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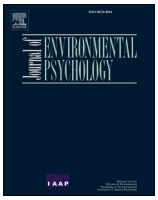

Quantifying the importance of socio-demographic, travel-related, and psychological predictors of public acceptability of low emission zones

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ABSTRACT

As ambient air pollution increases, governments are imposing traffic management strategies to improve air quality. A common strategy is the implementation of Low Emission Zones (LEZs), which have generated considerable public debate. Nonetheless, little research has explored which factors determine their public acceptability. Previous empirical studies have also typically lacked power for regression analyses and have not determined the relative importance of different predictors. After conducting a large online survey in a UK city, well-powered multiple regression and dominance analyses demonstrated that psychological factors, such as environmental moral obligation, were the most important predictors of LEZ acceptability. However, travel-related and socio-demographic factors, such as distance lived from the LEZ and having dependent children, were also unique and important predictors. Overall, we argue that, whilst psychological factors are important, travel-related and socio-demographic barriers must not be overlooked during LEZ implementation.

1. Introduction

Air pollution is consistently cited as the single largest environmental health risk worldwide, causing approximately 6.4 million premature deaths each year (European Environment Agency, 2018). This pollution is responsible for various adverse health effects, including cardiovascular and respiratory diseases, poorer mental health, and atypical cognitive development (e.g., Bakolis et al., 2020; Cepeda et al., 2017). As a result of such poor health outcomes, the Organisation for Economic Co-operation and Development (OECD, 2016) projects that air pollution will cost 1% of global GDP (~$2.6 trillion) by 2060 if no action is taken. The transportation sector is the world's second greatest carbon emitter (Giannakis et al., 2020) and is responsible for 21% of global greenhouse gas emissions (International Energy Agency, 2019). Moreover, road transport accounts for 92% of all carbon dioxide emissions within the sector (González et al., 2019). Since carbon dioxide produced by human activities is the largest contributor to climate change (Leduc et al., 2015), governments are urgently seeking to lower air pollution using traffic management strategies.

A common strategy to address air pollution in European cities is the introduction of Low Emission Zones (LEZs), also known as Clean Air Zones (Glazener & Khreis, 2019). LEZs aim to reduce combustion-powered vehicle use in urban areas and promote the use of ultra-low emission vehicles, public transport, and active travel (Szarata et al., 2017). Whilst restrictions differ between local authorities, this is typically achieved by charging vehicles that do not meet emission standards to enter the zone. In some cities, these charges apply to both commercial and private vehicles, whereas others only charge commercial vehicles. In the city explored in the current study, Bath, private cars are not charged, whilst all commercial vehicles, and private light- or heavy-goods vehicles, are subject to charges. Almost 300 LEZs have been implemented across Europe, and evidence supports their efficacy in reducing ambient Nitrogen Oxides (Morfeld et al., 2014) and particulate matter (Malina & Scheffler, 2015). However, whilst research has explored the efficacy of LEZs where it has been possible to implement them, little work has investigated their public acceptability, which has

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been a major barrier to their implementation more widely (e.g., Rye et al., 2008). Indeed, by considering the varying needs of different groups, policy measures are more likely to be widely accepted, and therefore successful (Howarth et al., 2020). With public opinion being such a core determinant of policy efficacy, governments are hesitant to implement policies that will not be accepted by the general public (Drews & van den Bergh, 2016). Since introducing policies that restrict personal mobility choice is highly contentious, LEZs have garnered significant public opposition (e.g., Christiansen, 2018). Unsurprisingly, this has led to the major redesign or even termination of LEZ plans in several regions, thereby hampering the reduction of air pollution (see Gaunt et al., 2007; Hysing & Isaksson, 2015; Vigar et al., 2011). For example, plans for the LEZ investigated in the current study were redesigned following public concerns (Jacobs Consultancy, 2019). Similarly, a road charging scheme in Edinburgh (UK) was overturned after three quarters of residents voted against its implementation (Gaunt et al., 2007) and a LEZ was abandoned in Manchester (UK) after rejection by 79 percent of voters (see Hensher & Li, 2013). This resulted in the costly redesign of both cities' LEZs, following public consultation (Edinburgh Council, 2022; UK Government, 2021). To help understand such outcomes, and improve future LEZ implementation, we sought to establish which factors were most important in determining the public rejection and acceptance of LEZs.

Emerging LEZ research has typically used psychological frameworks to select predictors of acceptability (Morton et al., 2021; Oltra et al., 2021) or taken a more data-driven approach (e.g., Tarriño-Ortiz et al., 2021). Whilst little research has specifically investigated LEZ acceptability, a larger body of work has explored the acceptance of similar environmental policies, such as congestion charges (e.g., Li et al., 2020). Although comparable, congestion charges primarily aim to improve the operation of a city's transport system and are not designed to reduce the concentration of local air pollutants or enhance the general liveability of cities (see Morton et al., 2021). Nonetheless, this body of work has provided useful clues about factors that might determine the public acceptability of LEZs. Collectively, these strands of environmental research have highlighted the importance of socio-demographic, travel-related, and psychological factors, which has informed the focus of the present study.

1.1. Socio-demographic factors

Existing research has indicated that, after accounting for travel-related and psychological variables, little variance in LEZ acceptability is uniquely explained by socio-demographic factors (Oltra et al., 2021). Nevertheless, small but relatively robust links exist between higher levels of education and stronger acceptability of congestion charges (Eliasson & Jonsson, 2011). Higher income is generally related to greater car use and fuel consumption (Oswald et al., 2020), and overall reduced acceptability of transport policies (Ejelöv & Nilsson, 2020). Equally, forced car use may occur in particularly low-income communities, in which individuals report being unable to afford alternative transportation (Curl et al., 2018; Currie & Senbergs, 2007), perhaps reducing LEZ acceptance.

