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RESEARCH ARTICLE

Does implementation of a low emission zone change perceptions of air quality, acceptability and travel behaviour? a longitudinal and repeated cross-sectional survey study in Bradford, UK

[version 1; peer review: 2 approved with reservations]

Teumzghi Mebrahtu [ID][1], Rosemary R. C. McEachan [ID][1,2], Cathy Knamiller [ID][1], Gillian Santorelli[1], Rumana Hossain[1], Maria Bryant [ID][3,4]

[1]Bradford Teaching Hospitals NHS Foundation Trust, Bradford Institute for Health Research, Bradford, England, BD9 6RJ, UK
[2]Population Health Improvement UK, UK, UK
[3]Hull York Medical School, Hull, England, UK
[4]University of York Department of Health Sciences, York, England, YO10 5DD, UK

Abstract

Background

Despite the popularity of low emissions zones (LEZ) across Europe their public acceptability and impact on travel behaviours are scarcely studied. We aimed to explore changes in acceptability, perceptions of air quality, and travel behaviours in a multi-ethnic sample living in Bradford, UK after the implementation of a Clean Air Zone (a type of LEZ).

Methods

Telephone, in-person and online surveys were conducted one year pre- and one year post implementation. Participants included members of the representative Born in Bradford (BiB) cohort and members of the general public. A repeated cross-sectional analysis explored changes in responses between baseline and follow-up questions using chi-square tests and tests of proportions. Multinomial regressions explored whether socio-demographic variables were associated with changes in attitudes longitudinally.

Results

A total of 1,949 and 2,085 individuals participated in the baseline and follow-up surveys; 814 participants completed both. Participants were mostly female, aged 35–44. Half were white British, and 30% of Pakistani origin. The majority of participants supported the clean air zone at follow-up (59–64%), although these figures were lower than at baseline (by 4.9% for BiB families and 10.8% for members of the general public). A third indicated high concern about air quality (34–38%). Personal travel behaviours showed little variation pre to post implementation. On the whole, attitudes of those completing both surveys remained stable, and there were no systematic relationships between socio-demographic variables and whether attitudes worsened or became more positive.

Conclusion

Whilst CAZ support remained high, we observed small decreases in support after the CAZ implementation. As public acceptability is a key facilitator to the success of initiatives such as CAZ, a decrease in public support may threaten their sustainability. Communication about the need for CAZ, and demonstrations of their positive impact will be important to maintain levels of acceptability.

Plain Language Summary

This study looked at how people in Bradford, UK, felt about a new Clean Air Zone (CAZ) and if it changed how they travelled. A CAZ is an area in cities where older, more polluting vehicles are charged a daily fee to enter. They aim to reduce pollution. In Bradford, a CAZ was implemented in 2022 which charges older taxis, buses, vans and lorries, but does not charge people's private vehicles. Researchers asked people living in Bradford questions one year before and one year after the CAZ was put in place to see what they thought about the CAZ, pollution in the city, and to ask about how they travelled about the city (for example, using private vehicles, public transport, or walking and cycling). A total of 1,949 people responded to the first questionnaire, and 2,085 to the second. Out of these, 814 people answered both times. About one-third of people were very worried about pollution. The number of people supporting the CAZ fell from about 70% before it was in place, to about 60% after it has been in place for a year. People did not change the way they travelled around the city after the CAZ was implemented, and generally attitudes remained similar before and after the CAZ was implemented. People's backgrounds, for example their ethnicity, age and whether they lived in the CAZ zone didn't seem to affect whether people's opinions changes. The study suggests that to keep people supporting the CAZ, it's important to explain why it is needed and show its benefits.

Keywords

Corresponding author: Rosemary R. C. McEachan (rosie.mceachan@bthft.nhs.uk)

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Introduction

Air pollution is a major environmental health risk and is associated with 6.7 million premature deaths annually worldwide (World Health Organisation, 2021). Deaths due to air pollution exposure in Europe alone costs around $1.4 trillion per year (United Nations, 2015). A total of 64,000 deaths occur due to air pollution in the UK every year (Lelieveld et al., 2019), costing the country $83 billion a year (World Health Organisation, 2015).

Around 64% of the exceedance of air quality standards in Europe are caused by traffic pollution (European Environment Agency, 2022). To counter this, urban vehicle access regulations have been introduced in many cities across Europe (CLARS, 2023). One example of how these are operationalised is via low emission zones (LEZ), where the most polluting vehicles have restricted access to certain areas (CLARS, 2023). LEZ are a popular solution to reduce outdoor pollution, with over 320 zones in place across EU member states by the end of June 2022 (Tiseo, 2023).

LEZ are complex interventions, usually implemented as part of wider city or regional strategies which aim to reduce pollution but also encourage more sustainable and active travel modes (Tarriño-Ortiz et al., 2022). They provide a catalyst for the upgrading and retrofitting of existing vehicles to compliant standards, encourage the purchase of cleaner vehicles, and may also reduce numbers of vehicles driving in the zone. They are also thought to impact on peoples' attitudes and behaviours by raising awareness of air quality issues, and thus encouraging people to use more sustainable travel options (McEachan et al., 2022; Public Health Scotland, 2023), although impacts on personal travel behaviour might be limited if LEZ do not target private vehicle use. While evidence of the impact of LEZ on health outcomes is emerging (Chamberlain et al., 2023), there is scant evidence exploring the impact of LEZ on other outcomes such as attitudes or personal travel behaviours.

Despite their increasing popularity, LEZs can be controversial, due to a perception that they can disadvantage some communities (De Vrij & Vanoutrive, 2022), with many examples of LEZ being delayed or abolished following vocal public opposition (Morton et al., 2021). A recent study conducted in real time as a LEZ was being planned highlighted how local political opposition and conflicts serve to shape negative public discourse and polarise opinions, heightening tensions and reducing the confidence of local implementers (Knamiller et al., 2024). However, these 'loud voices' may not be representative of wider public opinion. A number of recent cross-sectional surveys exploring public's acceptability of LEZ either pre (Mebrahtu et al., 2023; Player et al., 2023) or just after implementation (Oltra et al., 2021; Rizki et al., 2022; Tarriño-Ortiz et al., 2021) all reported finding majority support for a LEZ from the participants they surveyed.

Perceptions of LEZ acceptability can vary by demographic factors, beliefs about efficacy of the schemes, personality traits, and the extent to which citizens are personally affected (Kowalska-Pyzalska, 2022; Player et al., 2023). Mebrahtu et al.

(2023) found that concern about air quality and acceptability of a proposed LEZ was lower for more economically deprived and multi-ethnic populations in the City of Bradford, UK one year before its implementation. Within these communities, there had been concern that the introduction of a LEZ would disproportionately impact low-income families and thus exacerbate existing health inequalities (Rashid et al., 2021). As public acceptability of LEZ is vital to their continued success, it is important to understand how attitudes and acceptability may change after implementation, and whether changes vary by key socio-demographic characteristics. However there have been no studies which have explored changes in attitudes longitudinally after a LEZ had been implemented.

In terms of the impact of LEZ on travel behaviours, a descriptive analysis of the London Ultra Low Emission zone one year post implementation concluded that there was a 5% reduction in all vehicles in the zone, and 3% reduction in traffic flows (Mayor of London, 2023). Tarriño-Ortiz et al. (2022) reported a 28% reduction in self-reported car use, and 8% increases in reports of public transport and active travel in a cross-sectional sample of 799 residents after the implementation of the Madrid Central LEZ. In the same context, Gonzalez et al. found that evidence that the Madrid LEZ, combined with parking restrictions encouraged a shift to more sustainable behaviour (Gonzalez et al., 2023). However, like the studies on attitudes reported above, there has been no longitudinal study tracking changes in travel behaviour pre and post implementation of a LEZ.

In the UK, a number of Clean Air Zones (CAZ, a type of LEZ) have been implemented in urban areas as part of the Government's Clean Air Framework policy (Department of Transport, 2021a). The aim of the current study was to explore changes in acceptability, attitudes towards air quality and travel behaviours of residents one year after a CAZ had been implemented in a large Northern UK City. We also aimed to explore whether any changes in ratings of acceptability of the CAZ and attitudes towards air quality were related to key socio-demographic characteristics.

Methods

Patient and Public Involvement

A pollution research advisory group was formed including 12 members of the general public living within the CAZ boundary in Bradford. They met regularly throughout the duration of the study to provided advice on all aspects of the wider study. (McEachan et al., 2022). For the current study, they gave specific feedback on the wording of participant information sheets and content of questionnaires, and have helped to interpret key findings.

Study design

This study was part of a wider evaluation of the heath and economic impacts of a Clean Air Zone (CAZ) which was implemented in the city of Bradford, UK, in September 2022 (McEachan et al., 2022). We conducted a population-based survey prior to, and 12 months after the launch of the CAZ. The first survey was conducted between April 2021 and December 2021 (previously reported in Mebrahtu et al., 2023). The

second survey was conducted one year after the CAZ implementation (between July – November 2023) and included both participants who responded to the first survey, and additional participants responding to the second survey only. The study thus includes a longitudinal and repeated cross-sectional element.

Setting
Bradford is the fifth largest metropolitan district in England, with a population of over 546,000 (Office of National Statistics, 2022). Residents of the city are predominantly of white British (57%) and Pakistani origin (25%) (Bradford Metropolitan District Council (BMDC), 2022). A third of the population live in the most deprived Index of Multiple Deprivation (IMD) decile according to England averages (Bradford Metropolitan District Council (BMDC), 2019). The city has higher than average levels of respiratory morbidity (Mebrahtu, 2015; Mebrahtu et al., 2016; Mebrahtu et al., 2015). It is home to the representative longitudinal Born in Bradford (BiB) birth cohort, which recruited 12,453 mothers, with 13,776 pregnancies and 3,448 partners between 2007–2011; 42% of the BiB cohort are of Pakistani origin and 37% are of White British origin (McEachan et al., 2024).

In 2018, the UK government identified Bradford as exceeding legal limits of pollutants at several parts of the city and directed the local authority to develop and implement a charging Clean Air Zone as part of a wider plan to tackle pollution (McEachan et al., 2022). The resulting Bradford Clean Air Plan included a Class C CAZ, where non-compliant buses, coaches, heavy goods vehicles, vans, minibuses, taxis and private hire vehicles are charged a daily fee to enter the zone. Private vehicles are not charged (McEachan et al., 2022).

Procedure and participants
Details of baseline survey recruitment are reported in detail elsewhere (Mebrahtu et al., 2023). Eligible participants were either i) participants of the BiB cohort or ii) members of the general public. Our baseline sample included 1137 BiB participants and 812 members of the general public who completed the survey online, via telephone or via post. For the follow-up survey we recontacted all baseline BiB participants, and the general public participants who had provided contact details (N=340) via email (asking participants to complete an online survey) or telephone interview. These participants' questionnaires were given a unique ID code which allowed baseline and follow-up surveys to be matched. To boost the sample at follow-up, we recruited additional members of the general public online via a survey link which was distributed widely via online mailing lists. We also publicised the link in person via pop-up stands in three local hospital sites, 9 general practice sites, and at 12 community events (e.g. park fun days). See Figure 1.

