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Perceived usefulness of cycling safety countermeasures in Australia and New Zealand: do stigma, stress and self-reported behaviours play a role?

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ABSTRACT

Increasing modal share for cycling has many potential benefits for individuals and communities, especially in regions dominated by motor vehicle use and affected by issues such as extreme congestion. However, research suggests that cycling is not always a safe and positive experience, especially in car-centric communities that could benefit most from increasing cycling rates. Effective countermeasures can mitigate many issues that deter cycling, but their impact also depends on how useful they are perceived to be by riders. Therefore, the aim of this study was to understand the experiences of cyclists in terms of whether these are positive or negative and what factors underly these experiences (i.e. frequency of conflict with other road users, perceived stigma, cyclist behaviour) as well as to explore the perceived usefulness associated with a range of countermeasures considering safer behaviour, safer infrastructure, smarter cycles and more enforcement. Participants were 2135 cyclists living in Australia (n = 1239; average age 53.6; SD = 13.0; men = 74 %) and New Zealand (n = 896; average age = 46.8; SD = 14.6; men = 59 %) who completed an online questionnaire. Riders had mostly positive experiences with cycling, however 87 % felt there was a stigma towards cyclists and almost all riders (99 %) had experienced conflict with car drivers. These factors were associated with less positive perceptions of cycling. Understandably, almost all cyclists held positive views towards separated infrastructure countermeasures. Education campaigns for drivers were also seen as useful. Moreover, binary logistic regression analyses showed that across a range of countermeasures, cyclists who reported more positive experiences and more protective behaviours, yet also reported more conflict with other road users, tended to endorse infrastructure countermeasures. These cyclists may be more aware of safety concerns, adapt accordingly, and want to keep cycling. Riders perceiving stigma towards cyclists tended to support broader system-level changes; such as education and enforcement for drivers. Thus, a systems-level approach may be required to improve safety and positive riding experiences across a range of cyclists.

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1. Introduction

The benefits of cycling are well documented. Cycling is associated with fewer emissions and lower vehicle-related pollution, reductions in traffic collisions and better community health (de Hartog et al., 2011). By way of example, data from Sweden has shown that shifts from car commuting to cycling are associated with a 16 % reduction in yearly mortality rates (Sommar et al., 2021). For individuals, shifts from driving to cycling are associated with increased life duration of between 3 and 14 months, due to increased physical activity (de Hartog et al., 2011), as well as with lower trip-related stress and reduced Body Mass Index (BMI) among regular bike commuters (Useche et al., 2024). Such benefits have also been noted when using e-bikes, albeit to a lesser extent (Bourne et al., 2018). It is therefore evident that there are many gains to be made from mode shifts to cycling and the uptake should be encouraged, especially in communities that are currently heavily car-dependent, such as New Zealand and Australia (Buchanan et al., 2006). Here the distances to travel are typically short, but congestion is high due to the lack of alternative mode and route choices. The best way to encourage uptake is to ensure cycling is a safe and positive experience.

Countermeasures aimed at improving cycling safety and experience must respond to the concerns of both current and potential cyclists. Addressing these concerns may support uptake and retention, thereby helping to maximise the benefits of cycling. However, not all riders perceive the same measures as useful, which can limit their effectiveness. Perceived usefulness will depend on many factors, including what their experiences of cycling are as well as where and how cyclists ride.

1.1. Key challenges and deterrents to safe and sustained cycling

Researchers have found that interactions with motor vehicles often result in negative experiences for cyclists. Riding in traffic exposes them to air pollution (Götschi et al., 2016), potentially offsetting some of cycling's health benefits. Riders are also exposed to dangerous and aggressive driver behaviour, which often discourages continued cycling (Useche et al., 2019). Vehicle speed, passing behaviours and aggressive driving are key deterrents to riding on the roadway (Boufous et al., 2021; Pearson et al., 2023; Poulos et al., 2019) with even experienced cyclists reporting feeling unsafe due to the behaviour and potential danger of interacting with drivers (Beck et al., 2021; Sommar et al., 2021). This was evidenced in a naturalistic study conducted in Australia that had cyclists press a button whenever they felt unsafe due to a passing vehicle. Beck et al. (2021) found that closer passing distances were associated with a higher probability of cyclists feeling unsafe. The probability of feeling unsafe increased on roads with no dedicated cycling infrastructure and when larger vehicles were passing. These findings highlight the complexity of interactions between cyclists and different types of road users and reinforce the importance of understanding cyclists' general perceptions of safety and conflict. In the present study, we therefore assessed not only overall conflict but also how frequently cyclists reported conflict with different road-user groups (e.g., private cars, heavy vehicles, buses, pedestrians). Such perceptions play an important role in shaping cycling experiences and, ultimately, the decision to continue to ride.

Conflict or aggression from drivers is another common problem for cyclists. A study conducted in Australia found that, on average, cyclists experience at least one act of aggression from drivers for every three hours spent cycling (Poulos et al., 2019). Indeed, aggression from drivers is among the main reasons cyclists cease cycling in Australia (Boufous et al., 2021; Pearson et al., 2023) and is also the main source of anger in cyclists (O'Hern et al., 2019). Overall, the current literature supports the idea that, when angry, cyclists may themselves become aggressive, further increasing their risk of engaging in other unsafe behaviours (Møller & Haustein, 2017). Stephens et al. (2020) found that cyclists tend to be more aggressive towards drivers when angry, compared with when angered by pedestrians or other cyclists. This indicates an unofficial distinction between drivers and active transport users as sources of conflict, which raises two important points. First, it is important to understand not only the frequency of conflict, but also the source of conflict (i.e. type of road user). Second, cyclists may hold different attitudes towards different types of road users and adjust their behaviour accordingly. Together, these studies suggest that aggression reflects a broader pattern of conflict between cyclists and other road users. Given that conflict is a key influence on cycling experiences, it is important to understand cyclists' general perceptions of how often such conflict occurs.

It appears the biases against different modal users are reciprocal. Many drivers lack respect for on-road cyclists and hold negative views towards them (Delbosc et al., 2019). Indeed, Prati et al. (2017) argue that attitudes towards cyclists are analogous to how minority groups are viewed. They suggest that these attitudes also contribute to poor safety outcomes. Supporting this, researchers have demonstrated associations between attitudes towards cyclists and increased aggressive behaviour towards them (Delbosc et al., 2019; Fruhen et al., 2019). This perceived stigma of being a cyclist is another factor that influences uptake and retention (Daley & Rissel, 2011). Although rarely examined in cycling research, perceived stigma may play a significant role in shaping cyclists' experiences and their interactions with other road users.