Student status has also previously predicted high support of congestion charges (Li et al., 2020) and a major European LEZ (Tarriño-Ortiz et al., 2021). Other socio-demographic factors, such as having children, increase the likelihood of using private over public transportation (Ding et al., 2017). Therefore, whilst not directly investigated to date, LEZ acceptability is likely to be lower amongst parents with dependent children. More basic socio-demographic factors, such as sex and age, have yielded mixed results. For example, some studies found females were more likely than males to vote in favour of congestion charges (Hårsman & Quigley, 2010), yet others observed they were more likely to remain neutral (Li et al., 2020), or found no effect (Oltra et al., 2021). Similarly, whilst older age typically predicts lower LEZ acceptability due to increased dependence on automobility (Nikitas et al., 2018), some studies have found higher acceptability in older people (Basbas et al., 2015). These mixed findings, alongside predominantly data-driven approaches (Tarriño-Ortiz et al., 2021) and uncertainty surrounding variables' relative importance (Drews & van den Bergh, 2016), underscore the need for additional research to understand the unique contributions of socio-demographic factors to LEZ acceptability.

Another potentially critical reason previous research has found little contribution of socio-demographic factors to LEZ acceptance may be due to other individual differences not being accounted for in analyses. Most notably, preliminary work shows that physically disabled individuals are more averse to LEZs due to increased car dependency (Morton et al., 2018; Smith & Symonds, 2019). Similarly, individuals with mental health conditions report difficulties using public transport due to heightened anxiety, potentially limiting acceptability (Mackett, 2021; Taylor et al., 2021). Considering the United Nation's call for a 'disability-inclusive' approach to environmental policy (Human Rights Council, 2019), it is striking that no existing work has explored the contribution of disability to LEZ acceptability, which will be accounted for in our research. Overall, this study aimed to examine the contributions of several socio-demographic factors to LEZ acceptability, whilst accounting for travel-related and psychological factors.

1.2. Travel-related factors

Broadly speaking, whilst travel-related factors appear important predictors of LEZ acceptability, existing research is sparse and largely exploratory, as the psychological models adopted by previous research either exclude them (e.g., Morton et al., 2021) or only include limited travel-related variables (e.g., Nikitas et al., 2018; Oltra et al., 2021). A small body of data-driven research has explored the links between travel-related variables and LEZ acceptability, noting that they typically account for more variance than socio-demographic factors (e.g., Sfendonis et al., 2017; Tarriño-Ortiz et al., 2021). This work reliably identifies car ownership and access to a private vehicle as predictors of lower LEZ acceptability, potentially driven by self-interest (see Allen et al., 2006; Nielsen et al., 2021). Other travel-related factors, such as frequent use of shared mobility services, have also been linked to lower acceptability, whilst frequent public transport use has previously predicted higher acceptability (Tarriño-Ortiz et al., 2021). Two preliminary studies have explored how travel-related factors, such as living inside charging zones, impact acceptability, finding that individuals living within zones were marginally more likely to accept congestion tolls and LEZs (Hårsman & Quigley, 2010; Sfendonis et al., 2017). Both studies, however, used proxy measures of public acceptance such as likelihood to vote for a permanent congestion toll and willingness to pay to enter the zone. Additionally, neither study investigated how physical distance from a LEZ impacts acceptance. Accordingly, we propose that a more nuanced exploration is warranted, to understand if the public concerns often emphasised during consultation (Bath and North East Somerset Council [B&NES], 2021), about increased travel time, traffic displacement, and heightened air pollution in regions outside the LEZ, are conducive to reduced acceptance. The relative importance of these travel-related variables will be explored in the current study, whilst accounting for socio-demographic and psychological factors.

1.3. Psychological factors

Previous research has noted that psychological factors typically have the highest explanatory power to explain LEZ acceptability (Oltra et al., 2021). This work generally uses theoretical frameworks to explain acceptance. One common framework is the Value-Belief-Norm theory

(VBN; Stern et al., 1999), which proposes that acceptability is formed via values, beliefs, and personal moral norms. For example, pro-environmental beliefs predict LEZ acceptability, likely because environmentally conscious individuals are more likely to perceive the seriousness of urban pollution and importance of mitigation policies (see Eriksson et al., 2008). Research has also noted that other beliefs such as left-wing political ideologies predict acceptability, even when controlling for environmental identity (Ejelöv & Nilsson, 2020; Tarriño-Ortiz et al., 2021). This suggests that, when predicting policy acceptance, political ideology captures information that is distinct from other psychological factors (see Harring et al., 2017).

Other, more policy-specific beliefs, have previously been shown to predict LEZ support. For example, research suggests that individual, collective, and environmental perceptions of a policy's outcome impact acceptability (Ejelöv & Nilsson, 2020), as well as one's overall evaluation of a LEZ (Oltra et al., 2021). Despite this finding, existing work has not determined whether perceptions of a LEZ's suitability, particularly of its stringency, may affect acceptability. Considering that LEZs differ in their restrictions, such policy-level perceptions may be important determinants of acceptability and were investigated in the current study. Other core elements of the VBN framework, such as moral personal norms, experienced as feelings of moral obligation to preserve the environment (Kiatkawsin & Han, 2017) have been shown to reliably predict pro-environmental behavioural change such as reduced car use, and are especially predictive of accepting costlier behavioural changes, as is necessary for LEZs (Andersson, 2020). Previous research has demonstrated that moral obligation mediates the relationship between environmental identity and pro-environmental behaviour (van der Werff et al., 2013). Since place attachment has previously fostered a shared moral obligation to take climate action (Devine-Wright, 2013; Feitelson, 1991), it is likely that moral factors will impact local residents' attitudes towards LEZs. Previous work, however, has never investigated whether feelings of moral obligation uniquely predict LEZ acceptability when accounting for political orientation and environmental identity, which this study will address.

Further, whilst theoretical frameworks like the VBN allude to the importance of psychological factors when predicting LEZ acceptability, they have broadly neglected the contributions of socio-demographic and travel-related variables. Indeed, previous work has questioned the VBN's ability to predict higher-impact pro-environmental behaviours, owing to its omission of important contextual factors (Whitmarsh et al., 2021). Subsequently, previous work has not conclusively determined if psychological factors are the most important considerations when implementing LEZs, which we aim to determine in the current study.

1.4. Overview of the current research

Previous work has been either exploratory and data-driven or largely based upon psychological theories. The current research adopts a balanced approach: drawing upon relevant theory and literature to select predictors of LEZ acceptability, whilst considering previously overlooked socio-demographic and travel-related factors, such as disability and distance lived from the LEZ. Crucially, this study is the first to respond to calls for an evaluation of the relative importance of predictors (Drews & van den Bergh, 2016), where we precisely quantify the relative statistical contributions (and hence importance) of several socio-demographic, travel-related, and psychological factors to LEZ acceptability. Owing to their very recent introduction, LEZ acceptability has never been specifically explored in the UK. The current research therefore draws upon a timely opportunity to explore LEZs in a UK context, prior to the implementation of Bath's 'Clean Air Zone' (see Fig. 1), with the view of aiding LEZ development and implementation in other cities.