Survey variables
Three categories of variables were collected: 1) attitudes towards the CAZ, 2) air quality perceptions, 3) travel behaviours, see Table 1. Demographic data were already available for the BiB families. We asked members of the general public to complete demographic questions; however, in order to maximise completion rates, these questions were not mandatory and were located at the end of the questionnaire.
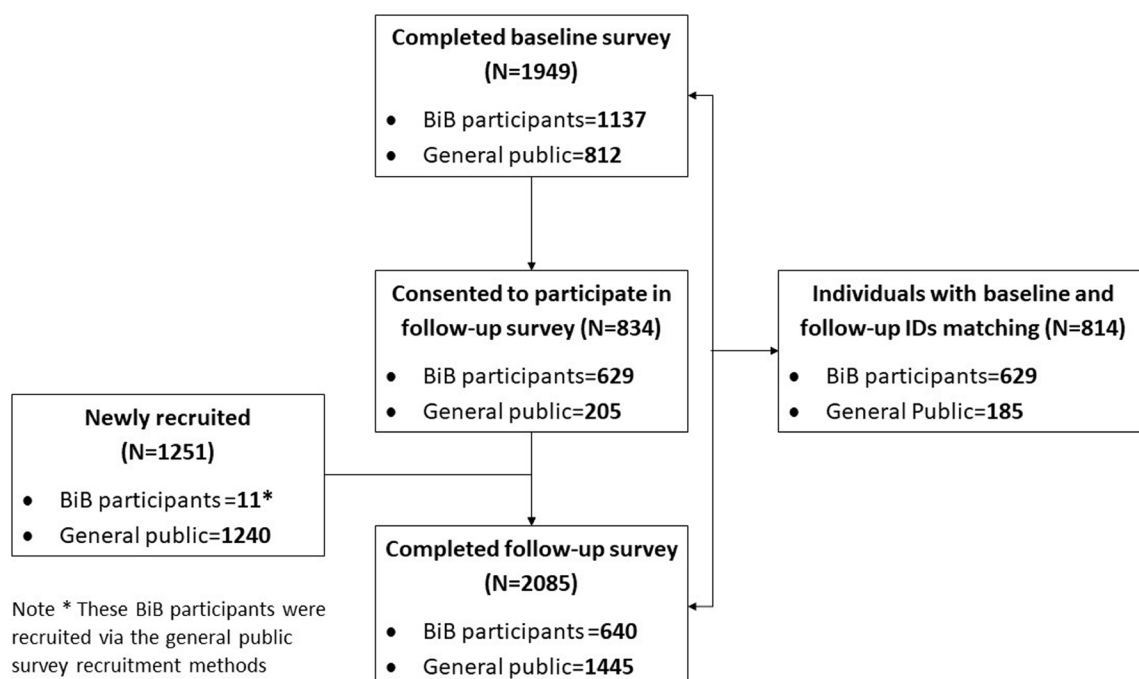

Figure 1. Survey recruitment flow chart.

Table 1. Summary of variables collected.

Item	Information collected	Categories	Simplified categories for longitudinal sample
Perception of CAZ	**1.** Do you think the Clean Air Zone is a good idea?	**Three** (yes, no, and don't Know)	No change
	2. To what extent do you agree or disagree that the Clean Air Zone covers the right areas of Bradford?	**Five** (strongly agree, agree, neither agree nor disagree, disagree, and strongly disagree)	**Three** (*Agree* [strongly agree/agree]; *Neutral* [neither agree nor disagree]; *Disagree* [Strongly disagree/Disagree])
	3. How much do you agree or disagree with the following statement: the CAZ will improve the health of my family/community?	**Five** (strongly agree, agree, neither agree nor disagree, disagree, and strongly disagree)	**Three** (*Agree* [strongly agree/agree]; *Neutral* [neither agree nor disagree]; *Disagree* [Strongly disagree/Disagree])
Perception of air quality	**1.** What do you think about the air quality in Bradford generally?	**Five** (very poor, poor, fair, good, and excellent)	**Two** (Negative [very poor/poor]; *Positive* [fair/good/excellent])
	2. How do you think this compares to other parts of the UK?	**Four** (don't know, better, about the same, and worse)	No change
	3. How concerned are you about air quality in Bradford?	**Six** (not at all concerned, slightly concerned, somewhat concerned, moderately concerned, extremely concerned, and don't know)	**Four** (*Not concerned* [Not at all concerned]; *Some concern* [slightly/somewhat concerned]; *Moderate to high concern* [moderately concerned and extremely concerned]; *Unsure* [Don't know])
	4. Do you think other people in Bradford are concerned about air quality?	**Six** (not at all concerned, slightly concerned, somewhat concerned, moderately concerned, extremely concerned, and don't know)	**Four** (*Not concerned* [Not at all concerned]; *Some concern* [slightly/somewhat concerned]; *Moderate to high concern* [moderately concerned and extremely concerned]; *Unsure* [Don't know])
	5. How important do you think it is to improve air quality?	**Six** (not at all important, slightly important, somewhat important, moderately important, extremely important, and don't know)	**Two** (*Less important* [not all important/slightly important/somewhat important]; *More important* [moderately important/extremely important]
Mode of travel	**1.** How does the main earner get to work?	**Three** (**public** (bus, taxi, and train), **private** (petrol/diesel car/van and electric/hybrid car), and **active travel** (bicycle and walking))	Not included in multinomial regressions
	2. How do your children normally travel to school now	**Three** (**public** (bus, taxi, and train), **private** (petrol/diesel car/van and electric/hybrid car), and **active travel** (bicycle and walking))	Not included in multinomial regressions
	3. How did you normally travel around Bradford District for things other than getting to work or school?	**Three** (**public** (bus, taxi, and train), **private** (petrol/diesel car/van and electric/hybrid car), and **active travel** (bicycle and walking))	Not included in multinomial regressions
	4. How often do you use your car for journeys of 0.5 miles or less? 0.5 miles is roughly the distance of a 10-minute walk	**Six** (never, rarely, sometimes, Often, All the time, and not applicable)	Not included in multinomial regressions
Demographics[a]	Age (in years)	**Six** (18–24, 25–34, 35–44, 45–54, 55–64, and 65+)	Three (18–34; 35–44; 45+)
	Ethnicity	**Three** (White British, Pakistani-origin and Other)	No change
	Gender	**Four** (male, female, prefer to use own term, and prefer not to say)	No change[c]
	Bradford Index of Multiple Deprivation (IMD)[b]	**Five** (quintile 1, quintile 2, quintile 3, quintile 4, and quintile 5)	No change
	CAZ boundary	**Two** (inside and outside)	No change

Notes: [a] demographics were obtained from existing information for BiB families, and were self-reported by members of the general public; [b] As there is limited variation in IMD score for Bradford (42% in most deprived quintile) we present the equivalised score using Bradford addresses; [c] Male and female were the only recorded responses in the longitudinal sample

Statistical analysis

First, sociodemographic characteristics of participants were tabulated and descriptively summarised. Individual items for perceptions of air quality, perceptions of the CAZ and travel mode behaviour were also summarised descriptively. Comparisons between the cross-sectional baseline and follow-up responses were made using chi-square tests and tests of proportions. We identified differences between patterns of responses for the two samples (BiB vs general public) in the baseline sample, and thus, for the repeated cross-sectional analysis, we report BiB participants and members of the general public separately.

To explore changes in attitudes towards the CAZ and perceptions of air quality (i.e., longitudinal analysis), response options were re-categorised to simplify interpretation of results (Table 1, final column). Multinomial regressions were used to explore whether changes in attitudes (reference: no change) were associated with demographic factors including ethnicity (white British[reference], Pakistani origin, other), sex (male[reference], female), Age (18–34[reference], 35–44, 45+), and Bradford IMD quintile (reference IMD 1 – most deprived) and whether respondents lived inside (reference) or outside the CAZ zone. The analyses were based on those who provided complete data (i.e., complete case analysis).

Results

Survey population characteristics

A total of 1,949 (BiB families=1,137; general public=812) and 2,085 (BiB families=640; general public=1,445) individuals participated in the baseline and follow up surveys, respectively. Demographic data were available for most of the BiB families but were missing for a substantial proportion of the general public sample (Table 2). BiB participants were predominately female (90% baseline, 92% follow-up), aged 35–54 (88% baseline, 85% follow-up). At baseline, 44% were of white British origin and 38% were of Pakistani origin. At follow up, these figures were 49% and 32% respectively. Around a quarter lived within the CAZ boundary at baseline and follow-up. At baseline, 42% lived in the most deprived quintiles in Bradford, compared with 35% at follow-up.

Where demographic data were reported for the general public sample, around half were female (52% baseline, 41% follow-up), two-fifths were aged 18–44 (41% baseline and 35% follow-up) and just over one-fifth reported living in the CAZ boundary (22% at baseline and 23% follow-up). At follow-up there was an increase in the proportion of Pakistani (19%) and other ethnic origin participants (14%) and more reported being living in the most deprived quintiles of Bradford (31% vs. 23% at baseline). See Table 2.

Cross-sectional comparisons

Acceptability of the Clean Air Zone. In our repeated cross-sectional data, acceptability of the CAZ at follow-up was lower for both BiB and general public samples than at baseline, see Figure 2. At follow-up, 64.2% of BiB participants, and 59.4% of general public participants said that they felt the

CAZ was a good idea; (a drop of 4.9% (95% CI: -9.4 to -0.3%, and 10.8% (95% CI: -14.9 to -6.8%), respectively). Fewer participants reported that they felt the CAZ covered the right geographical areas (i.e., responded agree or strongly agree) with 28.6% of BiB participants (a reduction of 8.7%, 95% CI: -13.0 to -4.2%) vs 31.6% of general public participants agreeing or strongly agreeing (reduction of 8.0%, 95%CI: -12.1 to -3.8%).

The numbers of respondents who agreed or strongly agreed that the CAZ would improve the health of their family or community also reduced. Agreement dropped by 13.4% for BiB participants (to 51.1%) and by 13% for general public participants (to 48%). See Table 3 and Figure 2.

Perceptions of air quality. Perceptions of air quality appeared relatively similar between baseline and follow-up for BiB participants but varied more for members of the general public (Table 3). For BiB participants, at follow-up, just over a third of the sample (37%) felt air quality was 'poor' or 'very poor', and 38% felt it was the same as other areas in the UK. Thirty-four percent were moderately to extremely concerned about air quality, and 18% thought other people in Bradford were moderately to extremely concerned. There was a drop of around 10% (95% CI: -15 to -0.05%) in the numbers reporting that it was 'extremely important' to improve air quality.

For the general public sample, there were significant differences in the distribution of responses to most air quality items. At follow-up, just over a third (36.5%) reported air quality to be 'poor' or 'very poor'; a drop of 24.7% (95% CI: -28.8 to -20.5 %). The proportions of people that reported air quality in Bradford was worse than other areas (46.9%), those that reported fewer people were 'extremely concerned' (32%) and those that felt it was 'extremely' important to improve air quality (70%) also fell by 20.6% (95% CI:16.5 to 24.7%), 14.3% (95% CI: -18.0 to -10.5 %) and 13.8% (95% CI: -17.8 to -9.7 %)) respectively (see Table 3). Perceptions of 'others' concern was more similar, with around 20% reporting that others were moderately or extremely concerned, with no significant change from baseline.

Travel behaviours

Private transport was the dominant mode of travel for getting to work and travelling for leisure for both samples. There were slight increases in the numbers reporting private transport for work in our repeated cross-sectional sample (64.6% baseline to 70.5% at follow up for BiB participants, and from 47.5% baseline to 57.5% follow up for general public participants). There was a slight decrease in the numbers of BiB participants reporting private transport for leisure (88.1% at baseline and 79.1% follow up) and a minor increase for the general public (64.4% baseline and 66.2% follow up) participants.