Cyclists may also face challenges related to environmental factors and/or costs associated with riding. For instance, the expense of purchasing a bicycle and necessary equipment can be a barrier (Logan et al., 2023), as can the lack of dedicated cycling infrastructure or paths (Manaugh et al., 2017). Additionally, the distance to the nearest path and the physical effort required to complete a journey, such as navigating long or steep routes, can discourage riding for some cyclists. In contrast, a supportive environment, including well-connected infrastructure, has been shown to encourage higher cycling levels (Logan et al., 2023). While these structural and environmental barriers shape cycling uptake more broadly, the present study focuses on cyclists' immediate experiences, such as safety, effort, conflict, and stigma, which underpin their ongoing engagement with cycling.

1.2. Potential countermeasures to promote safe cycling

There are numerous countermeasures that can promote positive and safe experiences for cyclists. These typically reflect a systems approach, addressing road design, vehicle interactions, and user behaviour. Key facilitators include more supportive attitudes towards cyclists, dedicated infrastructure, technological improvements, and greater awareness of cycling safety among drivers (Boufous et al., 2021; Useche et al., 2024). While such measures may improve safety and support both uptake and retention, their effectiveness depends on whether cyclists perceive them as useful. Perceived usefulness relates to how much a particular system is viewed as enhancing performance (e.g. Davis, 1989). In the case of cyclists, this would be how much countermeasures enhance their cycling experiences. Importantly, perceived usefulness is conceptually distinct from actual effectiveness. Perceptions reflect individuals' subjective evaluations, whereas effectiveness refers to objective performance outcomes (Davis, 1989). Perceived usefulness is crucial because it strongly predicts intentions to engage with or adopt safety solutions. Therefore, the present study focuses on cyclists' perceptions of usefulness rather than evaluating the true effectiveness of countermeasures.

Nevertheless, it is worth noting that, although crashes and other safety threats may affect all riders, cyclists represent a heterogeneous group who differ in their reasons for riding (commuting, leisure, work), their interest in cycling (Geller, 2006), and their riding patterns and risk-related behaviours. With respect to the latter, the Cycling Behaviour Questionnaire (CBQ) was developed to measures the degree to which cyclists of different profiles report violating the road rules, making errors, or engaging in protective behaviours (Useche et al., 2018; Useche et al., 2022). Cyclists who report high levels of violations and errors, and low positive behaviours tend to be high risk cyclists (Li et al., 2022). High risk cyclists tend to ride more frequently and are often younger and male. O'hern et al. (2021) found that higher levels of violations and errors were linked to greater self-reported crash involvement, suggesting that cycling experiences are closely tied to the reasons people ride, as well as to their riding style and context. Therefore, it makes sense to consider differences across rider profiles when developing or promoting countermeasures, since not all cyclists may perceive the same need for them or be equally willing to adopt them.

1.3. Study aims and hypotheses

The aim of the study was twofold. The first aim was to understand general experiences of cyclists who remain active riders, including both overall evaluations of cycling and the frequency of conflict with different types of road users. To this end, it was important to understand whether these experiences were positive or negative. Such experiences include perceptions of safety, effort, and self-reported frequency of conflict with other road users, alongside perceptions of cyclist stigma. All of these factors influence uptake, continued engagement in cycling and behaviour while cycling (Bishop et al., 2023).

The second study aim was to assess how cyclists perceive the usefulness of various safety-related countermeasures, including education campaigns, infrastructure improvements, technological advances and cyclist training. The influence of cyclist factors on perceived usefulness was then considered. This information helps develop an understanding of how to promote and encourage adoption of any countermeasures. Such an understanding is critical. It is important to note that the present study examines cyclists' perceptions of how useful different countermeasures might be, rather than evaluating their actual effectiveness or measuring behavioural support. Perceived usefulness and true effectiveness may align or differ, but perceptions remain critical because they influence acceptance, uptake, and behaviour (Suojanen et al., 2019). Research outside of transport areas has shown that individuals are more likely to engage with or endorse safety interventions they believe to be effective (Byrd et al., 2025). In this context, perceived

Table 1
Sample demographics collectively and across the New Zealand and Australia samples.

	Total sample (2135)	Australia (n = 1239)	New Zealand (n = 896)	Comparison statistics
Age: range (Mean, SD)	18–84 years (M = 50.7, SD = 14.1)	18–84 years (M = 53.6, SD = 13.0)	18–84 years (M = 46.8, SD = 14.6)	$t(2123) = 11.30$, $p < .001$, $d = 0.50$
Gender (%)				$X^2(2) = 60.23$, $p < .001$, Cramer's V = 0.17
Man	68 %	74 %	59 %	
Woman	30 %	24 %	39 %	
Non-binary	2 %	2 %	2 %	
	Reasons for riding (% yes)			
Commuting	63 %	61 %	67 %	$X^2(1) = 7.46$, $p = .006$, $\phi = 0.06$
Short trips	69 %	61 %	80 %	$X^2(1) = 80.96$, $p < .001$, $\phi = 0.20$
Leisure	91 %	92 %	90 %	$X^2(1) = 2.34$, $p = .12$, ϕ =0.03
Exercise	78 %	81 %	72 %	$X^2(1) = 24.70$, $p < .001$, $\phi = 0.11$
Work	9 %	9 %	8 %	$X^2(1) = 0.52$, $p = .47$, $\phi = 0.01$
Average riding per week: range (Mean, SD)	0–30 (M = 6.4, SD = 4.1)	1–30 h (M = 7.0, SD = 4.3)	0–30 h (M = 5.6, SD = 3.6)	$t(2081.78) = 8.04$, $p < .001$, $d = 0.34$
Average trip duration: range (Mean, SD)	5–180 min (M = 60.6, SD = 44.5)	5–180 min (M = 68.5, SD = 46.1)	5–180 min (M = 50.0, SD = 40.2)	$t(2056.58) = 9.78$, $p < .001$, $d = 0.42$
Crash involvement in the previous 5 years (% yes)	67 %	66 %	68 %	$X^2(1) = 0.71$, $p = .40$, $\phi = 0.02$

usefulness can be viewed as a precursor to broader acceptance, even though the present study did not directly assess support or advocacy for specific measures.

Based on the aims and considering the supporting evidence above (e.g. Beck et al., 2021; O'Hern et al., 2019; Poulos et al., 2019), two literature-based hypotheses were formulated.

1. Cyclists who report more frequent conflict with other road users and perceive greater stigma will describe less positive cycling experiences.
2. Cyclists' behaviours (errors, violations and protective behaviours) will be related to the types of experiences they have (i.e. positive or negative), level of conflict and their perceived countermeasure usefulness.