2. Method

2.1. Participants, measures, and procedure

A large, broadly representative sample of 1,281 residents in Bath completed a set of measures as part of a larger online study (see Table 1 for participant characteristics). The wider study consisted of measures not directly relevant to the current research question (e.g., identity strength to different transport types; Bath social identity). To maximise statistical power to address our main question, we did not include these measures in our analyses. The data used in the present study are provided in the Supplementary Material. Power analyses indicated that our sample size gave us 95% power to detect small ($f^2 = 0.02$) unique effects in the regression analyses ($\alpha = 0.05$, 2-tailed). The survey – advertised via local government newsletters, flyers, and social media – was completed between December 2019 and January 2020, that is, before both the COVID-19 pandemic and LEZ implementation (March 2021).

Ahead of the LEZ's introduction, this study was co-designed with Bath and North East Somerset Council's 'Clean Air Zone' project team to inform its implementation. Ethical approval was granted by the relevant University's local ethics committee (project code: 19-214). Participants gave informed consent, completed the following measures, and were debriefed upon study completion. To encourage diverse local participation, respondents entered a prize draw to win one of six £250 gift cards that could be spent at local businesses, thereby bringing an economic return to the city.

2.1.1. Socio-demographic factors

Participants reported their sex (male, female, other) and age (years). Participants also reported whether they had a physical and/or mental health condition, any dependent children, and their employment and/or student status. Educational level was assessed using an adapted 6-point scale from the International Standard Classification of Education (0 = No qualifications, 5 = Doctoral degree; UNESCO Institute for Statistics, 2012). Respondents also reported their annual salary, from 11 options (<£10,000 – >£100,000, in increments of £10,000).

2.1.2. Travel-related factors

2.1.2.1. Frequency of transportation use. Participants reported their frequency of using eight modes of transport per week (car, bus, train, park & ride, walking, bicycle, taxi, car club) on a 7-point scale (1 = Never, 2 = Occasionally, 3 = Once, 4 = Twice, 5 = 3-4 times, 6 = 5-6 times, 7 = Every day). Following previous research (e.g., Tarriño-Ortiz et al., 2021), mean composite variables were created for public transport (bus, train, park & ride), active transport (walking, bicycle), and shared

[2] Bath, a UNESCO World Heritage site and major city in southwest England, was the first to propose a UK charging zone outside of London. The scheme aimed to meet legal nitrogen dioxide concentrations (40μg/m^3) by December 2021 (B&NES, 2018). Whilst the zone was originally proposed to charge all vehicles, including privately-owned cars, this was changed in response to public concerns (B&NES, 2018). Bath's charging zone is formally known as the 'Clean Air Zone'. Since Clean Air Zones are known as LEZs outside of the UK, we henceforth refer to Bath's 'Clean Air Zone' as a LEZ. The current scheme, introduced in March 2021, charges a daily fee of £9 for vans and private hire vehicles such as taxis, and £100 for heavy goods vehicles, buses and coaches that do not meet the required emission standards (Euro 4 petrol; Euro 6 diesel). From *Charging Clean Air Zone Launches in Bath in Bid to Drastically Cut Air Pollution,* by Bath Echo, 2021. (https://www.bathecho.co.uk/news/community/charging-clean-air-zone-launches-in-bath-in-bid-to-drastically-cut-air-pollution-93838/). Copyright 2022 by Bath Echo.