More baseline BiB families than the follow up BiB families participants used active travel (walked or cycled) to take children

Table 2. Demographic characteristics of survey participants.

	BiB families		General public		Longitudinal sample (N=814)[a]
	Baseline (N=1,137), n (%)	Follow up (N=640), n (%)	Baseline (N=812), n (%)	Follow up (N=1,445), n (%)	
Age (in years)					
18–24	0 (0.0)	0 (0.0)	48 (5.9)	57 (3.9)	8 (1.0)
25–34	110 (9.7)	63 (9.8)	115 (14.2)	236 (16.3)	89 (10.9)
35–44	629 (55.3)	341 (53.3)	173 (21.3)	212 (14.7)	382 (46.9)
45–54	370 (32.5)	207 (32.3)	130 (16.0)	115 (8.0)	249 (30.6)
55–64	21 (1.9)	12 (1.9)	97 (12.0)	92 (6.4)	47 (5.8)
65+	0 (0.0)	2 (0.3)	89 (11.0)	94 (6.5)	33 (4.1)
Missing	*7(0.6)*	18 (2.8)	*160(19.7)*	639 (44.2)	6 (0.7)
Ethnicity					
White British	498 (43.8)	314 (49.1)	444 (54.7)	436 (30.2)	323 (39.7)
Pakistani origin	431 (37.9)	204 (31.9)	87 (10.7)	274 (19.0)	214 (26.3)
Other	170 (15.0)	87 (13.6)	82 (10.1)	200 (13.8)	261 (32.1)
Missing	*38(3.3)*	35 (5.5)	*199(24.5)*	*535 (37.0)*	*16 (2.0)*
Gender					
Male	104 (9.2)	32 (5.0)	214 (26.4)	304 (21.0)	105 (12.9)
Female	1026 (90.2)	590 (92.2)	418 (51.5)	592 (41.0)	701 (86.1)
Prefer to use own term	0 (0.0)	0 (0.0)	4 (0.5)	8 (0.6)	0 (0)
Prefer not to say	0 (0.0)	0 (0.0)	19 (2.0)	22 (1.5)	0 (0)
Missing	*7(0.6)*	*18 (2.8)*	*157 (19.3)*	*519 (35.9)*	*8 (1.0)*
Bradford IMD					
Quintile 1	228 (20.1)	105 (16.4)	92 (11.3)	224 (15.5)	117 (14.4)
Quintile 2	250 (22.0)	120 (18.8)	100 (12.3)	229 (15.8)	141 (17.3)
Quintile 3	255 (22.4)	137 (21.4)	158 (19.5)	279 (19.3)	196 (24.1)
Quintile 4	223 (19.6)	146 (22.8)	159 (19.6)	218 (15.1)	191 (23.5)
Quintile 5	104 (9.1)	78 (12.2)	116 (14.3)	149 (10.3)	107 (13.1)
Missing	77 (6.8)	54 (8.4)	187 (23.0)	346 (23.9)	62 (7.6)
CAZ boundary					
Inside	297(26.1)	148 (23.1)	181(22.3)	330 (22.8)	208 (25.6)
Outside	768(67.5)	446(69.7)	544(67.0)	904 (62.6)	544 (66.8)
Missing	*72(6.3)*	46 (7.2)	87(10.7)	211 (14.6)	62 (7.6)

Notes: [a] *The longitudinal samples includes 629 BiB participants, and 185 members of the general public who completed surveys twice.*

to school (55.6% baseline vs 49.4% follow up) whilst only a quarter of the general public used active travel during the same period (20.4% baseline vs 22.1% follow up).

Private transport was the most used mode of transport for leisure by the BiB families The proportion of using a car for a 10 minutes' walk by the BiB families (7% baseline vs 6%

% think CAZ is a good idea

% Agree/strongly agree that CAZ covers the right areas

% Agree/strongly agree that CAZ improves health of the family
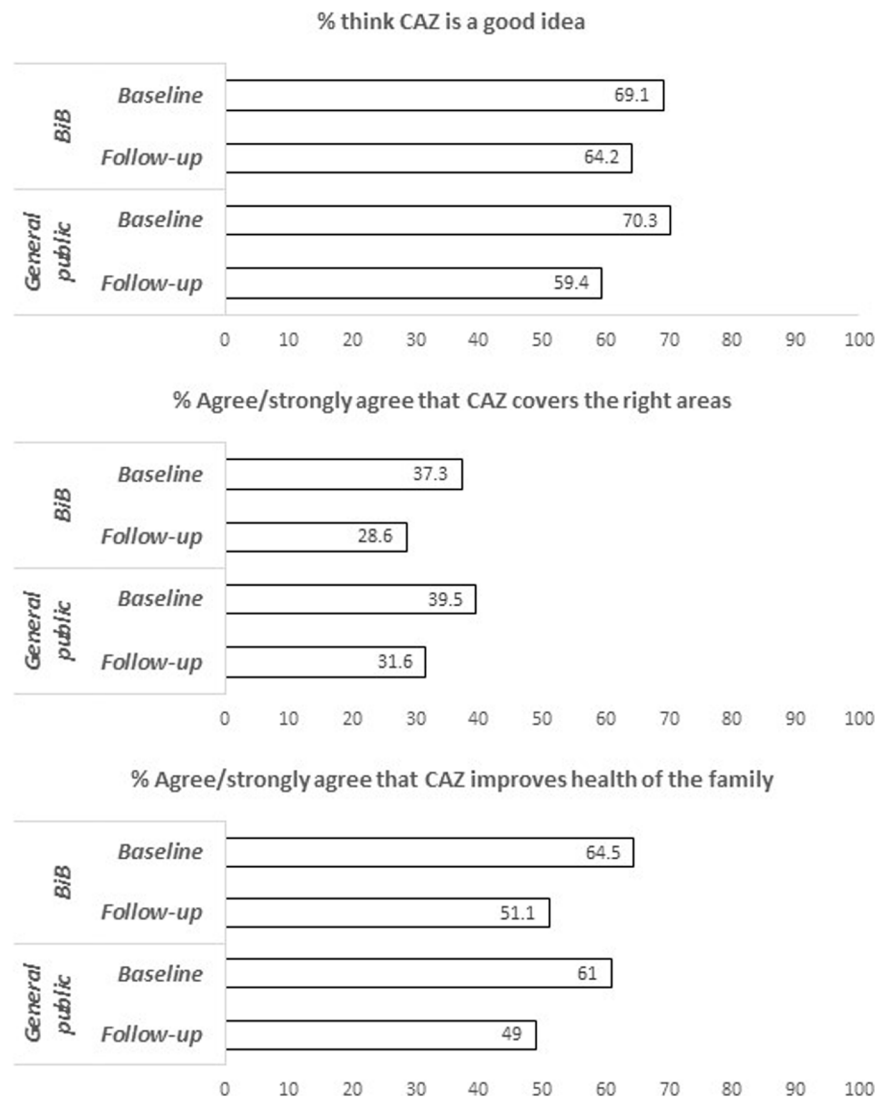
Figure 2. Percentage of respondents reporting positive CAZ attitudes at baseline, and follow-up.

follow up) and general public (4% baseline vs 8% follow up) remained small in both surveys (Table 3).

Longitudinal analysis
Perception of the CAZ. We include the full descriptives for CAZ and air quality perceptions for the N=814 participants completed both surveys in Table 4, for reference. These are not discussed further. Table 5 and Figure 3 show the percentage of people whose attitudes remained stable, or changed. The majority of participants attitudes towards the CAZ remained stable pre and post CAZ launch. Just over half (55.9%) of the longitudinal sample felt that the CAZ was a good idea, and two fifths (41%) agreed it would improve the health of their community at both baseline and follow-up (i.e. maintaining consistent attitudes).

Multinomial regressions comparing those whose attitudes had changed from baseline found few consistent relationships

with socio-demographic variables. We highlight significant relationships below. Full results can be found in Table 6.

Positive change in support for the CAZ: Those living outside the CAZ boundary were more likely to have a positive change in their support of the CAZ than those who lived inside the boundary (coefficient=0.71; 95% CI: 0.10 to 1.32). Participants from less deprived areas (quintile 3: coefficient=-0.82; 95% CI:-1.56 to -0.07; quintile 4 (coefficient=-0.87; 95% CI: -1.67 to -0.08) were less likely to be in this group compared with the most deprived participants.

Negative change in support for the CAZ: Compared to white British participants, the other ethnic minority participants were less likely to be in this group (coefficient=-0.79; 95% CI: -1.53 to -0.04). Those living in the in the least deprived areas were less likely to become negative about the CAZ than those in

Table 3. Summary of participants' responses to CAZ and air quality perceptions and mode of travel.

	BiB families			General Public		
	Baseline (N=1137)	**Follow-up (N=640)**	**X^2 p-value**	**Baseline (N=812)**	**Follow-up (N=1445)**	**X^2 p-value**
Do you think the Clean Air Zone is a good idea?						
Yes	786 (69.1)	411 (64.2)	0.02	571 (70.3)	859 (59.4)	<0.00
No	108 (9.5)	81 (12.7)		109 (13.4)	269 (18.6)	
Don't Know	213 (18.7)	96 (15.0)		84 (10.3)	146 (10.1)	
To what extent do you agree or disagree that the Clean Air Zone covers the right areas of Bradford?						
Strongly Agree	64 (5.6)	15 (2.3)	<0.01	60 (7.4)	63 (4.4)	0.01
Agree	360 (31.7)	168 (26.3)		261 (32.1)	393 (27.2)	
Neither Agree nor Disagree	483 (42.5)	313 (48.9)		269 (33.1)	525 (36.3)	
Disagree	125 (11.0)	62 (9.7)		106 (13.1)	161 (11.1)	
Strongly Disagree	52 (4.6)	28 (4.4)		74 (9.1)	133 (9.2)	
How much do you agree or disagree with the following statement: the CAZ will improve the health of my family/community?						
Strongly Agree	218 (19.2)	68 (10.6)	<0.01	170 (20.9)	255 (17.6)	<0.01
Agree	515 (45.3)	259 (40.5)		326 (40.1)	454 (31.4)	
Neither Agree nor Disagree	249 (21.9)	175 (27.3)		151 (18.6)	278 (19.2)	
Disagree	63 (5.5)	43 (6.7)		67 (8.3)	110 (7.6)	
Strongly Disagree	66 (5.8)	44 (6.9)		55 (6.8)	162 (11.2)	
What do you think about the air quality in Bradford generally?						
Excellent	12 (1.1)	2 (0.3)	0.16	10 (1.2)	50 (3.5)	<0.01
Good	156 (13.7)	78 (12.2)		63 (7.8)	211 (14.6)	
Fair	570 (50.1)	292 (45.6)		239 (29.4)	536 (37.1)	
Poor	303 (26.6)	192 (30.0)		347 (42.7)	392 (27.1)	
Very poor	83 (7.3)	46 (7.2)		150 (18.5)	136 (9.4)	
How do you think this compares to other parts of the UK?						
Better	114 (10.0)	49 (7.7)	0.28	66 (8.1)	163 (11.3)	<0.01
About the same	466 (41.0)	244 (38.1)		266 (32.8)	524 (36.3)	
Worse	294 (25.9)	180 (28.1)		381 (46.9)	380 (26.3)	
Don't Know	250 (22.0)	130 (20.3)		99 (12.2)	253 (17.5)	
How concerned are you about air quality in Bradford?						
Extremely Concerned	136 (12.0)	84 (13.1)	0.08	262 (32.3)	260 (18.0)	<0.01
Moderately Concerned	205 (18.0)	136 (21.3)		175 (21.6)	300 (20.8)	
Somewhat Concerned	310 (27.3)	155 (24.2)		152 (18.7)	302 (20.9)	
Slightly Concerned	282 (24.8)	156 (24.4)		130 (16.0)	208 (14.4)	
Not at all Concerned	123 (10.8)	50 (7.8)		74 (9.1)	210 (14.5)	
Don't Know	70 (6.2)	28 (4.4)		17 (2.1)	43 (3.0)	