2. Method

2.1. Participants

Participants were 2135 cyclists from New Zealand (n = 896) and Australia (n = 1239), who completed an online survey. The population of interest were "active" cyclists (they currently rode a bicycle) aged 18 and over. Participants were recruited via social media advertising which included paid advertising (i.e. Facebook) and unpaid advertising through University social media channels (Facebook, LinkedIn, X). Table 1 shows that, on average, most participants identified as men (68 %) and ranged in age from 18 to 84 years (mean age = 51 years. SD = 14). In both samples, leisure riding was the most common reason for riding.

Table 1 also shows the demographics of the sample split across the two countries. This shows that the two countries were suitably similar to group as one sample. The Australian sample were slightly older, had a higher percentage of men and rode for longer each week. However, the effect sizes of these differences were small to medium so these were deemed suitable to group as one sample.

2.2. Procedure

Independent, but similar, online surveys were conducted in Australia and New Zealand during the last half of 2023. These surveys formed part of a larger ongoing project, examining attitudes towards assisted technology on bicycles (see Useche et al., 2022). The survey took approximately 20–30 min to complete, and participants could skip questions or leave without finishing. Only people who had provided responses to more than 80 % of the survey were kept in the analysis. Therefore, 15 cases were excluded before arriving at the final sample reported here. At the end of the survey the Australian participants were offered the opportunity to go into a prize draw to win one of five $200 vouchers. Ethical approval for the studies were obtained from the Universities in Australia and New Zealand.

2.3. Measures

Several demographic variables were collected as shown in Table 1. These included gender, age, and crash involvement –regardless of severity– in the past five years. Reasons for riding were also sought. Participants were asked if they normally use a bicycle for commuting, short trips, leisure, exercise, and/or work. Participants provided a yes/no response for each of the options. Participants were also asked to indicate their average hours riding during a normal week as well as the average minutes cycled per trip.

2.3.1. Cycling behaviour questionnaire (CBQ)

Cyclist behaviour was measured with the 32-item CBQ (Useche et al., 2018; Useche et al., 2022). Each item represents a cyclist behaviour (e.g. not braking for a stop sign). Participants rate the frequency of engaging in each behaviour on a 5-point scale from 0 (never) to 4 (very frequently). The 32 items form three broader types of behaviours: violations riding (deliberate behaviours that

Table 2
Self-reported cycling experiences (N = 2135).

Item (Rating scale)	Total sample M (SD)
Considering all the resources (time, money, bike, maintenance, etc.) that I invest in these trips, their cost is: (1 Extremely exaggerated; 5 Extremely reasonable)	4.4 (0.8)
The time it takes me to make my usual cycling trips is (1 Extremely inadequate; 5 Extremely adequate)	4.2 (0.9)
At the end of these trips, I usually feel: (1 Extremely stressed/tense; 5 Extremely relaxed/smooth)	4.1 (0.7)
At the end of my cycling trips, the emotion best describing my mood is: (1 Extremely angry; 5 Extremely happy)	4.1 (0.7)
I perceive that, in terms of security (the fact of not being a victim of a crime), these trips are: (1 Extremely insecure; 5 Extremely secure)	4.0 (1.0)
Considering the physical efforts needed to make these trips, I find them: (1 Extremely demanding; 5 Extremely comfortable)	3.7 (1.0)
The weather conditions of the area where I cycle the most are: (1 Extremely adverse; 5 Extremely pleasant)	3.5 (0.8)
The things happening during these trips are usually (1 Extremely out of my control; 5 Extremely under my control)	3.2 (1.0)
My interactions with other road users are typically: (1 Extremely conflicting; 5 Extremely friendly)	3.1 (0.9)
I perceive that, in terms of safety (the fact of not having a crash), these trips are: (1 Extremely unsafe; 5 Extremely safe)	3.1 (0.9)
TOTAL SCORE (possible range 1 to 50)	37.4 (4.8)

often contravene road rules), errors (unintentional errors), and protective behaviours (behaviours to support safety). Items are averaged into their factors with higher scores indicating more frequent behaviours. These have demonstrated good reliability with composite reliabilities ranging from 0.77 (violations) to 0.91 (errors)(Useche et al., 2022).

2.3.2. Cycling experiences

Cycling experiences were sought by asking participants about aspects of their trips. These are shown in Table 2 in the results section. Participants responded on a 5-point scale with anchors representing positive and negative experiences (e.g., 1 = extremely negative; 5 = extremely relaxed). Higher scores on these variables therefore represent more positive experiences. The questions covered aspects related to interactions with other road users, safety, security, effort, and mood after riding. An overall riding experience score was created by summing responses, with Cronbach alpha of 0.71 for this study.

2.3.3. Frequency of road user conflict and perceived stigma

Participants were also asked to rate the frequency of experiencing "any form of conflict" with the following road users: trucks and large vehicles, buses, taxis and ride share, private cars, motorcycles, e-scooters, other cyclists, and pedestrians. Participants rated the frequency of conflict with each type (see Table 3 in the results section). Responses were on a 5-point scale from 0 (never) to 4 (very frequently). Responses were summed to create a total conflict score, with higher scores indicating more frequent conflict with all road users. Cronbach alpha for this study was 0.81.

Stigma was collected through one question that asked: "Do you think that there is currently a "stigma" against cyclists in your city/town? A "stigma" refers to a negative stereotype from other users" Response options were: "Yes, and its now stronger than in the past"; "Yes, but it is weaker now than it was"; "No, but there has been one"; and "No, but there might be one".

2.3.4. Potential countermeasures

Finally, participants were asked to rate the usefulness of 9 potential countermeasures to improve bicycle safety in the next decade. These were related to **cyclists** (having to receive road training to ride a bike, incentive programs for good cycling behaviour and smarter bicycles with rider assistance technology), **drivers or other road users** (More / better education on road safety, awareness campaigns through the media and law enforcement for road behaviour) **infrastructure level** (separation of different vehicle types, infrastructure improvement and **technology levels** (technology in the mobile environment). These countermeasures represent the major categories of interventions commonly used in cycling safety policy and research, including cyclist-focused measures (e.g., education or additional training), road-user and regulatory strategies (e.g., law enforcement, awareness campaigns, community involvement), and infrastructure or technology-based improvements (e.g., changes to bicycle or environmental technologies). This range reflects a systems approach to road safety and aligns with the key challenges identified in the literature (e.g. conflict with other road users, perceptions of stigma, skill gaps, and the role of inadequate infrastructure) and therefore allows examination of how different cyclist characteristics shape perceived usefulness across intervention types. For each countermeasure, participants rated its perceived usefulness on a 5-point scale from 1 (not useful) to 5 (totally useful).