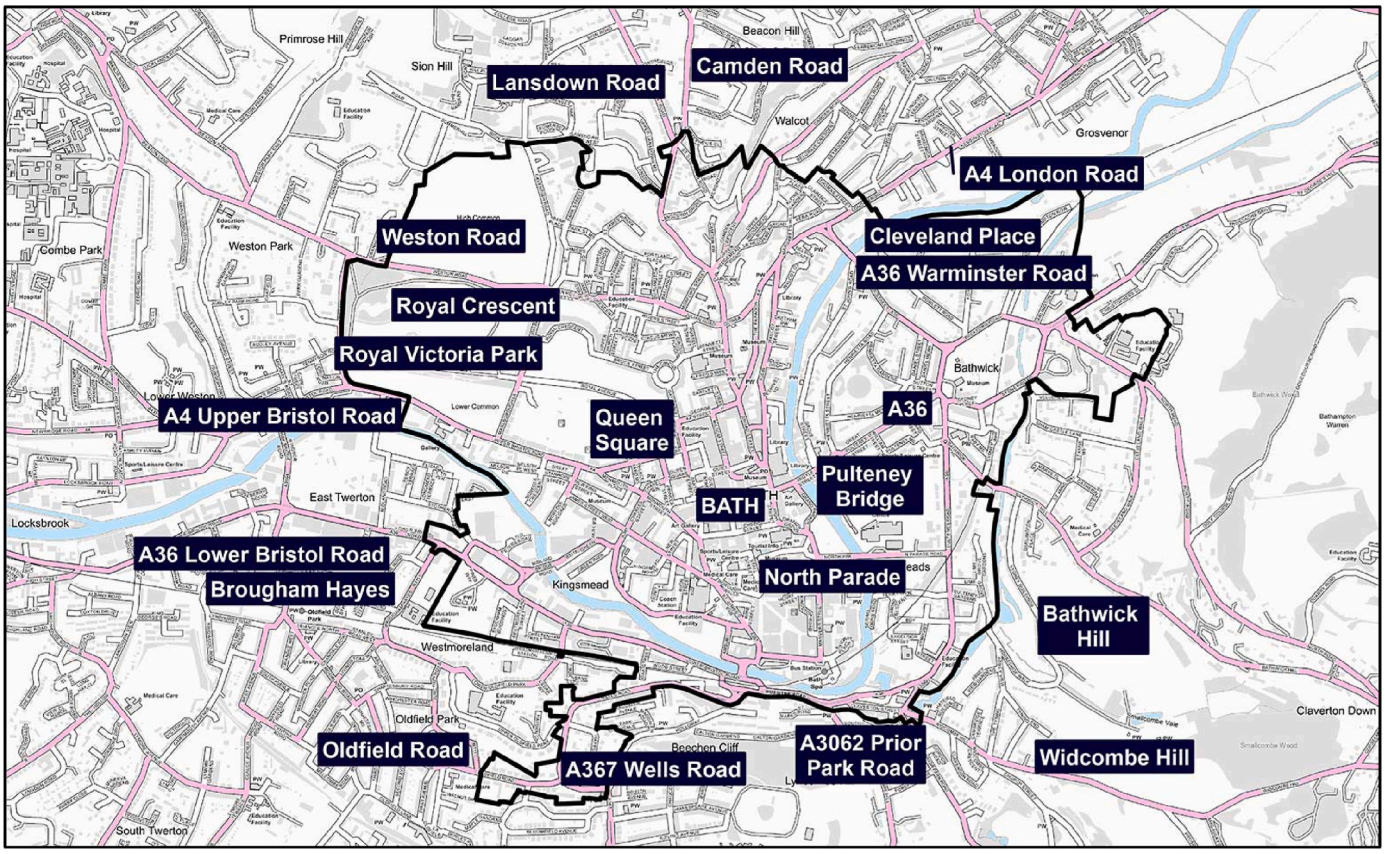

Fig. 1. *Bath's 'Clean Air Zone' Low Emission Zone*[2].

Table 1
Sample characteristics compared to Bath and North East Somerset Census Statistics.

Characteristic	Current Sample	Bath Census 2011
Sex (% Male)	41.1	48.9
Mean Age	39.0	40.3
Employment Status (% Employed)	69.6	61.0
Disability (% Prevalence)	16.8	16.1
Dependent Children (%)	29.7	26.0

mobility (taxi, car club) use.

2.1.2.2. Distance lived from LEZ. Participants reported their postcodes and we filtered out entries that were not valid Bath and North East Somerset codes (6-8 characters long and start with 'BA', 'BS14', 'BS18', 'BS31', 'BS39', 'BS40', or 'BS41'). Postcodes were transformed to latitude and longitude coordinates using gridreferencefinder.com/postcodeBatchConverter and the Great-Circle Distance Equation (see Equation (1)) was used to calculate the participant's distance (in kilometres) from the centre of the LEZ.

$$d = r\,\theta \tag{1}$$

Where d = distance, r = average radius of the earth, θ = angle between the two locations, with respect to the centre of the earth.

2.1.3. Psychological factors

2.1.3.1. Environmental moral obligation. Participants answered five questions adapted from Onwezen et al. (2013), on a 7-point scale (1 = Strongly disagree, 7 = Strongly agree). Items read: 1) '*People have a responsibility to avoid driving in the Clean Air Zone*'; 2) '*People shouldn't have to feel guilty if they use a car in the Clean Air Zone*'; 3) '*It would be socially unacceptable to choose to drive in the Clean Air Zone*'; 4) '*Continuing to drive in the Clean Air Zone wouldn't really cause any harm*'; 5) '*I feel personally responsible for limiting how often I will drive through the Clean Air Zone*'. Items (2) and (4) were reverse coded. A composite variable was created using their mean ($\alpha = 0.81$).

2.1.3.2. Environmental identity. Participants reported their environmental identity using three questions adapted from Carfora et al. (2017) on a 7-point scale (1 = Totally disagree, 7 = Totally agree). Items read: 1) '*Acting in an environmentally-friendly way is an important part of who I am*'; 2) '*I am the type of person who acts in an environmentally-friendly way*'; 3) '*I see myself as an environmentally-friendly person*'. A composite variable was created using their mean ($\alpha = 0.89$).

2.1.3.3. Political orientation. Participants reported their political orientation in response to a widely used question (e.g., Nilsson et al., 2020): *'In politics people sometimes talk of 'left' and 'right'. Please indicate on the scale where you consider yourself to be on the left-right political spectrum'*, on an 11-point scale (0 = Very left-wing, 10 = Very right-wing).

2.1.3.4. Perceptions of LEZ stringency. Participants reported their perceptions of the current LEZ's stringency in response to the statement: '*We are interested to hear your opinion about whether or not you think the currently-proposed scheme goes too far, doesn't go far enough, or is about right in terms of its approach to addressing the air quality issues associated with vehicles in Bath*', on an 11-point scale (0 = Not far enough, 10 = Too far).

2.1.4. LEZ acceptability

After reading a description of the proposed LEZ, participants

reported their support for the LEZ in response to the question, '*On the scale below, please indicate your level of* support *for the above scheme*', on a 7-point scale (1 = Completely oppose, 7 = Completely support).

3. Results

3.1. Descriptive statistics and correlational analyses

The means and variances were examined, and correlational analyses showed that several variables were related to LEZ acceptability (Table 2). Two socio-demographic variables, higher education level ($r = 0.07$, $p = .008$), and not having dependent children ($r = -0.07$, $p = .013$), were significantly correlated with higher acceptability. A travel-related variable, active transport use, was correlated with higher LEZ acceptability ($r = 0.10, p < .001$), whereas increased distance lived from the LEZ was correlated with lower acceptability ($r = -0.15$, $p < .001$). All psychological factors were correlated with LEZ acceptability. Perceiving the LEZ as not stringent enough ($r = -0.32$, $p < .001$) and more left-wing political orientation ($r = -0.13$, $p < .001$) were correlated with increased LEZ acceptability, alongside increased environmental identity ($r = 0.24, p < .001$), and moral obligation ($r = 0.36, p < .001$). Crucially, however, since several variables were significantly related to LEZ acceptability, a regression approach was essential to establish the unique contributions of each variable.