	BiB families			General Public		
	Baseline (N=1137)	Follow-up (N=640)	X^2 p-value	Baseline (N=812)	Follow-up (N=1445)	X^2 p-value
Do you think other people in Bradford are concerned about air quality?						
Extremely Concerned	34 (3.0)	22 (3.4)	0.13	54 (6.7)	65 (4.5)	0.55
Moderately Concerned	141 (12.4)	94 (14.7)		138 (17.0)	218 (15.1)	
Somewhat Concerned	302 (26.6)	153 (23.9)		201 (24.8)	325 (22.5)	
Slightly Concerned	244 (21.5)	151 (23.6)		181 (22.3)	303 (21.0)	
Not at all Concerned	133 (11.7)	65 (10.2)		120 (14.8)	216 (14.9)	
Don't Know	273 (24.0)	122 (19.1)		114 (14.0)	199 (13.8)	
How important do you think it is to improve air quality?						
Extremely Important	733 (64.5)	347 (54.2)	<0.01	568 (70.0)	812 (56.2)	<0.01
Moderately Important	185 (16.3)	155 (24.2)		107 (13.2)	224 (15.5)	
Neutral	126 (11.1)	56 (8.8)		65 (8.0)	123 (8.5)	
Slightly Important	45 (4.0)	30 (4.7)		43 (5.3)	79 (5.5)	
Not at all Important	6 (0.5)	5 (0.8)		16 (2.0)	67 (4.6)	
Don't Know	33 (2.9)	17 (2.7)	<0.01	8 (1.0)	23 (1.6)	<0.01
How does the main earner get to work?*						
Public transport	77 (6.8)	70 (10.9)	0.56	87 (10.7)	180 (12.5)	0. 1
Private transport	734 (64.6)	451 (70.5)	<0.01	386 (47.5)	831 (57.5)	<0.01
Active travel	109 (9.6)	78 (12.2)	0.023	117 (14.4)	163 (11.3)	0.01
Not applicable	78 (6.9)	21 (3.3)	<0.01	85 (10.5)	168 (11.6)	0.40
How do your children normally travel to school now*						
Public transport	246 (21.6)	158 (24.7)	0.07	49 (6.0)	114 (7.9)	0.05
Private transport	652 (57.3)	284 (44.4)	<0.01	159 (19.6)	360 (24.9)	<0.01
Active travel	632 (55.6)	316 (49.4)	<0.01	166 (20.4)	319 (22.1)	0.18
Not applicable	4 (0.4)	158 (24.7)	<0.01	377 (46.4)	114 (7.9)	<0.01
How did you normally travel around Bradford District for things other than getting to work or school?*						
Public transport	218 (19.2)	149 (23.3)	0.02	224 (27.6)	428 (29.6)	0.15
Private transport	1002 (88.1)	506 (79.1)	<0.01	523 (64.4)	956 (66.2)	0.20
Active travel	351 (30.9)	179 (28.0)	0.9	264 (32.5)	385 (26.6)	<0.01
Not applicable	9 (0.8)	3 (0.5)	0.43	30 (3.7)	41 (2.8)	0.26
How often do you use your car for journeys of 0.5 miles or less? (0.5 miles is roughly the distance of a 10 minute walk?						
All the time	82 (7.2)	39 (6.1)	0.793	32 (3.9)	112 (7.8)	<0.001
Often	129 (11.3)	60 (9.4)		51 (6.3)	122 (8.4)	
Sometimes	262 (23.0)	144 (22.5)		106 (13.1)	257 (17.8)	
Rarely	344 (30.3)	185 (28.9)		228 (28.1)	363 (25.1)	
Never	214 (18.8)	122 (19.1)		190 (23.4)	308 (21.3)	
Not Applicable	69 (6.1)	30 (4.7)		78 (9.6)	63 (4.4)	

N.B: *, response categories are not mutually exclusive.

Table 4. CAZ and air quality attitudes of participants who participated in baseline and follow-up surveys (N=814).

	Baseline, n (%)	Follow Up, n (%)
Do you think the Clean Air Zone is a good idea?		
Yes	595 (73.1)	554 (68.1)
No	85 (10.4)	106 (13.0)
Don't Know	126 (15.5)	108 (13.3)
Missing	8 (1.0)	46 (5.7)
To what extent do you agree or disagree that the Clean Air Zone covers the right areas of Bradford?		
Strongly Agree	47 (5.8)	28 (3.4)
Agree	273 (33.5)	229 (28.1)
Neither Agree nor Disagree	324 (39.8)	370 (45.5)
Disagree	106 (13.0)	94 (11.5)
Strongly Disagree	45 (5.5)	46 (5.7)
Missing	19 (2.3)	47 (5.8)
How much do you agree or disagree with the following statement: the CAZ will improve the health of my family/ community?		
Strongly Agree	153 (18.8)	114 (14.0)
Agree	383 (47.1)	318 (39.1)
Neither Agree nor Disagree	170 (20.9)	214 (26.3)
Disagree	47 (5.8)	60 (7.4)
Strongly Disagree	51 (6.3)	61 (7.5)
Missing	10 (1.2)	47 (5.8)
What do you think about the air quality in Bradford generally?		
Excellent	6 (0.7)	5 (0.6)
Fair	360 (44.2)	355 (43.6)
Good	90 (11.1)	94 (11.5)
Poor	263 (32.3)	270 (33.2)
Very Poor	91 (11.2)	73 (9.0)
Missing	4 (0.5)	17 (2.1)
How do you think this compares to other parts of the UK?		
Better	73 (9.0)	65 (8.0)
About the same	298 (36.6)	306 (37.6)
Worse	283 (34.8)	266 (32.7)
Don't Know	153 (18.8)	150 (18.4)
Missing	7 (0.9)	27 (3.3)

	Baseline, n (%)	Follow Up, n (%)
How concerned are you about air quality in Bradford?		
Don't know	38 (4.7)	29 (3.6)
Extremely Concerned	167 (20.5)	151 (18.6)
Moderately Concerned	155 (19.0)	185 (22.7)
Somewhat Concerned	198 (24.3)	183 (22.5)
Slightly Concerned	177 (21.7)	178 (21.9)
Not at all Concerned	74 (9.1)	67 (8.2)
Missing	5 (0.6)	21 (2.6)
Do you think other people in Bradford are concerned about air quality?		
Extremely Concerned	30 (3.7)	30 (3.7)
Moderately Concerned	132 (16.2)	130 (16.0)
Somewhat Concerned	0 (0.0)	0 (0.0)
Slightly Concerned	93 (11.4)	93 (11.4)
Not at all Concerned	174 (21.4)	202 (24.8)
Don't know	158 (19.4)	142 (17.4)
Missing	5 (0.6)	21 (2.6)
How important do you think it is to improve air quality?		
Extremely Important	550 (67.6)	488 (60.0)
Moderately Important	116 (14.3)	177 (21.7)
Neutral	84 (10.3)	60 (7.4)
Slightly Important	32 (3.9)	41 (5.0)
Not at all Important	6 (0.7)	11 (1.4)
Don't know	22 (2.7)	17 (2.1)
Missing	4 (0.5)	20 (2.5)

the most deprived category (coefficient=-1.25; 95% CI: -2.51 to -0.01).

Decrease in agreement, or becoming unsure that CAZ will improve health: White British participants were more likely to be in the group that reported a decrease in agreement that the CAZ would improve health compared with Pakistani participants (coefficient: -0 .77, 95%CI: -1.51 to -0.04), or be in the group that reported becoming neutral compared with other ethnic minority participants (coefficient: -0.76, 95%CI: (-1.27 to -0.25).

Perception of air quality. Attitudes towards air quality remained mostly stable pre and post CAZ launch. (Figure 4, Table 5). Where changes did occur, roughly equal numbers changed

Table 5. Changes in CAZ and air quality attitudes between baseline and follow-up by ethnicity and location.

	Overall (N=814)	Ethnicity			CAZ Boundary	
		white British (N=323)	Pakistani (N=214)	Other (N=261)	Outside (N=544)	Inside (N=208)
Do you think the Clean Air Zone is a good idea?						
Became unsure	76 (9.3)	34 (10.5)	26 (12.1)	16 (6.1)	47 (8.6)	15 (7.2)
Move to negative	66 (8.1)	33 (10.2)	19 (8.9)	12 (4.6)	64 (11.8)	18 (8.7)
Move to positive	91 (11.2)	32 (9.9)	29 (13.6)	28 (10.7)	30 (5.5)	8 (3.8)
Remained negative	40 (4.9)	16 (5.0)	6 (2.8)	17 (6.5)	289 (53.1)	129 (62.0)
Remained positive	455 (55.9)	175 (54.2)	104 (48.6)	165 (63.2)	16 (2.9)	11 (5.3)
Remained unsure	32 (3.9)	14 (4.3)	12 (5.6)	6 (2.3)	0 (0)	0 (0)
Missing	54 (6.6)	19 (5.9)	18 (8.4)	17 (6.5)	41 (7.5)	10 (4.8)
To what extent do you agree or disagree that the Clean Air Zone covers the right areas of Bradford?						
Agreement decreased	91 (11.2)	39 (12.1)	16 (7.5)	33 (12.6)	57 (10.5)	23 (11.1)
Agreement increased	110 (13.5)	41 (12.7)	32 (15.0)	36 (13.8)	70 (12.9)	30 (14.4)
Became neutral	168 (20.6)	75 (23.2)	44 (20.6)	46 (17.6)	121 (22.2)	35 (16.8)
Remained in agreement	140 (17.2)	44 (13.6)	34 (15.9)	57 (21.8)	77 (14.2)	51 (24.5)
Remained in disagreement	47 (5.8)	14 (4.3)	7 (3.3)	23 (8.8)	39 (7.2)	8 (3.8)
Remained neutral	192 (23.6)	89 (27.6)	54 (25.2)	48 (18.4)	132 (24.3)	47 (22.6)
Missing	66 (8.1)	21 (6.5)	27 (12.6)	18 (6.9)	48 (8.8)	14 (6.7)
How much do you agree or disagree with the following statement: the CAZ will improve the health of my family/community?						
Agreement decreased	91 (11.2)	41 (12.7)	15 (7.0)	32 (12.3)	64 (11.8)	19 (9.1)
Agreement increased	92 (11.3)	33 (10.2)	33 (15.4)	24 (9.2)	60 (11.0)	23 (11.1)
Became neutral	145 (17.8)	75 (23.2)	34 (15.9)	34 (13.0)	96 (17.6)	39 (18.8)
Remained in agreement	334 (41.0)	120 (37.2)	84 (39.3)	124 (47.5)	214 (39.3)	96 (46.2)
Remained in disagreement	30 (3.7)	7 (2.2)	7 (3.3)	15 (5.7)	25 (4.6)	4 (1.9)
Remained neutral	65 (8.0)	29 (9.0)	21 (9.8)	14 (5.4)	45 (8.3)	14 (6.7)
Missing	57 (7.0)	18 (5.6)	20 (9.3)	18 (6.9)	40 (7.4)	13 (6.3)
What do you think about the air quality in Bradford generally?						
Negative change	111 (13.6)	53 (16.4)	27 (12.6)	30 (11.5)	79 (14.5)	26 (12.5)
Positive change	114 (14.0)	32 (9.9)	31 (14.5)	50 (19.2)	80 (14.7)	28 (13.5)
Remained negative	231 (28.4)	79 (24.5)	45 (21.0)	98 (37.5)	129 (23.7)	77 (37.0)
Remained positive	337 (41.4)	153 (47.4)	104 (48.6)	75 (28.7)	245 (45.0)	72 (34.6)
Missing	21 (2.6)	6 (1.9)	7 (3.3)	8 (3.1)	11 (2.0)	5 (2.4)