2.4. Data analysis

Before analysis, data were reviewed for completeness and consistency; responses with more than 20 % missing data were excluded, and no imputation was performed for remaining missing values. Further missing data were not treated, and this will be reflected in differing degrees of freedom. A principal axis factoring analysis was conducted on the general cycling experiences to determine if these conceptually and statistically grouped together. The Kaiser-Meyer-Olkin Measure of sampling adequacy (KMO) and Bartlett's test of sphericity were used to determine suitability of the items for analysis. A significant value for Bartlett's test of sphericity coupled with a KMO greater than 0.80 (Field, 2018), was used to determine suitability of the data for factor analysis. All items were subjected to Maximum Likelihood methods. Direct Oblimin method of rotation was used, which accounts for correlated factors. Items were removed based on initial examination of the item-interrelationships and those with no correlations removed. Items with low communalities or low factor loadings were also removed (<0.30). The number of factors to retain was determined by both examination of the scree plot and subsequent parallel analysis (O'connor, 2000).

Table 3
The frequency of self-reported conflict with different types of road users.

Road user (0 = never, 4 = very frequently)	Total (N = 2135) M (SD)
Private cars	2.5 (0.9)
Trucks and other large vehicles	1.7 (1.0)
Large public transport vehicles (buses)	1.5 (1.0)
Taxis and Rideshare (e.g. Ubers)	1.6 (1.0)
E-scooters	1.4 (1.1)
Motorbikes	1.0 (0.8)
Other bicycles	1.1 (0.8)
Pedestrians	1.6 (0.9)
Total conflict	12.3 (4.9)

Because these analyses are not central to the study's core questions, group comparisons between Australia and New Zealand are reported in the Supplementary Material. Group mean comparisons were made with independent *t*-tests. Effect sizes were represented by Cohen's *d* and interpreted as 0.20 small, 0.50 medium, and 0.80 large (Cohen, 1988). In cases where the assumption of equal variances was violated, an adjusted degree of freedom statistic is reported. Relationships between categorical variables were examined using Chi-Square statistic. Effect sizes for these were determined with Cramer's *V* and Phi (ϕ) and interpreted as 0.10 weak, 0.30 moderate and 0.50 strong.

Regarding bivariate analyses, Pearson's correlations were used to assess relationships between variables. Here relationship strength was determined by 0.10 small, 0.30 medium and 0.50 large (Cohen, 1988). Binary logistic regression analyses were used to understand associations between cyclist factors (experiences while cycling, stigma, conflict, age, gender and self-reported violations behaviour, errors and protective behaviour) perceptions regarding different types of countermeasures. For these analyses, the 10 countermeasure variables were recoded into binary variables that represented (useful [responses scoring 4 or 5] or not useful [any other response]).

All statistical analyses were conducted using SPSS for windows, version 29.0. Graphs were produced in R.

3. Results

3.1. Cyclist behaviour

Overall, the sample reported relatively safe riding behaviours. Violations measured with the CBQ were infrequent, with average scores in the sample of 0.6 ($SD = 0.4$) on a 0 to 4 scale. Errors were also low frequency ($M = 0.5$, $SD = 0.4$), while the sample reported frequent protective behaviours ($M = 3.26$; $SD = 0.46$).

3.2. General cycling experiences and stigma

The factor analysis showed that the data were suitable for analysis represented by a KMO of 0.79 and significant value for Bartlett's test of sphericity ($p < .001$). The items formed one factor which accounted for 32 % of the explained.

Table 2 displays the average responses for each item, presented in order of most to least positive. Notably, across all experience items, the average scores were in the top half of what was possible, indicating that for the most part cycling was a positive experience. The highest scores were reflected for the cost of cycling and the time taken to cycle, with these seen as reasonable to extremely reasonable. Interestingly, on average, cyclists reported feeling relaxed, rather than tense, after a cycling trip.

The lowest scores (while still positive) were for the perceived safety of avoiding a crash and friendly interactions with other road users (3.1 out of 5). Taken together these scores suggest that cycling was a positive experience for the respondents in the sample.

Despite the tendency for cycling to be a positive experience, most (87 %) respondents reported feeling that cyclists have a negative stereotype.

3.3. Conflict

In line with our first aim to characterise cyclists' experiences of conflict with different road users, Table 3 presents the mean scores

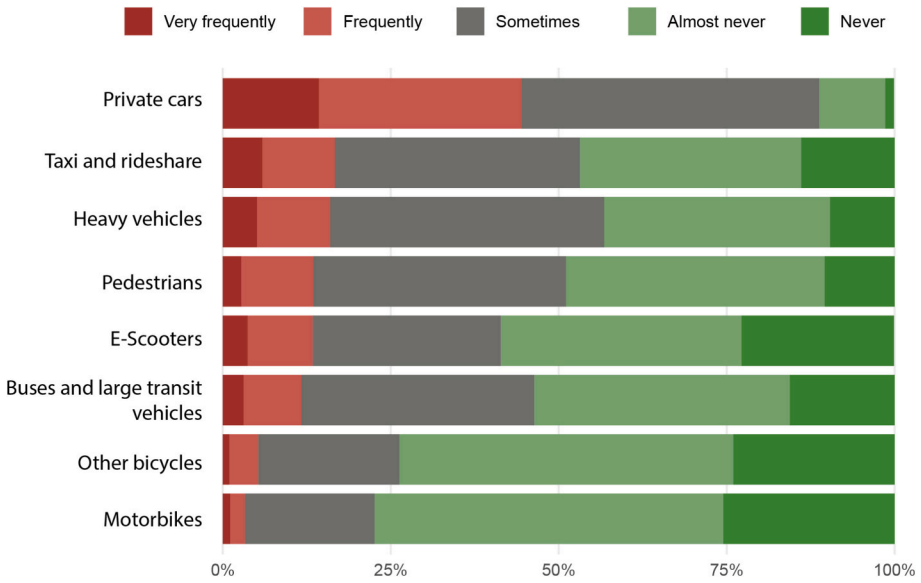

Fig. 1. Frequency of conflict with different road users across.

for each type of conflict reported, displayed in order of what was most common. Conflict with private cars was the most common form of conflict occurring sometimes to frequently on average. Conflict among the remaining road user types was infrequent, with average scores showing that at a sample level this occurred almost never to sometimes.

While the frequency of conflict was low within the sample, the discrepancy between a cyclist and the motorised road users in terms of vulnerability means that even low levels of conflict are concerning. Fig. 1 shows the frequency of conflict while cycling, split across never, almost never, sometimes, frequently and very frequently. Only 1 % of the sample reported never experiencing conflict with private cars with almost half (44 %) reporting this happens frequently to very frequently. Conflict with motorbikes was the least occurring form of conflict with approximately one quarter (26 %) never experiencing this form of conflict.