3.2. Regression and dominance analyses

A multiple regression quantified the unique associations of the outlined socio-demographic, travel-related, and psychological predictors with LEZ acceptability (Table 3). Considering the socio-demographic variables, younger age ($\beta = -0.01$, $p = .032$), higher income ($\beta = 0.05$, $p = .036$), and not having dependent children ($\beta = -0.32$, $p = .002$) predicted higher acceptability. Education no longer predicted acceptability, once other variables had been accounted for. Similarly, active transport was no longer a significant predictor in the regression, and car use positively predicted LEZ acceptability ($\beta = 0.09, p < .001$). Shorter distance lived from the LEZ ($\beta = -0.05$, $p < .001$) predicted increased acceptability. Perception that the LEZ was not stringent enough ($\beta = -0.12, p < .001$) was predictive of higher LEZ acceptability and political orientation was no longer predictive. As expected, stronger environmental identity ($\beta = 0.16$, $p < .001$) and moral obligation ($\beta = 0.32$, $p < .001$) predicted increased acceptability.

Much existing research draws conclusions about the importance of predictor variables in a multiple regression by comparing their standardised beta coefficients. However, this practice has been increasingly cited as a misuse of regression approaches (see Karpen, 2017), and criticised due to potential suppression effects that arise when one predictor is more strongly correlated with other predictors than it is with the outcome variable (Mizumoto, 2022). This can result in standardised beta coefficients becoming skewed and difficult to compare accurately. Since predictors are almost always correlated (as in our study; see Table 2), it is possible that some predictors may have been suppressed, yielding skewed beta coefficients. It was therefore not appropriate to use the size of a predictor's beta coefficients to determine its relative importance to LEZ acceptability (Budescu, 1993).

To allow for comparison of the relative importance of predictors, novel approaches such as dominance analyses have been suggested (Budescu, 1993; see Mizumoto, 2022). Dominance analysis, as increasingly used in psychological science (e.g., Hargitai et al., 2023), estimates a predictor's importance by determining the change in R^2 of the regression model when adding one predictor to all possible predictor combinations. This yields General Dominance Weights (GDWs), which reflect the predictor's importance by itself, and in combination with other model predictors - thereby ranking each predictor's relative importance to the outcome variable. This technique allows for model-independent conclusions about the statistical importance of each

Table 2
Descriptive statistics and correlations.

Predictor	*M (SD)*	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. LEZ Acceptability	5.03 (1.66)	–																
2. Sex	0.41 (0.49)	−.01	–															
3. Education	3.07 (0.99)	.07*	−.02	–														
4. Age	38.98 (15.26)	−.02	.11**	.12**	–													
5. Employed	0.70 (0.46)	−.03	.05	.23**	.15**	–												
6. Student	0.19 (0.39)	.03	−.04	−.24**	−.54**	−.72**	–											
7. Income	3.28 (2.30)	.02	.28**	.26**	.31**	.44**	−.43**	–										
8. Children	0.30 (0.46)	−.07*	.00	.16**	.20**	.29**	−.29**	.27**	–									
9. Disability	1.83 (0.37)	−.01	−.08*	.03	.05	−.09**	−.04	−.08*	−.10**	–								
10. Public Transport	2.07 (0.73)	.05	−.07*	−.07*	−.24**	−.27**	.33**	−.17**	−.20**	.06*	–							
11. Active Transport	2.75 (0.93)	.10**	.12**	.12**	.04	.02	.00	.05	.04	−.07*	.08*	–						
12. Shared Mobility	1.54 (0.56)	.01	−.02	−.04	−.11**	−.02	.05	.03	−.04	.01	.05	−.06*	–					
13. Car Use	4.05 (2.14)	−.05	.04	.02	.28**	.28**	−.34**	.20**	.30**	−.07*	−.38**	−.31**	.01	–				
14. Distance from LEZ	3.08 (3.56)	−.15**	.01	−.06*	.04	.11**	−.12**	.03	.10**	.01	−.04	−.27**	−.04	.31**	–			
15. Stringency Perception	4.27 (2.41)	−.32**	−.04	−.18**	−.10**	−.07*	.08*	−.20**	−.07*	.01	.00	−.28**	.02	.08*	.14**	–		
16. Political Orientation	3.89 (1.81)	−.13**	.15**	−.14**	.06*	−.04	−.01	.14**	−.01	−.09*	−.05	−.11**	−.01	.10**	.05	.25**	–	
17. Environmental ID	5.55 (0.94)	.24**	−.17**	.08*	−.01	.02	.02	−.09*	−.03	.03	.07*	.21**	−.02	−.16**	−.07*	−.30**	−.28**	–
18. Moral Obligation	4.62 (1.32)	.36**	−.10**	.08*	.03	−.08*	.06*	−.07	−.03	.01	.13**	.27**	−.03	−.23**	−.15**	−.46**	−.22**	.44**

*$p < .05$, **$p < .001$.

Table 3
Multiple regression and dominance analyses for LEZ acceptability.

Category	Predictor	*B*	SE_B	*β*	*t*	*p*	sr^2	95% BCa CI		GDW	Predictor Rank
								Lower	Upper		
Socio-Demographic	Sex	0.08	0.09	0.02	0.80	.421	0.000	−0.10	0.26	–	–
	Education	0.03	0.05	0.02	0.71	.480	0.000	−0.06	0.13	–	–
	Age	−0.01	0.00	−0.08	−2.14	.032	0.003	−0.02	0.00	0.002	7
	Employed	−0.14	0.16	−0.04	−0.89	.375	0.000	−0.44	0.17	–	–
	Student	−0.07	0.20	−0.02	−0.32	.752	0.000	−0.46	0.36	–	–
	Income	0.05	0.02	0.07	2.10	.036	0.003	0.00	0.10	0.002	8
	Dependent Children	−0.32	0.10	−0.09	−3.11	.002	0.006	−0.52	−0.12	0.006	5
	Disability	−0.05	0.12	−0.01	−0.42	.677	0.000	−0.16	0.29	–	–
Travel-Related	Public Transport Use	0.06	0.06	0.03	0.93	.354	0.001	−0.07	0.19	–	–
	Active Transport Use	−0.07	0.05	−0.04	−1.33	.183	0.001	−0.17	0.03	–	–
	Shared Mobility Use	0.01	0.08	0.00	0.07	.945	0.000	−0.13	0.13	–	–
	Car Use	0.09	0.03	0.11	3.47	<.001	0.008	0.04	0.14	0.004	6
	Distance from LEZ	−0.05	0.01	−0.11	−4.16	<.001	0.011	−0.08	−0.03	0.014	4
Psychological	Stringency Perception	−0.12	0.02	−0.18	−5.88	<.001	0.022	−0.17	−0.07	0.057	2
	Political Orientation	−0.02	0.03	−0.02	−0.65	.517	0.000	−0.07	0.04	–	–
	Environmental ID	0.16	0.05	0.09	3.17	.002	0.006	0.05	0.28	0.026	3
	Moral Obligation	0.32	0.04	0.25	8.01	<.001	0.041	0.23	0.41	0.078	1