	Overall (N=814)	Ethnicity			CAZ Boundary	
		white British (N=323)	Pakistani (N=214)	Other (N=261)	Outside (N=544)	Inside (N=208)
How do you think this compares to other parts of the UK?						
Became Unsure	92 (11.3)	35 (10.8)	24 (11.2)	33 (12.6)	68 (12.5)	21 (10.1)
Negative change	132 (16.2)	55 (17.0)	43 (20.1)	33 (12.6)	87 (16.0)	34 (16.3)
Positive change	113 (13.9)	45 (13.9)	24 (11.2)	38 (14.6)	80 (14.7)	24 (11.5)
Remained negative	160 (19.7)	55 (17.0)	24 (11.2)	77 (29.5)	89 (16.4)	57 (27.4)
Remained neutral/unsure	264 (32.4)	120 (37.2)	77 (36.0)	64 (24.5)	189 (34.7)	58 (27.9)
Remained positive	20 (2.5)	5 (1.5)	9 (4.2)	5 (1.9)	14 (2.6)	5 (2.4)
Missing	33 (4.1)	8 (2.5)	13 (6.1)	11 (4.2)	17 (3.1)	9 (4.3)
How concerned are you about air quality in Bradford?						
Became unsure	24 (2.9)	8 (2.5)	13 (6.1)	2 (0.8)	13 (2.4)	10 (4.8)
Concern increased	114 (14.0)	55 (17.0)	25 (11.7)	32 (12.3)	85 (15.6)	24 (11.5)
Concern reduced	114 (14.0)	39 (12.1)	39 (18.2)	34 (13.0)	75 (13.8)	32 (15.4)
Remained concerned	222 (27.3)	54 (16.7)	47 (22.0)	114 (43.7)	125 (23.0)	75 (36.1)
Remained unconcerned	310 (38.1)	160 (49.5)	79 (36.9)	67 (25.7)	229 (42.1)	60 (28.8)
Remained unsure	4 (0.5)	1 (0.3)	1 (0.5)	2 (0.8)	3 (0.6)	1 (0.5)
Missing	26 (3.2)	6 (1.9)	10 (4.7)	10 (3.8)	14 (2.6)	6 (2.9)
Do you think other people in Bradford are concerned about air quality?						
Became unsure	84 (10.3)	30 (9.3)	33 (15.4)	21 (8.0)	54 (9.9)	24 (11.5)
Concern increased	102 (12.5)	47 (14.6)	22 (10.3)	31 (11.9)	74 (13.6)	22 (10.6)
Concern reduced	156 (19.2)	58 (18.0)	45 (21.0)	50 (19.2)	104 (19.1)	46 (22.1)
Remained concerned	57 (7.0)	15 (4.6)	14 (6.5)	28 (10.7)	29 (5.3)	18 (8.7)
Remained unconcerned	332 (40.8)	155 (48.0)	63 (29.4)	105 (40.2)	231 (42.5)	74 (35.6)
Remained unsure	57 (7.0)	11 (3.4)	27 (12.6)	18 (6.9)	38 (7.0)	17 (8.2)
Missing	26 (3.2)	7 (2.2)	10 (4.7)	8 (3.1)	14 (2.6)	7 (3.4)
How important do you think it is to improve air quality?						
Became unsure	16 (2.0)	2 (0.6)	10 (4.7)	4 (1.5)	8 (1.5)	8 (3.8)
Importance decreased	62 (7.6)	17 (5.3)	36 (16.8)	9 (3.4)	42 (7.7)	16 (7.7)
Importance increased	81 (10.0)	39 (12.1)	17 (7.9)	22 (8.4)	61 (11.2)	16 (7.7)
Remained important	582 (71.5)	237 (73.4)	132 (61.7)	201 (77.0)	387 (71.1)	151 (72.6)
Remained unimportant	49 (6.0)	22 (6.8)	11 (5.1)	16 (6.1)	34 (6.3)	12 (5.8)
Remained unsure	1 (0.1)	0 (0)	1 (0.5)	0 (0)	12 (2.2)	5 (2.4)
Missing	23 (2.8)	6 (1.9)	7 (3.3)	9 (3.4)	57 (10.5)	17 (8.2)

to a more positive standpoint (e.g. thinking air quality is better: 14%, compares better to other areas of the UK: 13.9%, and less concerned (e.g. reporting less concern: 14.0%, reporting others concern reduced 19.2%) compared with a more negative one (thinking air quality is worse: 13.6% and compares worse with other areas: 16.2%) or more concerned standpoint (14% and others more concerned: 12.5%).

Multinomial regressions identified no relationships between any demographic factors and those whose attitudes or concern

1. DO YOU THINK THE CAZ IS A GOOD IDEA?

Missing 7%
Became negative 8%
Remained negative 5%
Became unsure 9%
Remained unsure 4%
Became positive 11%
Remained positive 56%

2. DO YOU THINK THE CAZ COVERS THE RIGHT AREAS?

Missing 8%
Disagreement increased 11%
Remained in disagreement 6%
Became neutral 21%
Remained in agreement 17%
Agreement increased 13%
Remained neutral 24%
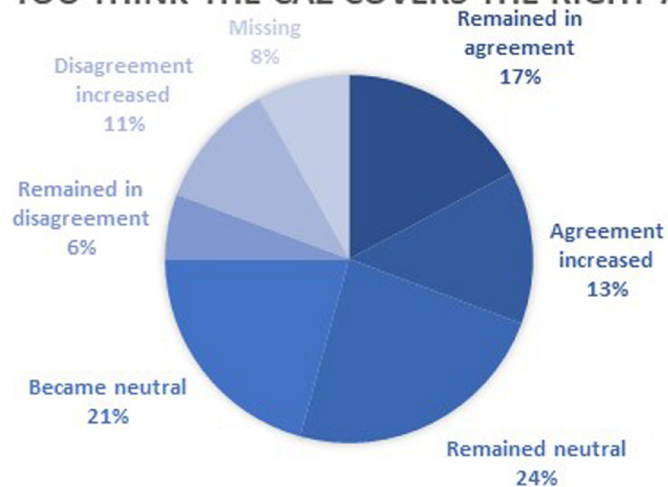
3. DO YOU THINK THE CAZ WILL IMPROVE HEALTH?

Disagreement increased 11%
Missing 7%
Remained in disagreement 4%
Became neutral 18%
Remained neutral 8%
Agreement increased
Remained in agreement 41%

Figure 3. Changes in attitudes towards the clean air zone from baseline to follow-up.

Table 6. Results of multinomial regression for changes in Clean Air Zone attitudes.

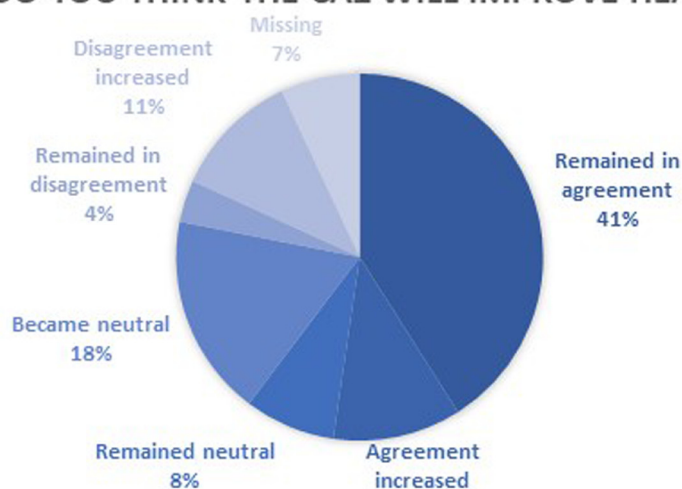| Item responses		Coefficient (95% CI)
Do you think the Clean Air Zone is a good idea? (N=686)		
No change		**Ref.**
Became positive	Pakistani ethnic origin	0.36 (-0.30 to 1.02)
	other ethnic origin	0.05 (-0.56 to 0.67)
	CAZ boundary: Outside	**0.71 (0.10 to 1.32)**
	Sex: Female	-0.69 (-1.40 to 0.01)
	Age: 35–44	0.22 (-1.27 to 0.26)
	Age: 45+	-0.17 (-1.02 to 0.69)
	IMD: Quintile 2	-0.50 (-1.27 to 0.26)
	IMD: Quintile 3	**-0.82 (-1.56 to -0.07)**
	IMD: Quintile 4	**-0.87 (-1.67 to -0.08)**
	IMD: Quintile 5	-0.58 (-1.45 to 0.30)
Became negative	Pakistani ethnic origin	-0.41 (-1.13 to 0.30)
	other ethnic origin	**-0.79 (-1.53 to -0.04)**
	CAZ boundary: Outside	0.39 (-0.29 to 1.06)
	Sex: Female	0.53 (-0.72 to 1.77)
	Age: 35–44	0.17 (-0.72 to 1.07)
	Age: 45+	0.10 (-0.84 to 1.04)
	IMD: Quintile 2	0.23 (-0.61 to 1.06)
	IMD: Quintile 3	-0.52 (-1.40 to 0.36)
	IMD: Quintile 4	-0.73 (-1.65 to 0.20)
	IMD: Quintile 5	**-1.25 (-2.51 to -0.01)**
Became unsure	Pakistani ethnic origin	0.30 (-0.36 to 0.96)
	other ethnic origin	-0.50 (-1.18 to 0.18)
	CAZ boundary: Outside	0.39 (-0.24 to 1.02)
	Sex: Female	-0.12 (-1.06 to 0.82)
	Age: 35–44	0.42 (-0.40 to 1.24)
	Age: 45+	-0.67 (-1.61 to 0.27)
	IMD: Quintile 2	-0.79 (-1.66 to 0.06)
	IMD: Quintile 3	-0.48 (-1.25 to 0.29)
	IMD: Quintile 4	-0.30 (-1.11 to 0.51)
	IMD: Quintile 5	-0.32 (-1.27 to 0.62)