3.4. Relationships between cyclist demographics, self-reported riding behaviour, conflict frequency and cycling experiences

The relationships between self-reported riding behaviour, conflict frequency and cycling experiences are shown in Table 4. Age was weakly related to cycling experiences with older riders tending to report more positive experiences. Age was also weakly related to violations. Younger cyclists also tended to report more violations. Hours ridden per week were largely unrelated to riding behaviour, frequency of conflict or cycling experiences. The exception was a weak relationship between hours riding per week and frequency of conflict, indicating that cyclists who rode for longer also tended to report more conflict.

The cycling behaviour factors shared moderate relationships in the expected directions. Increased frequency of violations was related to increased frequency of riding errors, while increases in both were related to less protective behaviours. There were also relationships between cycling behaviour and the frequency of conflict. Interestingly, the strongest relationship was between increases in errors with increases in the frequency of conflict, while protective behaviour was very weakly negatively related to the frequency of conflict. Frequency of conflict was related to cycling experiences with less conflict related to more positive experiences.

The associations between these variables on positive experiences were further examined using linear regression. An initial model included hours cycling per week, violations, errors, protective behaviours, frequency of conflict, age, gender and stigma. While this model was significant $F(4,1209) = 51.04$, $p < .001$, violations, errors, protective behaviours, gender and age were removed due to lack of significant association with positive cycling experiences (see Table 5 for the final model: $F(4,1203) = 77.40$, $p < .001$). The final model showed that increases in positive cycling experiences were associated with riding for longer, experiencing less conflict with other road users and not perceiving that there was a stigma about cyclists.

3.5. Countermeasures

Fig. 2 shows the perceived usefulness of a range of countermeasures to improve cycling safety. As can be seen, almost all (97 %) felt that improvements to infrastructure would be a useful countermeasure. Enforcement and education / awareness campaigns were also viewed by most respondents as being usual for improving safety (80 % for enforcement; 66 % for awareness campaigns).

Among the proposed countermeasures, three focused on actions that cyclists themselves could do to improve safety: road training to ride a bike, incentive programs for good cycling behaviour and using smarter bicycles with advanced rider assistance technologies. Nevertheless, only about one third of respondents considered these measures to be useful for cycling safety.

Logistic regressions were conducted to see if there were characteristics of riders associated with this perception (see Table 6). More positive experiences when cycling, more conflicts, more protective behaviours, being older and a woman were all significantly associated with positive views about the usefulness of cyclist training. Similarly, higher error frequency and protective behaviours, along with being older and identifying as a woman were associated with perceiving assistive technologies as beneficial for cyclist safety. Furthermore, riders who described their cycling experiences as generally positive but also reported frequent conflict showed higher odds of supporting incentives for good cycling behaviour, suggesting that positive engagement combined with exposure to risk may increase receptiveness to these types of countermeasures.

Table 7 shows cyclist factors associated with countermeasures targeted at other road users. These included, more or better education about road safety, enforcement for bad road behaviour and awareness campaigns through the media. Riders who perceived a stigma against cyclists were more likely to view all three as useful. Higher levels of reported conflict were also consistently associated with stronger perceptions of usefulness for these measures.

Table 8 shows the infrastructure or technology-based solutions. These included more technology in the mobile environment and separation of different vehicle types. Infrastructure improvements could not be modelled because almost all of the participants agreed

Table 4
Relationships between cyclist age, average hours travelling per week, self-reported behaviour, cycling experiences and conflict.

	Age	Hours per week	Violations	Errors	Protective riding	Frequency of conflict
Hours per week cycling	0.16***	–				
Violations	−0.17***	0.00	–			
Errors	0.03	0.03	0.34***	–		
Protective riding	0.05*	−0.04	−0.36***	−0.15***	–	
Frequency of conflict	−0.01	0.15***	0.14***	0.29***	−0.06*	–
Cycling experiences	0.26***	0.00	−0.03	−0.04	0.01	−0.21***

Notes: *** $p < .001$; ** $p < .010$; * $p < .050$.

Table 5
Factors associated with positive cycling experiences.

	B	*SE*	*p*	*β*	95 % CI B
Stigma (no to yes)	−1.64	0.40	<0.001	−0.11	[−2.42, −0.86]
Total conflict experienced	−0.32	0.03	< 0.001	−0.33	[−0.38, −0.27]
Hours ridden per week	0.10	0.03	0.001	0.09	[0.04,0.16]

Notes: *** $p < .001$; **$p < .010$; *$p < .050$.

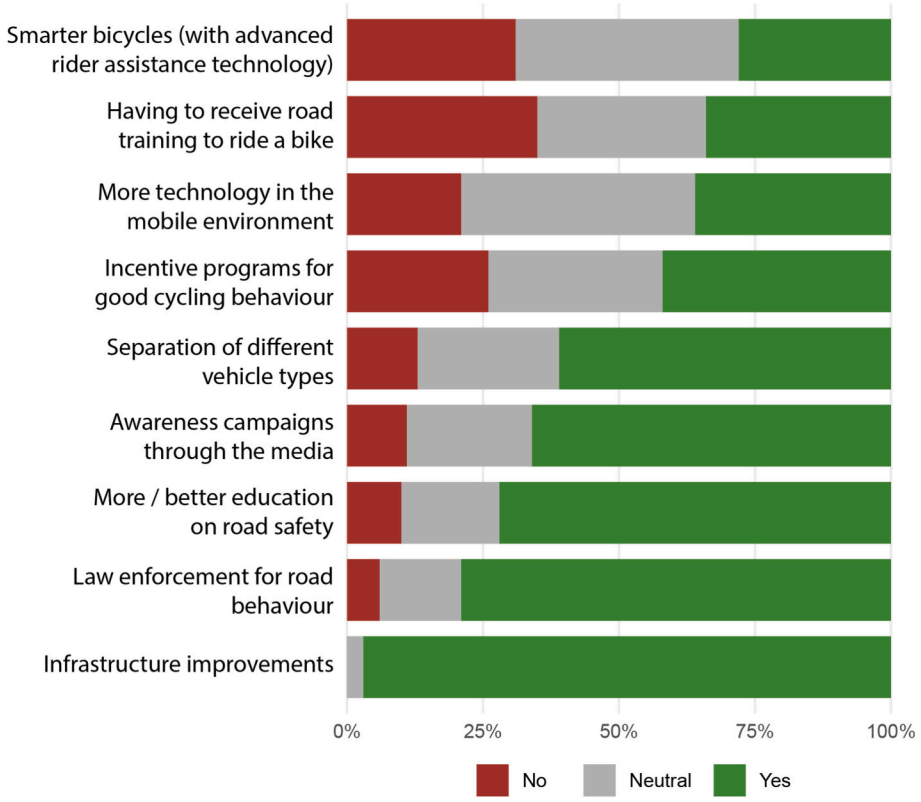

Fig. 2. Agreement in the usefulness of potential countermeasures.

these would be useful. As with the countermeasures for other road users, riders who perceived a stigma against cyclists were more likely to view more technology as useful, and this may relate to a perceived accountability or monitoring of other's behaviours.