Model Fit: $F(17, 1280) = 17.70$, $p < .001$, $R^2 = 0.192$, $R^2_{adj} = 0.182$.
Note. Sex was coded as female = 0, male = 1. Employment status was coded as 0 = unemployed, 1 = employed, student status as 0 = non-student, 1 = student. Disability was coded as 0 = no disability, 1 = disability. 95% bootstrapped bias-corrected and accelerated confidence intervals (95% BCa CI) with 1,000 resamples are reported. Ranked predictors are based on General Dominance Weights (GDW).

predictor, which is otherwise not possible using multiple regression (Nimon & Oswald, 2013). The dominance analysis was conducted using the *yhat* package in R (Nimon et al., 2013). Since this analysis sought to understand the order of importance of predictive variables, variables that were not significant in the regression were excluded from the model.

The dominance analysis showed that high environmental moral obligation was the most dominant predictor of acceptability, followed by perception that the LEZ is not stringent enough, high environmental identity, shorter distance lived from the LEZ, and having no dependent children (see Table 3 for GDWs and ranked predictors). Bootstrapping with 1,000 resamples quantified the likelihood that the same sequence of predictors would emerge in the population based upon the frequency of their occurrence in the bootstrapped sample, that is, Reproducibility Rates (RRs). As all RRs were ≥70%, there was high confidence that the observed dominance ranking would exist in the population (Azen, 2013). Indeed, the analysis suggested that moral obligation dominated perceptions of LEZ stringency (RR = 89.1%), perceptions of LEZ stringency dominated environmental identity (RR = 96.8%), environmental identity dominated distance from LEZ (RR = 88.1%), and distance from LEZ dominated having dependent children (RR = 89.1%).

4. Discussion

This study quantified the relative contributions of socio-demographic, travel-related, and psychological variables to LEZ acceptability, in a UK city. Whilst psychological predictors yielded the highest explanatory power, certain travel-related and socio-demographic factors were also unique and important predictors of LEZ acceptability.

4.1. Socio-demographic factors

Whilst the largely non-significant findings of socio-demographic factors initially appeared to support previous thinking (e.g., Ejelöv & Nilsson, 2020), having dependent children was the fifth most important predictor of lower acceptability. Considering that parents generally perceived the current car-exempting LEZ as not stringent enough (see Table 2), their lower LEZ acceptance may be due to concerns that exempting cars may increase their children's exposure to pollutants when travelling to school. Indeed, it has previously been demonstrated that, compared to being driven, children are exposed to more pollutants when walking or cycling to school (Dirks et al., 2016; Karanasiou et al., 2014).

Alternative explanations, such as perceived inconvenience, may also explain low parental support of LEZs. For example, parents may anticipate an increase in public transport and shared mobility demand and prices driven by charges to commercial vehicles. Similarly, parents may be concerned about the potential inconvenience of taking their children into the city centre if the scheme was updated to charge private cars. Indeed, parents typically opt to drive their children to school and activities for convenience-, time-, and safety-related reasons (Westman et al., 2017). In these scenarios, these behaviours are often perceived as being 'essential' (Lee et al., 2013), demonstrating a lack of perceived behavioural control, and reducing one's feelings of responsibility towards changing their behaviour (see Schade & Schlag, 2003). Such convenience explanations are consistent with theories suggesting that personal outcome expectations are one of the most influential predictors of policy acceptability, meaning that individuals are less accepting of policies when they involve a high personal cost and little perceived personal benefit (Schade & Schlag, 2003).

Given that the relationship between having dependent children and LEZ acceptance has seldom been considered in previous research, policy-specific beliefs, such as high perceived personal costs, may have previously explained lower acceptability of LEZs amongst parents with dependent children (Morton et al., 2021). Future work would therefore benefit from exploring whether the association between having children and lower LEZ acceptability is best explained by psychological factors, such as perceived personal costs, or the practical barriers associated with parenthood (e.g., convenience or safety concerns). For example, future research could explore whether implementing accessible, safer public transport could enhance LEZ acceptance due to a reduced need to accompany their children, or if low parental acceptance stems from a lack of understanding of the potential personal benefits of LEZs.

Although not as important as having dependent children, and a relatively weak finding, lower income was a unique predictor of low LEZ acceptability. Our finding that people on lower incomes perceived the LEZ as too stringent indicates that they may be concerned about the financial cost of an ultra-low emission vehicle if a future LEZ charged private cars. Therefore, despite lower income communities generally being exposed to more traffic-related pollution (Finkelstein et al., 2003), our finding reflects previous research showing that people on lower

incomes are typically more car dependent (Curl et al., 2018), and may be more likely to reject a future car-inclusive LEZ. Considering the onus on policy-specific beliefs in previous research (e.g., Morton et al., 2021), variables such as lower perceived fairness of LEZ charges may have previously accounted for the variance explained by income in the current study. It is therefore unclear if people on lower incomes are less accepting of LEZs because they perceive the policy as less fair or if more practical financial barriers underpin this low acceptability. Although the former is often assumed, this gap in understanding highlights the complexities of this relationship and the need for better consultation of lower income communities.

Such findings echo the importance of understanding the divergent needs of different groups to address barriers to the overall public acceptance of LEZs. Extending previous literature, the current study accounted for disability when measuring LEZ acceptance. Whilst no relationship was found, this null result may have arisen because different conditions predict acceptability in differing ways. For example, those with mobility impairments, who are particularly reliant on buses and taxis (Clery et al., 2017), may be less accepting of LEZs due to concerns about charges to commercial vehicles being passed onto them. In contrast, those with respiratory conditions may be more accepting, given the air quality benefits (Morfeld et al., 2014). Whilst the current dataset does not permit the separation of disability types, future work should explore whether different disabilities predict differing levels of acceptance. Relatedly, future research could also investigate how interactions between disability and other socio-demographic variables may influence LEZ acceptability. Previous research, for example, has theorised that disabled individuals on lower, compared to higher, incomes are more likely to experience environmental harms (Jampel, 2018), indicating that there may be a complex relationship between disability, income, and LEZ acceptance.