Item responses		Coefficient (95% CI)
To what extent do you agree or disagree that the Clean Air Zone covers the right areas of Bradford? (N=675)		
No change		**Ref.**
Agreement increased	Pakistani ethnic origin	0.58 (-0.06 to 1.23)
	other ethnic origin	0.08 (-0.49 to 0.65)
	CAZ boundary: Outside	0.07 (-0.45 t0 0.59)
	Sex: Female	0.23 (-0.54 to 1.00)
	Age: 35–44	-0.39 (-1.17 to 0.38)
	Age: 45+	-0.09 (-0.87 to 0.70)
	IMD: Quintile 2	-0.00 (-0.81 to 0.81)
	IMD: Quintile 3	0.16 (-0.60 to 0.92)
	IMD: Quintile 4	0.30 (-0.51 to 1.11)
	IMD: Quintile 5	0.34 (-0.58 to 1.27)
Agreement decreased	Pakistani ethnic origin	-0.31 (-1.04 to 0.43)
	other ethnic origin	-0.10 (-0.70 to 0.50)
	CAZ boundary: Outside	0.06 (-0.52 to 0.64)
	Sex: Female	-0.52 (-1.24 to 0.20)
	Age: 35–44	-0.17 (-1.04 to 0.69)
	Age: 45+	-0.21 (-1.10 to 0.68)
	IMD: Quintile 2	0.62 (-1.53 to 0.29)
	IMD: Quintile 3	-0.22 (-1.0 to 0.55)
	IMD: Quintile 4	-0.18 (-0.97 to 0.61)
	IMD: Quintile 5	-0.96 (-2.04 to 0.12)
Became neutral	Pakistani ethnic origin	-0.07 (-0.61 to 0.47)
	other ethnic origin	-0.25 (-0.74 to 0.23)
	CAZ boundary: Outside	0.39 (-0.09 to 0.87)
	Sex: Female	0.17 (-0.52 to 0.86)
	Age: 35–44	-0.28 (-0.92 to 0.34)
	Age: 45+	-0.56 (-1.23 to 0.11)
	IMD: Quintile 2	0.17 (-0.48 to 0.81)
	IMD: Quintile 3	-0.12 (-0.76 to 0.53)
	IMD: Quintile 4	-0.32 (-1.0 to 0.36)
	IMD: Quintile 5	0.28 (-0.45 to 1.01)

Item responses		Coefficient (95% CI)
How much do you agree or disagree with the following statement: the CAZ will improve the health of my family/community? (N=685)		
No change		Ref.
Agreement increased	Pakistani ethnic origin	0.57 (-0.09 to 1.23)
	other ethnic origin	-0.19 (-0.83 to 0.45)
	CAZ boundary: Outside	0.13 (-0.44 to 0.69)
	Sex: Female	0.27 (-0.56 to 1.10)
	Age: 35–44	0.70 (-967 to 947)
	Age: 45+	-0.68 (-0.30 to 1.69)
	IMD: Quintile 2	-0.06 (-0.90 to 0.77)
	IMD: Quintile 3	0.32 (-0.45 to 1.09)
	IMD: Quintile 4	0.02 (-0.85 to 0.89)
	IMD: Quintile 5	-0.11 (-1.12 to 0.91)
Agreement decreased	Pakistani ethnic origin	**-0.77 (-1.51 to -0.04)**
	other ethnic origin	0.00+ (-0.56 to 0.56)
	CAZ boundary: Outside	0.34 (-0.27 to 0.95)
	Sex: Female	0.54 (-0.33 to 1.41)
	Age: 35–44	0.00+ (-0.81 to 0.81)
	Age: 45+	0.09 (-0.75 to 0.93)
	IMD: Quintile 2	0.19 (-0.64to 1.02)
	IMD: Quintile 3	-0.14 (-0.95 to 0.67)
	IMD: Quintile 4	-0.40 (-1.23 to 0.44)
	IMD: Quintile 5	-0.55 (-1.52 to 0.42)
Became neutral	Pakistani ethnic origin	-0.50 (-1.06 to 0.07)
	other ethnic origin	**-0.76 (-1.27 to -0.25)**
	CAZ boundary: Outside	-0.22 (-0.69 to 0.25)
	Sex: Female	0.34 (-0.37 to 1.06)
	Age: 35–44	-0.14 (-0.78 to 0.50)
	Age: 45+	-0.18 (-0.85 to 0.49)
	IMD: Quintile 2	-0.15 (-0.84 to 0.54)
	IMD: Quintile 3	-0.11 (-0.77 to 0.54)
	IMD: Quintile 4	-0.05 (-0.72 to 0.63)
	IMD: Quintile 5	-0.13 (-0.90 to 0.65)

N.B: N based on complete case analysis: Reference categories: Ethnicity: white British; Sex: male; Age: 18–34 years; Deprivation: most deprived (quintile 1); CAZ boundary: inside.
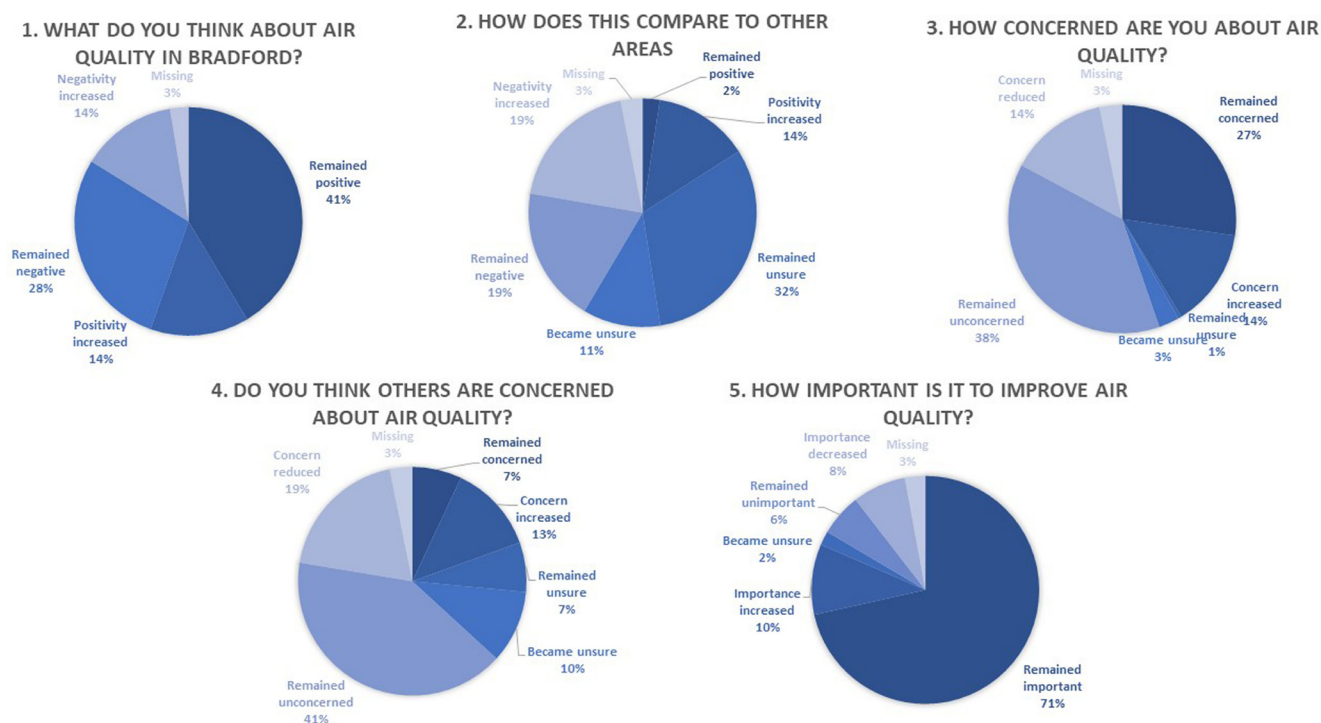
Figure 4. Changes in attitudes towards air quality from baseline to follow-up.

towards air quality had worsened (e.g. more likely to rate it worse, and compare it negatively to other areas of the UK) and those whose concern had either increased or reduced (see Table 7). However, there were some significant associations as follows:

Positive change in attitudes towards air quality: Those in the 'other' ethnic origin category were more likely to have positive change of attitude about Bradford air quality than white British ethnic origin participants (coefficient=0.78; 95% CI:0.26 to 1.31).

Positive change in how Bradford compares to the rest of the UK: Compared to the most deprived group, those in IMD quintile 2 were more likely to report change comparing Bradford favourably to the rest of the UK compared to those in the most deprived quintile (co-efficient=0.83, 95%CI - 0.03 to 1.62).

Increase in perceptions of others concern about air quality: Those in the oldest age group (45+) were more likely to be in the group whose perceptions of others concern about air quality increased compared with those in the younger age group (18–34, coefficient=1.32, 95%CI 0.22-2.22).

Importance of improving air quality increased: There were some differences by IMD quintile. Compared with the most deprived areas, those in more affluent areas were less likely to report increased importance of tackling pollution (compared with quintile 1: quintile 3 coefficient= -0.87, 95%CI -1.64 to -0.10; quintile 5 coefficient=-1.11; 95% CI: -2.06 to -0.17).

Importance of improving air quality decreased. Those 45+ years old were less likely to say that importance of improving air quality decreased (coefficient=-1.13; 95% CI: -2.00 to -0.26) compared with those 18–34 age group.

Discussion

We explored whether perceptions of acceptability of the CAZ, air quality, and travel behaviours changed after the implementation of a CAZ in a large, urban multi-ethnic city. On the whole, the majority of participants felt that the CAZ was a good idea and had the potential to improve health. However, there was a slight drop in the number of people finding that it was acceptable between the baseline and follow-up surveys. We found that just over a third of respondents thought air quality was poor and were concerned about air quality at follow-up.

Travel behaviour remained similar over the implementation year. Private car was the most used mode of transport during the baseline and follow-up survey periods for main earners of the household This is not surprising, as unlike the previous studies which did indicate changes in travel behaviour (Gonzalez *et al.*, 2023; Mayor of London, 2023; Tarriño-Ortiz *et al.*, 2022), the current CAZ did not charge private vehicles. We found low numbers reporting using public transport to get to work or school (~10%), with slightly higher numbers using public transport for leisure purposes (30%). In order to encourage shifts to more sustainable travel modes other initiatives which discourage private vehicle use such as reducing parking availability may be more effective than

Table 7. Results of multinomial regression for changes in air quality attitudes.

Item responses		Coefficient (95% CI)
What do you think about the air quality in Bradford generally? (N=721)		
No change		Ref.
Negative change	Pakistani ethnic origin	-0.25 (-0.86 to 0.35)
	other ethnic origin	-0.07 (-0.59 to 0.46)
	CAZ boundary: Outside	0.14 (-0.38 to 0.67)
	Sex: Female	0.89 (-0.01 to 1.79)
	Age: 35–44	0.28 (-0.49 to 1.06)
	Age: 45+	0.42 (-0.37 to 1.22)
	IMD: Quintile 2	0.07 (-0.65 to 0.80)
	IMD: Quintile 3	-0.33 (-1.05 to 0.38)
	IMD: Quintile 4	-0.21 (-0.94 to 0.52)
	IMD: Quintile 5	0.15 (-0.63 to 0.94)
Positive change	Pakistani ethnic origin	0.28 (-0.33 to 0.89)
	other ethnic origin	**0.78 (0.26 to 1.31)**
	CAZ boundary: Outside	0.24 (-0.26 to 0.75)
	Sex: Female	0.11 (-0.55 to 0.78)
	Age: 35–44	0.26 (-0.48 to 1.01)
	Age: 45+	0.36 (-0.41 to 1.13)
	IMD: Quintile 2	0.71 (-0.03 to 1.45)
	IMD: Quintile 3	0.17 (-0.56 to 0.91)
	IMD: Quintile 4	0.17 (-0.60 to 0.94)
	IMD: Quintile 5	-0.20 (-1.12 to 0.72)
How do you think this compares to other parts of the UK? (N=712)		
No change		**Ref.**
Negative change	Pakistani ethnic origin	0.19 (-0.38 to 0.75)
	other ethnic origin	-0.21 (-0.74 to 0.32)
	CAZ boundary: Outside	0.13 (-0.36 to 0.62)
	Sex: Female	-0.05 (-0.74 to 0.65)
	Age: 35–44	0.50 (-0.28 to 1.28)
	Age: 45+	0.51 (-0.30 to 1.33)
	IMD: Quintile 2	0.02 (-0.65 to 0.70)
	IMD: Quintile 3	-0.38 (-1.05 to 0.29)
	IMD: Quintile 4	-0.36 (-1.05 to 0.33)
	IMD: Quintile 5	0.11 (-0.65 to 0.87)