4. Discussion

This study aimed to examine cyclists' experiences and their perceived usefulness of different countermeasures to improve safety, with a focus on how these perceptions relate to conflict, stigma, and self-reported behaviours. Understanding the factors that shape perceived usefulness is important given that perceptions influence acceptance, engagement, and support for safety interventions. The study provides insight into the level of perceived usefulness of cyclist-focussed, other-road user focussed, infrastructure-level or technology-based measures, and how these perceptions differ depending on their experiences and behavioural tendencies. To this end, we had two hypotheses. First, that cyclists who report more frequent conflict with other road users and feel greater stigma would describe less positive cycling experiences. Second, that cyclists' behaviours (errors, violations and protective behaviours) will be related to the types of experiences they have (i.e. positive or negative), level of conflict and their perceived countermeasure usefulness. The findings in relation to these are discussed below.

On average, the experience of cycling was rated more positively than negatively in our sample. Cyclists find the weather extremely pleasant, they feel safe from crime, the travel time is adequate, cycling is affordable and requires a comfortable amount of effort. At the end of the trips, cyclists reported generally positive moods. Thus, cycling was overall a positive experience, or at least the people who cycle (i.e., our participants) may do so because it is a positive experience, or when the weather is good. Lower, but still positive, scores were found for the amount of control cyclists felt they had over what happens when cycling, negative interactions with other road users and fear of crash. This suggests that the participants in this study had positive experiences with cycling. These are important to

Table 6
Cyclist factors associated with belief that countermeasures for cyclists would be useful.

Study Variable	*B*	*SE*	*p*	OR	95 % CI OR
Road training to ride a bicycle					
Stigma (reference is no)	−0.06	0.20	0.75	1.07	[0.72, 1.56]
Total experience cycling	0.03	0.01	0.04	1.03	[1.00, 1.06]
Total conflict experienced	0.05	0.01	< 0.001	1.05	[1.02, 1.08]
Violation frequency	−0.01	0.18	0.98	1.00	[0.71, 1.41]
Errors frequency	0.36	0.19	0.07	1.43	[0.97, 2.11]
Protective behaviours frequency	0.47	0.15	0.002	1.59	[1.19, 2.13]
Age	0.02	0.01	< 0.001	1.02	[1.01, 1.04]
Gender (women as reference)	−0.39	0.15	0.009	0.68	[0.51, 0.91]
Smarter bicycles with advanced rider assistance technology)					
Stigma (reference is no)	−0.15	0.20	0.45	0.86	[0.58, 1.28]
Total experience cycling	−0.01	0.02	0.42	0.99	[0.96, 1.02]
Total conflict experienced	−0.01	0.01	0.44	0.99	[0.96, 1.02]
Violation frequency	0.25	0.19	0.18	1.28	[0.89, 1.85]
Errors frequency	0.74	0.21	< 0.001	2.09	[1.39, 3.15]
Protective behaviours frequency	0.84	0.17	< 0.001	2.32	[1.66, 3.28]
Age	0.03	0.01	< 0.001	1.03	[1.02, 1.04]
Gender (women as reference)	−0.34	0.15	0.03	0.71	[0.53, 0.96]
Incentives programs for good cycling behaviour					
Stigma (reference is no)	0.22	0.19	0.26	1.24	[0.85, 1.81]
Total experience cycling	0.04	0.14	0.006	1.04	[1.01, 1.07]
Total conflict experienced	0.06	0.14	<0.001	1.05	[1.03, 1.09]
Violation frequency	0.01	0.17	0.95	1.01	[0.73, 1.40]
Errors frequency	−0.21	0.19	0.26	0.81	[0.56, 1.17]
Protective behaviours frequency	0.15	0.13	0.28	1.16	[0.89, 1.50]
Age	0.01	0.01	0.95	1.00	[0.99, 1.01]
Gender (women as reference)	−0.21	0.14	0.14	0.81	[0.61, 1.07]

Table 7
Cyclist factors associated with the belief that countermeasures for other road users would be useful.

	B	*SE*	*p*	OR	95 % CI OR
More / Better education about road safety					
Stigma (reference is no)	0.45	0.21	0.03	1.56	[1.04, 2.36]
Total experience cycling	0.02	0.02	0.14	1.02	[0.99, 1.06]
Total conflict experienced	0.04	0.02	0.03	1.04	[1.00, 1.07]
Violation frequency	−0.15	0.19	0.42	0.86	[0.59, 1.24]
Errors frequency	−0.14	0.19	0.54	0.87	[0.57, 1.35]
Protective behaviours frequency	0.15	0.15	0.32	1.16	[0.86, 1.57]
Age	0.02	0.01	0.01	1.08	[1.00, 1.03]
Gender (male as reference)	0.08	0.17	0.63	1.08	[0.78, 1.50]
Law enforcement for road behaviour					
Stigma (reference is no)	0.92	0.21	< 0.001	2.52	[1.68, 3.79]
Total experience cycling	−0.03	0.02	0.08	0.97	[0.93, 1.00]
Total conflict experienced	0.08	0.02	< 0.001	1.08	[1.04, 1.12]
Violation frequency	−0.82	0.21	< 0.001	0.44	[0.29, 0.66]
Errors frequency	0.74	0.21	< 0.001	2.09	[1.39, 3.15]
Protective behaviours frequency	0.17	0.17	0.31	1.19	[0.85, 1.65]
Age	−0.01	0.01	0.91	0.99	[0.99, 1.01]
Gender (male as reference)	0.18	0.19	0.23	1.20	[0.83, 1.73]
Awareness campaigns through the media					
Stigma (reference is no)	0.87	0.20	< 0.001	2.38	[1.62, 3.48]
Total experience cycling	0.01	0.02	0.66	1.00	[0.98, 1.03]
Total conflict experienced	0.03	0.02	0.07	1.03	[1.00, 1.06]
Violation frequency	0.06	0.19	0.73	1.07	[0.74, 1.53]
Errors frequency	−0.05	0.21	0.81	0.95	[0.62, 1.44]
Protective behaviours frequency	0.27	0.14	0.06	1.31	[0.99, 1.74]
Age	0.01	0.01	0.09	1.01	[1.00, 1.02]
Gender (women as reference)	−0.13	0.16	0.44	0.88	[0.64, 1.21]

Notes: NB: Bold denotes significance.

