., Musil, C.M., 2004. How to determine whether a convenience sample represents the population. Appl. Nurs. Res. 17 (2), 130–133. https://doi.org/10.1016/j.apnr.2004.03.003.
Sundararajan, S., Yousuf, M., Omay, M., Steinfeld, A., Owens, J.M., 2019. Automated vehicles (AVs) for people with disabilities. Road Vehicle Automation 5, 85–90.
Tan, S.Y., Taeihagh, A., 2021. Adaptive governance of autonomous vehicles: Accelerating the adoption of disruptive technologies in Singapore. Gov. Inf. Q. 38 (2), 101546. https://doi.org/10.1016/j.giq.2020.101546.
Transport for NSW. (2022). NSW connected and automated vehicles plan. Retrieved from https://www.transport.nsw.gov.au/data-and-research/future-mobility/CAV-readiness-strategy.
Transport for NSW. (2024). Transport technology strategy. Retrieved from https://www.transport.nsw.gov.au/.
U.S. Department of Transportation. (2018). Preparing for the Future of Transportation: Automated Vehicles 3.0. National Highway Traffic Safety Administration. https://www.transportation.gov/av/3.
Young, I.M., 1990. Justice and the Politics of Difference. Princeton University Press.