Item responses		Coefficient (95% CI)
Positive change	Pakistani ethnic origin	-0.32 (-0.95 to 0.31)
	other ethnic origin	0.00+ (-0.53 to 0.54)
	CAZ boundary: Outside	0.32 (-0.22 to 0.87)
	Sex: Female	-0.27 (-0.96 to 0.42)
	Age: 35–44	-0.07 (-0.82 to 0.70)
	Age: 45+	0.16 (-0.62 to 0.93)
	IMD: Quintile 2	**0.83 (0.03 to 1.62)**
	IMD: Quintile 3	0.30 (-0.49 to 1.09)
	IMD: Quintile 4	-0.03 (-0.86 to 0.79)
	IMD: Quintile 5	-0.13 (-1.09 to 0.83)
Became unsure	Pakistani ethnic origin	0.18 (-0.48 to 0.83)
	other ethnic origin	0.24 (-0.32 to 0.81)
	CAZ boundary: Outside	0.32 (-0.25 to 0.89)
	Sex: Female	0.15 (-0.62 to 0.92)
	Age: 35–44	-0.33 (-1.07 to 0.41)
	Age: 45+	-0.12 (-0.88 to 0.64)
	IMD: Quintile 2	-0.13 (-1.00 to 0.74)
	IMD: Quintile 3	0.33 (-0.41 to 1.08)
	IMD: Quintile 4	-0.34 (-0.57 to 1.21)
	IMD: Quintile 5	0.32 (-0.57 to 1.21)
How concerned are you about air quality in Bradford? (N=695)		
No change		Ref.
Concern increased	Pakistani ethnic origin	-0.34 (-0.93 to 0.26)
	other ethnic origin	-0.52 (-1.05 to 0.01)
	CAZ boundary: Outside	0.28 (-0.25 to 0.82)
	Sex: Female	0.18 (-0.54 to 0.89)
	Age: 35–44	-0.01 (-0.80 to 0.79)
	Age: 45+	0.47 (-0.33 to 1.28)
	IMD: Quintile 2	0.43 (-0.33 to 1.19)
	IMD: Quintile 3	0.15 (-0.59 to 0.88)
	IMD: Quintile 4	-0.34 (-1.13 to 0.45)
	IMD: Quintile 5	0.14 (-0.71 to 0.98)
Concern reduced	Pakistani ethnic origin	0.38 (-0.20 to 0.97)
	other ethnic origin	0.01 (-0.53 to 0.55)
	CAZ boundary: Outside	-0.01(-0.51 to 0.49)
	Sex: Female	0.30 (-0.47 to 1.07)
	Age: 35–44	-0.31 (-0.96 to 0.34)
	Age: 45+	-0.47 (-1.16 to 0.23)

Item responses		Coefficient (95% CI)
	IMD: Quintile 2	-0.01 (-0.66 to 0.69)
	IMD: Quintile 3	-0.53 (-1.24 to 0.18)
	IMD: Quintile 4	-0.06 (-0.76 to 0.64)
	IMD: Quintile 5	-0.13 (-0.96 to 0.70)
Do you think other people in Bradford are concerned about air quality? (N=717)		
No change		**Ref.**
Concern increased	Pakistani ethnic origin	-0.09 (-0.75 to 0.56)
	other ethnic origin	-0.29 (-0.85 to 0.27)
	CAZ boundary: Outside	0.25 (-0.32 to 0.82)
	Sex: Female	0.29 (-0.47 to 1.05)
	Age: 35–44	0.76 (-0.32 to 1.85)
	Age: 45+	**1.32 (0.22 to 2.22)**
	IMD: Quintile 2	0.19 (-0.63 to 1.01)
	IMD: Quintile 3	-0.31 (-1.11 to 0.50)
	IMD: Quintile 4	-0.25 (-1.08 to 0.58)
	IMD: Quintile 5	0.16 (-0.72 to 1.03)
Concern reduced	Pakistani ethnic origin	0.33 (-0.12 to 0.79)
	other ethnic origin	0.02 (-0.39 to 0.44)
	CAZ boundary: Outside	-0.01 (-0.39 to 0.39)
	Sex: Female	0.46 (-0.11 to 1.04)
	Age: 35-44	-0.37 (-0.90 to 0.15)
	Age: 45+	0.02 (-0.52 to 0.57)
	IMD: Quintile 2	-0.30 (-0.86 to 0.25)
	IMD: Quintile 3	-0.46 (-0.99 to 0.07)
	IMD: Quintile 4	-0.38 (-0.94 to 0.18)
	IMD: Quintile 5	-0.47 (-1.13 to 0.18)
How important do you think it is to improve air quality? (N=705)		
No change		**Ref.**
Importance increased	Pakistani ethnic origin	-0.33 (-1.02 to 0.36)
	other ethnic origin	-0.35 (-0.97 to 0.26)
	CAZ boundary: Outside	0.41 (-0.24 to 1.05)
	Sex: Female	-0.03 (-0.90 to 0.84)
	Age: 35-44	0.53 (-0.38 to 1.45)
	Age: 45+	-0.07 (-1.04 to 0.90)
	IMD: Quintile 2	-0.68 (-1.50 to 0.14)
	IMD: Quintile 3	**-0.87 (-1.64 to -0.10)**
	IMD: Quintile 4	-0.52 (-1.26 to 0.23)
	IMD: Quintile 5	**-1.11 (-2.06 to -0.17)**

Item responses		Coefficient (95% CI)
Importance decreased	Pakistani ethnic origin	1.23 (0.49 to 1.98)
	other ethnic origin	-0.22 (-1.11 to 0.68)
	CAZ boundary: Outside	0.38 (-0.29 to 1.05)
	Sex: Female	-0.50 (-1.48 to 0.48)
	Age: 35-44	-0.42 (-1.16 to 0.32)
	Age: 45+	**-1.13 (-2.00 to -0.26)**
	IMD: Quintile 2	0.26 (-0.56 to 1.07)
	IMD: Quintile 3	-0.10 (-0.97 to 0.76)
	IMD: Quintile 4	0.07 (-0.91 to 1.05)
	IMD: Quintile 5	-1.83 (-3.95 to 0.29)

N.B: N based on complete case analysis: Reference categories: Ethnicity: white British; Sex: male; Age: 18–34 years; Deprivation: most deprived (quintile 1); CAZ boundary: inside.

CAZ, but these need to be done in the context of strong public transport links (Department of Transport, 2021b).

Our findings add to the limited literature on the acceptability of policies such as LEZ amongst communities living in areas directly affected by the policy. Like others (Oltra *et al.*, 2021) we found that the majority of respondents expressed support for the CAZ, after it has been in place for over a year, despite the 'loud' vocal opposition that was apparent before the CAZ was launched (Knamiller *et al.*, 2024).

To our knowledge, this is first repeated survey study that has explored the changes in perceptions of air quality, acceptability of CAZ and travel behaviours. The survey participants' increase in positivity about air quality, decrease in acceptability of CAZ, and a decrease in the importance of improving air quality may imply two competing scenarios. On the positive side, it could mean that participants felt the air quality has improved after the implementation of CAZ, so it has become less of a concern and priority for them. However, on the negative side, it could also mean that although the air quality has improved, CAZ popularity has dropped after implementation due to its impact on the residents' daily life.

Amongst our longitudinal sample we found that on the whole attitudes remained largely stable pre to post implementation. This is in contrast to other research similar initiatives which found an increase in positivity towards the interventions (Oltra *et al.*, 2021; Schuitema *et al.*, 2010; Seter *et al.*, 2023) after their implementation. Where attitudes for some did change, there were largely no relationships between key socio-demographic variables and perception changes, which is common with other studies in which there were no visible or very weak trends, and inconclusive evidence from different studies (Oltra *et al.*, 2021; Player *et al.*, 2023). Certain groups, for example, ethnic minority groups, and those living outside of the CAZ boundary were more likely to report a positive change of views (or lack of negative change) towards the CAZ. Those in more affluent areas were less likely to report increases in the importance of tackling pollution compared with deprived areas. The reasons for any change in attitudes cannot be deduced from the current study and future research should aim to qualitatively explore which key factors of LEZ policy may impact on support over time.

Our study has a number of strengths. It recruited a large multi ethnic sample of participants, living in deprived areas of a large city which has recently introduced a CAZ. Previous research has found that these communities may be more likely to be impacted by pollution, and can also be seldom heard in research and therefore this is an important group to study. Second, the study used comparative analyses of pre and post implementation attitudes which has provided useful information of the perception of residents on air quality and acceptability of CAZ at different stages of implementation. The information can be useful for efforts to understand how public acceptability of CAZ may influence implementation. Third, by including a longitudinal component we were able to directly test whether attitudes changed after the implementation of the CAZ. We found attitudes to be relatively stable, indicating that assessment prior to initiatives being implemented are a valid way of predicting later opinions.

However, there are some weaknesses. First, our surveys are prone to selection bias due to participants being those who were willing to participate. In particular, the general public participants may have been motivated mainly by a vested interest in the topic, whereas BiB participants were approached directly to take part as part of routine research interactions. This was particularly apparent in the baseline survey where large variations in the patterns of responses were seen between the general public and BiB participants. In particular, the baseline general public survey appeared to have higher numbers of people who were extremely concerned about air quality. In order to mitigate

against self-selection bias for the follow-up survey we attempted to recruit members of the general public in a variety of ways, including attending community events and healthcare settings. This approach appears to have also helped to boost numbers of ethnic minority participants in the follow-up sample. Second, information on socio demographic factors were substantially missing for the follow up general public survey participants hence the responses obtained here may not reflect the district's population view.

In conclusion, we found concerns about air quality, the need to improve air quality and support of CAZ were felt by the majority of residents we surveyed, and these remained stable over the duration of the study. Systematically assessing communities' support for measures such as LEZ is an important step in the implementation process and ensuring that communities who are 'seldom-heard' are included is crucial to balance what can be often loud and vocal opposition. Whilst small, we did find some evidence of a decrease in support for the CAZ. If this drop in support continues, it may threaten the sustainability of the CAZ. Continuous communication with stakeholders and communities will be important to share benefits and outcomes of the CAZ to maintain levels of public support.

Ethics and consent

Ethical approval was granted from the Bradford Leeds Research NHS research ethics committee on the 30/06/2020 (Ref 20/YH/0158), in accordance with the declaration of Helsinki.

All participants received a participant information sheet and were asked to indicate their written consent which was recorded on the landing page of the survey prior to completing the questionnaires.

Data availability

Data are available for sharing can be requested via the Born in Bradford executive group (borninbradford@bthft.nhs.uk). A detailed data dictionary can be found here: https://borninbradford.github.io/datadict/bib_breathes.html and further details on how to make an application can be found here: https://borninbradford.nhs.uk/research/how-to-access-data/. Information sheets and questionnaires can be found on the Born in Bradford website: https://borninbradford.nhs.uk/research/study-documents/

Author contributions

TM: Conceptualisation, Formal Analysis, Methodology, Supervision, Writing-original draft, Writing -review and editing

RM: Conceptualisation, Funding acquisition, Methodology, Project administration, Supervision, Writing – review and editing

CK: Conceptualisation, Investigation, Project administration, Writing – review and editing

GS: Funding acquisition, Data curation, Supervision, Writing – review and editing

RH: Investigation, project administration, Writing – review and editing

MB: Conceptualisation, Funding acquisition, Methodology, Project administration, Supervision, Writing – review and editing

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❓ **Christian Oltra**

Socio-Technical Research Centre, CIEMAT, Barcelona, Spain

I would like to congratulate you on your article, which addresses a highly relevant topic. Its longitudinal approach and the wealth of data presented are undoubtedly a valuable contribution to the field.