Table 8
Cyclist factors associated with the belief that countermeasures for infrastructure and technology improvements would be useful.

	B	*SE*	*p*	OR	95 % CI OR
More technology in the mobile environment					
Stigma (reference is no)	−0.08	0.20	0.68	0.92	[0.63, 1.35]
Total experience cycling	−0.04	0.01	0.79	1.00	[0.97, 1.02]
Total conflict experienced	0.02	0.01	0.11	1.02	[0.99, 1.05]
Violation frequency	0.18	0.17	0.30	1.20	[0.85, 1.68]
Errors frequency	0.32	0.20	0.11	1.37	[0.93, 2.02]
Protective behaviours frequency	0.56	0.15	< 0.001	1.75	[1.30, 2.35]
Age	0.03	0.01	< 0.001	1.03	[1.02, 1.04]
Gender (women as reference)	−0.29	0.15	0.052	0.75	[0.56, 1.00]
Separation of different vehicle types					
Stigma (reference is no)	0.41	0.19	0.03	1.50	[1.03, 2.19]
Total experience cycling	−0.02	0.02	0.11	0.98	[0.95, 1.00]
Total conflict experienced	0.06	0.02	< 0.001	1.06	[1.03, 1.09]
Violation frequency	0.40	0.18	0.03	1.49	[1.04, 2.14]
Errors frequency	−0.08	0.21	0.70	0.92	[0.62, 1.38]
Protective behaviours frequency	0.30	0.14	0.83	1.03	[0.79, 1.36]
Age	−0.02	0.01	0.65	1.00	[1.00, 1.08]
Gender (women as reference)	0.08	0.15	0.59	1.09	[0.81, 1.45]

maintain cycling and promote uptake.

The largely positive experiences reported by cyclists in our sample may initially seem surprising given the predominantly negative experiences usually reported in the literature (e.g. Beck et al., 2021; Götschi et al., 2016; Sommar et al., 2021; Useche et al., 2019). However, this contrast is likely a function of our participant group: these are current cyclists who have continued riding despite the challenges described in prior literature. For such riders, the benefits of cycling may outweigh the barriers, leading to generally positive evaluations even in the context of frequent conflict or perceived stigma. This distinction between population-level barriers and the experiences of active cyclists helps reconcile the literature with our findings and underscores the importance of examining both the motivations and deterrents among those who currently cycle.

Previous research has underlined the importance of positive cyclist experiences (Clayton & Musselwhite, 2013; Zander et al., 2013). Clayton and Musselwhite (2013), for instance, sought opinions of cyclists in the UK regarding the role of infrastructure in positive experiences and cycling participation. They found that families would be more likely to cycle when infrastructure was in place to support positive experiences, such as the enjoyment and feel of cycling, and the reduction of fear. Similar insights were noted by Pucher and Buehler in the context of the United States, suggesting that encouraging cycling could help increase its regularity and, in turn, contribute to addressing the country's low levels of physical activity (Pucher & Buehler, 2016). Moreover, a study in Australia has shown confidence around cycling is a key motivator for maintaining the behaviour (Zander et al., 2013). By contrast, negative experiences may undermine confidence and lead to reduced cycling. Within this context, the positive experiences reported by the samples in the current study are promising and likely to be important to maintain the motivation to continue to keep cycling.

Hypothesis one was supported. Cyclists who reported less conflict and did not believe there was a current stigma towards cyclists reported more positive experiences. The frequency of conflict, however, was high. Conflict with vehicles was a big issue, with almost all cyclists experiencing conflict with cars and almost half reported this conflict occurred frequently to very frequently. To provide a more granular understanding that has been explored previously, conflict was asked about across a range of vehicles beyond cars. In this study, there was also a notable percentage of cyclists who sometimes experienced conflict with trucks and other large vehicles. This is unlikely to be specific to our antipodean sample, given data from the UK show that one in five cyclist fatalities in Britain involve a heavy vehicle (British Cycling, 2025). In contrast, few cyclists reported experiencing conflict with other cyclists, suggesting this is not yet an issue in Australia or New Zealand, possibly due to the low mode share and the fact that there are relatively few bike lanes.

These findings align with current research regarding aggression towards cyclists (Poulos et al., 2019). For example, Poulos et al. (2019) found that one in three cyclists in Australia experience aggression from motorists on a weekly basis. Indeed, a recent parliamentary inquiry into vulnerable road users in Victoria, Australia, noted that almost one third of the submission pertained to aggression and risky behaviour around cyclists (Legislative Assembly Economy and Infrastructure Committee, 2024). Further, many felt that this was increasing, or had increased since COVID. Research into the change in behaviour towards cyclists is lacking in Australia and New Zealand yet may be warranted. In line with our initial expectations (see Hypothesis 1), higher perceived conflict and exposure to stigma were common, even though participants generally described their cycling experiences as positive.

Our findings support previous studies suggesting a stigma towards cyclists (Delbosc et al., 2019; Oldmeadow et al., 2019). These studies usually focus on drivers' opinions and show cyclists are seen as not legitimate road users, in the minority, or out-group. Such differences are likely to explain the high conflict with drivers reported in the current study. Research in cycling and driving has shown that anger and aggression are more likely when the target is of lower perceived status, or not in the “in-group”. These hierarchies may also exist within the cycling culture. For example, Daley et al. found that cyclists who are commuters and couriers are often viewed negatively as risk-takers, creating a hierarchy where recreational cycling is more accepted than cycling for transport, which can influence individuals' decisions about cycling (Daley & Rissel, 2011). Other studies have demonstrated a driver vs. active transport

divide by showing that cyclists blame drivers for crashes, but not pedestrians (Paschalidis et al., 2016). Our study adds to these findings by seeking opinions of whether cyclists perceive that stigma from drivers. Almost all did and this was significantly associated with how positive they felt about their cycling experiences.