4.2. Travel-related factors

Beyond socio-demographic factors, previous literature has overlooked the importance of travel-related variables. Our finding that greater car use predicted higher LEZ acceptability was perhaps unsurprising, given that Bath's LEZ currently exempts private cars. Drivers may therefore be more likely to accept the LEZ, as no behavioural change is required (Ockwell et al., 2009). More interestingly, we show that living further from the LEZ is the fourth most important predictor of low acceptability, even after accounting for both socio-demographic and psychological factors. This may be explained by those living further away being concerned that regions outside the LEZ will become more polluted due to increased traffic displacement (see Verbeek & Hincks, 2022). Alternatively, it may simply be harder for those living further away to travel into the LEZ. Whilst Bath's current LEZ exempts private cars, residents living further away may be concerned that public transport will become less frequent due to commercial charges, or that future charges will affect private cars, making it more difficult for them to travel into the LEZ from areas that may be underserved by public transportation. Our finding that people living further from the LEZ generally perceived it as too stringent provides tacit support for these interpretations, and points towards potential concerns about, and opposition to, a future car-inclusive LEZ.

Interestingly, distance from the LEZ remained an important predictor even after controlling for income. This is particularly notable, since public discourse typically focuses on financial concerns as the biggest barrier to LEZ acceptance, with governmental agencies stressing the importance of financial support for local residents and businesses (Borrowman, 2021). However, the current analysis suggests that geographical location may be a far more important contributor to acceptability than financial deprivation. If replicated, this finding may help to shift the discourse from the financial burden of LEZs to overcoming the practical barriers to acceptability. For policymakers, this implies that improved public transport and accessibility into the LEZ may boost future acceptance, more so than providing financial assistance.

4.3. Psychological factors

The finding that two psychological factors, environmental moral obligation and identity, were the first and third most important predictors of LEZ acceptability is consistent with prior research. The strong explanatory power of moral obligation is consistent with theoretical frameworks, such as the VBN (Stern et al., 1999), and previous empirical work (Drews & van den Bergh, 2016; Ejelöv & Nilsson, 2020). Across the literature, high moral obligation towards the environment has been reported as the strongest predictor of several environmental behaviours, such as reduced car use (Andersson, 2020) and green purchasing behaviours (Liu et al., 2020). In line with this, the current findings imply that boosting residents' environmental moral obligation may enhance LEZ acceptance. Drawing on work suggesting that presenting pro-environmental behaviours as 'moral' increases engagement (Lindenberg & Steg, 2007), further research (e.g., experimental studies) should seek to understand if policymakers can facilitate acceptance by highlighting the collective benefits of LEZs in ways that valorise this moral dimension.

Environmental identity being the third most predictive variable is also notable, since it is thought to invoke a strong 'problem awareness', activating a personal norm experienced as feelings of moral obligation to act (Eriksson et al., 2006). Whilst environmental identity and moral obligation may be linked (van der Werff et al., 2013), our findings show that, although environmental moral obligation is a more important predictor of LEZ acceptance, environmental identity is a unique and important determinant of acceptability. During LEZ implementation, policymakers might therefore seek to increase the salience of residents' environmental identities. In line with work suggesting that 'green labelling' can guide those with strong environmental identities to engage in pro-environmental behaviour (Schwartz et al., 2020), it is possible that policymakers could foster acceptance by labelling the LEZ as an environmental initiative. However, given that we cannot draw causal conclusions from this work, further research is required to understand if such interventions would be effective in boosting LEZ acceptance. For example, experimental work may seek to understand if labelling a LEZ as an environmental initiative impacts one's environmental identity and consequential acceptance, when directly compared to labelling focussing on other LEZ benefits (e.g., health and wellbeing). Taken together, people high in environmental moral obligation and identity were most supportive of the LEZ, even when controlling for differences in perceptions of stringency. This indicates that moral, psychological factors may be important drivers of acceptance for any type of LEZ, regardless of its stringency.

Despite this finding, it is worth noting that perceived LEZ stringency was, in and of itself, a unique and important predictor of LEZ acceptability. Theoretical frameworks such as the VBN have previously been extended to include behaviour specific beliefs (e.g., Hunecke et al., 2001; Nordlund & Garvill, 2003), which are typically more strongly related to behaviour change than general environmental beliefs (Steg et al., 2005). This likely explains why perceptions of stringency was a more important predictor than general environmental identity, and is in line with existing literature finding that policy-specific beliefs are important predictors of LEZ acceptability (see Ejelöv & Nilsson, 2020; Oltra et al., 2021). Interestingly, our results demonstrated that people were most likely to support the LEZ when they perceived it as not stringent enough. Whilst preliminary, this perhaps indicates a degree of support for all types of LEZs and even a desire for more stringent restrictions amongst its strongest supporters.

Another finding of the study was that, after accounting for all other variables, there was no evidence for a relationship between political orientation and LEZ acceptability. This is contrary to broader literature linking left-leaning political ideologies to increased climate concern and

receptiveness to climate policies (Leiserowitz et al., 2015; Whitmarsh, 2011) and LEZ-specific work demonstrating that left-leaning orientations predict increased acceptability (Tarriño-Ortiz et al., 2021). This lack of relationship between political orientation and acceptability may indicate that political orientation does not directly influence LEZ acceptability after accounting for other factors and mediators (see Ejelöv & Nilsson, 2020). Indeed, Oltra et al. (2021) suggested that left-leaning political ideologies indirectly predict acceptance, via factors such as high governmental trust and environmental identity, suggesting that a more nuanced investigation into the link between political ideology and LEZ acceptance is warranted in future. However, since Bath's LEZ does not charge private cars, people may have perceived the policy as having limited environmental benefits, and the LEZ may not have been universally viewed as a 'climate' policy. This may provide an alternative explanation for why political orientation was not related to LEZ acceptability, despite political ideology typically being related to climate policy acceptance. Therefore, the current findings underscore the importance of considering psychological factors beyond left-right political orientation when understanding LEZ acceptance, particularly where private cars are not charged. Building upon existing literature using political framings to enhance acceptance (Whitmarsh & Corner, 2017), the current findings point towards the future opportunity of understanding how environmental moral obligation and identity may be utilised to foster LEZ acceptance, over and above left-right political orientation.