However, to further improve the clarity and accessibility of the article, I would like to offer some suggestions that could help focus the analysis and make it easier for readers to understand:

1. Prioritise key findings. I recommend focusing on the findings most directly related to the objectives of the study, such as:

   - Changes in support for CAZ.

   - Perception of air quality.

   - Impacts on transport modes.

This would allow the reader to focus on the most relevant results

2. Restructure the narrative: I would propose organising the results around three broad thematic blocks:

   - Perception of the CAZ.

   - Perception of air quality.

   - Travel behaviours.

This will provide a clearer framework for presenting the findings and hold the reader's attention.

3. Eliminating some tables and grouping similar results together or: Several tables could be synthesised into a summary graph or deleted if they are not directly connected to the main research questions.

4. Simplifying the presentation of statistical models: I find it useful to include a compact table summarising only the significant findings from the regression models. Technical details can be moved to the appendix, allowing the text to flow in a more narrative fashion.

5. Optimise data visualization: Replacing some dense tables with graphs could make the results more accessible.

These recommendations are not intended to detract from the breadth of your work, but to highlight it in a way that allows readers to grasp the impact of your findings more easily. I am

convinced that these small modifications could further enhance the scope and clarity of your contribution.
Yours sincerely

Is the work clearly and accurately presented and does it cite the current literature?
Yes

Is the study design appropriate and is the work technically sound?
Yes

Are sufficient details of methods and analysis provided to allow replication by others?
Yes

If applicable, is the statistical analysis and its interpretation appropriate?
Yes

Are all the source data underlying the results available to ensure full reproducibility?
No

Are the conclusions drawn adequately supported by the results?
Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Risk perception

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

> Author Response 05 Mar 2025
> **Rosemary McEachan**
>
> We thank the reviewer for their positive and constructive comments.
>
> 1. Prioritise key findings. I recommend focusing on the findings most directly related to the objectives of the study, such as: Changes in support for CAZ. Perception of air quality. Impacts on transport modes. This would allow the reader to focus on the most relevant results
> 2. Restructure the narrative: I would propose organising the results around three broad thematic blocks: Perception of the CAZ. Perception of air quality. Travel behaviours.
> This will provide a clearer framework for presenting the findings and hold the reader's attention.
> > ○ We thank the reviewer for these two thoughtful suggestions and have restructured our findings as follows:
> > > ○ 1. Acceptability of the clean air zone, presenting first the cross-sectional

analyses and subsequently the longitudinal analysis (e.g. attitude change);
- ○ 2. Perceptions of air quality (cross-sectional, then changes;
- ○ 3. Travel behaviors
- ○
- ○ We have restructured the discussion. This covers:
  - ○ Overall summary of results
  - ○ Discussion about changes in attitudes to CAZ and air quality
  - ○ Discussion about stability of attitudes
  - ○ Discussion about travel behaviour
  - ○ Strengths and limitations
  - ○ Conclusion

3. Eliminating some tables and grouping similar results together or: Several tables could be synthesised into a summary graph or deleted if they are not directly connected to the main research questions.
- ○ We agree – we have now uploaded three tables into extended data:

Table S1. CAZ and air quality attitudes of participants who participated in baseline and follow-up surveys (N=814).
Table S2. Results of multinomial regression for changes in Clean Air Zone attitudes.
Table S3. Results of multinomial regression for changes in air quality attitudes.

4. Simplifying the presentation of statistical models: I find it useful to include a compact table summarising only the significant findings from the regression models. Technical details can be moved to the appendix, allowing the text to flow in a more narrative fashion.
5. Optimise data visualization: Replacing some dense tables with graphs could make the results more accessible.
- ○ Thank you for these two comments. We have included a summary figure (Figure 4) which highlights the key findings from the multinomial regression and have removed the tables to the extended data (see response above).

Competing Interests: No competing interests were disclosed.

Reviewer Report 22 November 2024

https://doi.org/10.3310/nihropenres.14911.r33648

? **Yifu Ou** 🆔

Hong Kong Baptist University Department of Geography, Hong Kong, Hong Kong

This study investigates the impact of implementing a low emission zone (LEZ) on perceptions of air quality, acceptability, and travel behavior in Bradford, UK. Overall, the manuscript is well-structured, addressing an interesting and relevant topic with satisfactory writing quality. My detailed comments for further improvement are as follows:

(1) In the **Statistical Analysis** section, the authors are advised to provide a more detailed explanation of their choice of model. Specifically, why was Multinomial Regression chosen over other commonly used statistical models, such as Structural Equation Modeling?

(2) **Multicollinearity Problem:** The authors are advised to test for potential multicollinearity problems, using variance inflation factor (VIF) before conducting regression analysis. For example, the IMD quintile might be correlated with other demographic characteristics like sex, age, and ethnicity. Including all these variables in a regression model could potentially cause multicollinearity problems and bias the estimation results.

(3) **Omitted Variable Problem:** Since LEZ is essentially a type of transport policy, people's perceptions of LEZ-related issues may also be influenced by the availability of transport infrastructure. Specifically, failing to account for various forms of transport services (e.g., increased bus frequency, urban rail transit development) provided during the study period could lead to an omitted variable problem and bias the estimation results.

(4) The authors should include more in-depth discussions when interpreting their results. For example, they could provide a detailed explanation of why the number of people finding the LEZ acceptable decreased after its implementation. In addition, they should also explore why the travel behavior of residents remained unchanged, in contrast to other parts of Europe where LEZs have significantly influenced travel patterns.

(5) The authors are advised to include a detailed model specification that allows the analysis and method to be replicated by others.

Is the work clearly and accurately presented and does it cite the current literature?
Yes

Is the study design appropriate and is the work technically sound?
Partly

Are sufficient details of methods and analysis provided to allow replication by others?
Partly

If applicable, is the statistical analysis and its interpretation appropriate?
Yes

Are all the source data underlying the results available to ensure full reproducibility?
Yes

Are the conclusions drawn adequately supported by the results?
Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Environmental Economics, Air Pollution, Sustainable Transport and Land Use Planning

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 05 Mar 2025

Rosemary McEachan

○ We thank the reviewer for their positive and constructive comments.

My detailed comments for further improvement are as follows:
(1) In the Statistical Analysis section, the authors are advised to provide a more detailed explanation of their choice of model. Specifically, why was Multinomial Regression chosen over other commonly used statistical models, such as Structural Equation Modeling?

○ As our outcome variable was categorical (e.g. relating to whether attitudes had remained stable, or increased or decreased in valence) multi-nomial regression is a suitable analysis technique. We have added justification of our choice n the statistical analysis methods section as follows:

We have added further justification as follows:
"Multinomial regressions, which are appropriate for multi-category outcomes, were used to explore whether changes in attitudes (reference: no change) were associated with demographic factors including ethnicity (white British[reference], Pakistani origin, other), sex (male[reference], female), Age (18–34[reference], 35–44, 45+), and Bradford IMD quintile (reference IMD 1 – most deprived) and whether respondents lived inside (reference) or outside the CAZ zone."

(2) Multicollinearity Problem: The authors are advised to test for potential multicollinearity problems, using variance inflation factor (VIF) before conducting regression analysis. For example, the IMD quintile might be correlated with other demographic characteristics like sex, age, and ethnicity. Including all these variables in a regression model could potentially cause multicollinearity problems and bias the estimation results.

○ Thank you for this suggestion. We have tested for multi-collinearity by running a series of ordinary least square regression for each independent variable against all other variables. We limited risk of multi-collinearity. We have added an addition to the manuscript as follows:

"Multi-collinearity was first assessed by running a series of ordinary logistic least square regressions of each independent variable against all other variables. The mean variance inflation factor for all regressions was <2, indicating limited risk of multi-collinearity between the independent variables."

(3) Omitted Variable Problem: Since LEZ is essentially a type of transport policy, people's perceptions of LEZ-related issues may also be influenced by the availability of transport infrastructure. Specifically, failing to account for various forms of transport services (e.g., increased bus frequency, urban rail transit development) provided during the study period could lead to an omitted variable problem and bias the estimation results.

- Thank you for this comment, we agree that wider contextual factors may impact on CAZ related attitudes. Unfortunately, we were not able to measure these in the current study, however, we have explored these in depth in related qualitative work. We have added a limitation as follows:

"Finally, we did not ask about attitudes to wider transport policy, which may impact on CAZ-related views."

(4) The authors should include more in-depth discussions when interpreting their results. For example, they could provide a detailed explanation of why the number of people finding the LEZ acceptable decreased after its implementation. In addition, they should also explore why the travel behavior of residents remained unchanged, in contrast to other parts of Europe where LEZs have significantly influenced travel patterns.

- We have restructured the discussion (see also Reviewer 2). The drop in acceptability was small. Further qualitative research which is in preparation can shed some light on the reasons for the changes in additions. We have amended the text as follows:

"We did however find a small drop in support for the CAZ, along with less agreement that the CAZ would benefit the health of families, an increase in positivity about air quality, and a drop in numbers reporting it was important to improve air quality at follow-up. This may imply two competing scenarios. On the positive side, it could mean that participants felt the air quality has improved after the implementation of CAZ, so it has become less of a concern and priority for them. However, on the negative side, it could also mean that although the air quality has improved, CAZ popularity has dropped after implementation due to its impact on the residents' daily life.
Evidence from qualitative interviews and focus groups with members of the public ((Knamiller et al, in preparation) suggests some potential reasons for this decline in acceptability including the pressures felt by communities by the 'cost of living' crisis (which saw increases in cost of energy, fuel and food), a lack of trust in the authorities implementing the zone, and a lack of knowledge about whether the zone was working."

- We hypothesise the reason that we do not see shifts in travel behaviour is because the CAZ did not charge private vehicles, and therefore there was less incentive for individuals to change their personal travel behaviours. We feel that we have adequately covered this in the discussion (line 398-407) and so for parsimony have not changed the text further.

"Travel behaviour remained similar over the implementation year. Private car was the most used mode of transport during the baseline and follow-up survey periods for main earners of the household This is not surprising, as unlike the previous studies which did indicate changes in travel behaviour (Gonzalez *et al.*, 2023; Mayor of London, 2023; Tarriño-Ortiz *et al.*, 2022), the current CAZ did not charge private vehicles."

(5) The authors are advised to include a detailed model specification that allows the analysis and method to be replicated by others.

○ We have clarified the program (Stata 17, Statacorp, 2023) and the command used (mlogit); this together with information on the variables included should enable replication.

"Multinomial regressions, which are appropriate for multi-category outcomes, were used to explore whether changes in attitudes (reference: no change) were associated with demographic factors including ethnicity (white British[reference], Pakistani origin, other), sex (male[reference], female), Age (18–34[reference], 35–44, 45+), and Bradford IMD quintile (reference IMD 1 – most deprived) and whether respondents lived inside (reference) or outside the CAZ zone. Analyses were conducting using the mlogit command in Stata (v17 Statacorp 2023). The analyses were based on those who provided complete data (i.e., complete case analysis)."

Competing Interests: No competing interests were disclosed.