Our results provided support for the second hypothesis regarding individual differences in the perceived usefulness of countermeasures. Here, we found that cyclists who engaged more often in protective behaviours, reported more conflict, and generally had more positive experiences cycling were also more likely to perceive countermeasures, particularly infrastructure improvements and driver-focused education, as useful. Improved infrastructure was almost unanimously viewed as useful. Given the degree of conflict with drivers and stigma felt by cyclists, it was no surprise that separation of different vehicle types, and education for drivers were also seen by most as useful. It is also interesting to note that our findings suggest cyclists view that the change needs to happen outside of the cycling group. For example, training for cyclists, smart bicycles or more technology in the environment had the lowest percentage of perceived usefulness. This again emphasises the divide between cyclists and motor vehicle drivers and the possible in-group out-group distinction. This pattern is not unexpected as cyclists who experience stigma or frequent conflict may tend to attribute safety problems to the behaviour of other road users or the wider traffic environment rather than to their own skills and therefore feel strongly towards system-level rather than individual-level changes. This leads cyclists to the perception that changing or enforcing driver behaviour is the best countermeasure after infrastructure improvements. Evaluation studies suggest this is a reasonable assumption (King et al., 2020).

Evaluation studies have shown that separation is an effective way to increase safety for cyclists (King et al., 2020). Separation was also one of the recommendations for the recent Parliamentary Inquiry (Legislative Assembly Economy and Infrastructure Committee, 2024). This may have the added benefit of reducing anger or aggression related to perceived legitimacy of road use, stigma and increasing the overall experience of cyclists. Education programs, however, have been shown to be less effective in reducing cyclist trauma (King et al., 2020). However, whether these include elements to reduce stigma or have been effective in reducing stigma, which may then have a knock-on effect on behaviour, is less clear. In Australia and New Zealand, more focus on the reduction of stigma in awareness campaigns would be beneficial.

Any countermeasure will need to be seen as useful to maximise its benefits (Hassel & Wegrich, 2022). If cyclists do not believe a countermeasure is useful, they may be less likely to use it, engage with it or comply with any associated rules. For instance, when infrastructure is not perceived as useful or safe, many cyclists still avoid certain routes or stop cycling altogether. Although our focus is on perceived usefulness, it is important to note that perceptions often reflect broader contextual factors. For example, inadequate infrastructure has been shown to intensify conflicts between drivers and cyclists (Mora et al., 2025) which may in turn shape cyclists' perceptions of what types of countermeasures are useful. In our study, several cyclist factors were linked to perceived usefulness of different measures. Consistent with Hypothesis 2, these characteristics functioned as predictors of perceived usefulness. In particular, cyclists who reported more positive experiences, more frequent conflict, and higher protective behaviour tended to view countermeasures such as training, incentives, or technological support as more useful.

Stigma, in turn, was associated with stronger support for system-level countermeasures such as infrastructure, education, and enforcement, but not with those directly targeting cyclists, like training or improved bicycles. Cyclist-focused measures were instead related to self-reported behaviours, age, and gender. Cycling experiences also played a role: riders who generally enjoyed cycling but still reported frequent conflict were more inclined to endorse improvements, consistent with findings from previous studies in other countries (Mora et al., 2024). Likewise, cyclists reporting more protective behaviours were more likely to value technological interventions, suggesting receptiveness to environmental support when aiming to ride as safely as possible.

To aid interpretation of these findings, the countermeasures can be considered according to the level at which they must be implemented. System-level measures that require legislative or regulatory action, such as enforcement, driver-focused education, or infrastructure separation, showed a consistent pattern in which perceived stigma and more frequent conflict are key predictors of perceived usefulness. This suggests that cyclists who feel marginalised (i.e. perceive more stigma) or less safe (i.e. more conflict) may place greater value on interventions that require structural change beyond their individual control. Infrastructure-based interventions, such as improvements to cycling networks, were also more likely to be viewed as useful by cyclists reporting more frequent conflict and protective behaviour, indicating a desire for environmental solutions to risk. In contrast, individual-level countermeasures, such as cyclist training, incentives, or smart bicycles with assistance technologies were primarily associated with riders' own behaviours, age, and gender. This conceptual grouping clarifies the distinctions between countermeasures and highlights that different cyclist characteristics predict perceived usefulness depending on whether a measure targets individual skills, environmental design, or broader systemic change.

4.1. Limitations of the study

While this research covered a broad sample of cyclists from two countries, some limitations should be considered when interpreting the findings. First, the study relied on self-reported data, which may be affected by socially desirable responding. As with most survey-based designs, it is not possible to fully verify whether participants' answers reflect their actual attitudes and behaviours, or what they believe is expected. Responses may also have been influenced by memory limitations or other common psychosocial biases (Podsakoff et al., 2012; Selaya et al., 2024). Further, the concept of conflict was not defined beyond asking respondents if they had experienced "any form" of conflict. This may have individual variation in what this represented. Steps were taken to reduce the possibility of this, which included ensuring anonymity of respondents and allowing participants to complete the questionnaire at a time and location of their choosing.

Another limitation is that the sample included only current cyclists. Attitudes towards cycling, stigma, and safety countermeasures

may differ among those who ride infrequently, have stopped cycling, or do not intend to ride. We believe that including these groups in future research would provide a broader perspective on the topic.

The sample was also predominantly men. However, this fits with the gender breakdown of adult cyclists in both Australia (men = 60 %; Munro, 2023) and New Zealand (men = 65 %; Shaw et al., 2020). Our sample had an average age of 50, which means that younger adults riders are less represented in the sample.

Finally, stigma was assessed using a single-item measure. Given the potential importance of stigma demonstrated in previous literature and in our current study, a multidimensional measure of stigma may be needed to comprehensively understand elements underpinning this. While this study captures cyclists' perceptions of countermeasure usefulness, it is important to note that these perceptions may not align with actual efficacy. Cyclists may have incomplete understandings of traffic dynamics or safety interventions. Therefore, future research should triangulate perception data with empirical safety outcomes to ensure that recommended measures are both subjectively reassuring and objectively effective.

5. Conclusions

Our findings suggest that cyclists generally support a variety of safety countermeasures, although their perceived usefulness appears to depend on individual riding experiences and behavioural profiles. These countermeasures range across the transport system including cyclist-focussed, other-road user focused and safer infrastructure. Particularly, riders reporting more conflict or protective behaviours were more likely to endorse countermeasures, while those perceiving stigma tended to support broader system-level changes.

From a practical perspective, these countermeasures likely vary in the time and effort required to implement. Some (e.g., promoting more supportive attitudes towards cyclists and reducing perceived stigma) may be more immediately actionable for improving cycling experiences, enhancing safety outcomes, and supporting cycling as a forward-looking mode of transport.

CRediT authorship contribution statement

A.N. Stephens: Writing – review & editing, Writing – original draft, Software, Resources, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation. **S. O'Hern:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Data curation, Conceptualization. **D. Yong:** Writing – review & editing, Writing – original draft. **V. Beanland:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Funding acquisition, Data curation, Conceptualization. **S.A. Useche:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Data curation, 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.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.trf.2025.103498.

Data availability

The data that has been used is confidential.

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