4.4. Strengths, limitations, and future directions

By utilising a large dataset and an appropriate range of predictors, we performed well-powered statistical analyses to detect small, interesting effects. Importantly, the sample was also diverse and representative of the local population. By using geographically targeted social media advertising, we were able to recruit from underrepresented, lower income communities, alongside individuals not engaged with social media via local government newsletters. Offering incentives for participation mitigated against self-selection biases (e.g., people with particularly strong opinions about the LEZ). Most notably, novel analytical approaches quantified the relative importance of significant predictors. Such analyses usefully highlight which factors warrant further investigation and provide policymakers with concrete, tangible recommendations when designing LEZs. A final strength of this study is its co-production alongside local policymakers, in response to a practical need to design a widely accepted LEZ in Bath. Considering that consulted citizens are more likely to accept policies (Kevins, 2020), this community-led strategy sets the standard for future work informing environmental policy.

However, further research is required to extend, and overcome the limitations of, the current work. For example, the present study is limited by its correlational nature and is therefore unable to draw causal conclusions or understand the directionality of relationships. For instance, it could be that those who accept the LEZ, over time, develop strong feelings of environmental moral obligation or environmental identity as a result of taking on this opinion-based group membership (see Bliuc et al., 2015; Maher et al., 2020). To remedy this and extend the current exploratory work, future research may adopt longitudinal approaches and structural equation modelling to determine the causal paths of the current variables to acceptability. It is also possible that the current findings may be specific to the local context and type of LEZ. Whilst an important consideration, our findings are broadly in line with both previous LEZ-specific literature in other European cities (e.g., Oltra et al., 2021; Tarriño-Ortiz et al., 2021), and more general transport policy acceptance (e.g., Ejelöv & Nilsson, 2020) finding that psychological factors are most important to acceptability, followed by travel-related and socio-demographic variables. With Bath's LEZ being amongst the first in the UK, our findings may provide important insights into the factors affecting acceptability ahead of similar LEZs being implemented, but must be generalised with caution.

The limitations of self-report should also be considered. Whilst our measure of acceptability was in line with previous research (e.g., Drews et al., 2022; Nilsson et al., 2016), existing literature often finds that self-reported attitudes do not always translate to behavioural change (e.g., Kollmuss & Agyeman, 2002). Therefore, increased acceptability may not be related to behavioural outcomes such as reduced car use, and future longitudinal work should ascertain if increased acceptability relates to long-term reduced car use. However, increased acceptability is important for reasons beyond facilitating direct behavioural change, since there is evidence that support for one environmental policy can spill over into support for other environmental policies or actions (Thøgersen & Noblet, 2012).

Since Bath's LEZ initially included private cars, but excluded them after public consultation, respondents may have been primed to consider their opinions of not only the current LEZ, but also a future car-inclusive LEZ. Whilst we controlled for this by considering perceptions of LEZ stringency, it is possible this may have skewed participants' reported acceptability. Addressing this issue, future research should replicate this study in another city with plans for a car-exempting LEZ. Such a replication would also demonstrate the stability of results across similar samples in a UK context and allow more robust policy implications to be drawn. Relatedly, a comparison study may explore a car-inclusive LEZ, to understand if predictors of acceptability are consistent across different types of LEZs. Whilst this study explored the basic socio-demographic, travel-related, and psychological predictors of LEZ acceptability, it did not consider other theoretically relevant predictors, for example policy-specific beliefs surrounding individuals' problem awareness, governmental trust, and perceptions of the LEZ's fairness and effectiveness (Ejelöv & Nilsson, 2020; Schade & Schlag, 2003). It is therefore possible that these hidden policy-specific variables could play a role in driving results, and they should be accounted for in future work. Extending the current work, future research could therefore draw further on theoretical work to explore the importance of policy-specific beliefs relative to those explored in the current study. Finally, considering the sparsity of prior work investigating travel-related variables, future work could further explore the mechanisms of why living closer to the LEZ increased acceptability and, equally, how acceptance could be enhanced in people living further away.

5. Summary and conclusion

The present study indicates that psychological factors, such as environmental moral obligation, perceptions of LEZ stringency, and environmental identity, are the most important predictors of LEZ acceptability. Nonetheless, several socio-demographic and travel-related factors, such as having dependent children and distance lived from the LEZ, were unique and important predictors of acceptability. The null relationships between disability and acceptability, and political orientation and acceptability were of interest and warrant further investigation. Taken together, our findings have numerous policy implications, particularly surrounding the importance of addressing the practical barriers to acceptability whilst maintaining an emphasis on crucial psychological factors. Overall, the current research has laid important groundwork, helping to foster the public acceptance of LEZs, and moving us towards a future of cleaner air.

Author contribution statement

Lois Player: Conceptualisation (Supporting); Data Curation (Lead); Formal Analysis (Lead); Methodology (Equal); Writing – Original Draft (Lead); Writing – Review & Editing (Equal); Visualization (Lead). **Annayah M. B. Prosser:** Conceptualisation (Supporting); Investigation (Equal); Methodology (Equal); Writing – Review & Editing (Supporting). **Dan Thorman:** Conceptualisation (Supporting); Investigation (Equal); Methodology (Equal); Writing – Review & Editing (Supporting). **Anna S.**

C. Tirion: Conceptualisation (Supporting); Funding Acquisition (Supporting), Writing – Review & Editing (Supporting). **Lorraine Whitmarsh:** Writing – Review & Editing (Supporting); Supervision (Supporting). **Tim Kurz:** Conceptualisation (Supporting); Investigation (Equal); Methodology (Equal); Funding Acquisition (Lead); Project Administration (Equal); Writing – Review & Editing (Supporting). **Punit Shah:** Conceptualisation (Lead); Data Curation (Supporting); Formal Analysis (Supporting); Methodology (Equal); Funding Acquisition (Supporting); Writing – Original Draft (Supporting); Writing – Review & Editing (Equal); Supervision (Lead); Project Administration (Equal).

Data availability statement

The data are provided in the Supplementary Material, and on the Open Science Framework at https://osf.io/kvwm6.

Declaration of competing interest

None.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jenvp.2023.101974.

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