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HEaLth iMpact of E-bikes and e-scooTers (HELMET)

Project Protocol

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OXFORD BROOKES UNIVERSITY

UNIVERSITY OF BATH

UNIVERSITY OF LEEDS

Leeds CITY COUNCIL

Contents

2.1 KEY PROJECT CONTACTS

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Funders	NIHR Public Health Research Programme

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Key collaborators:

- Bristol City Council
- Leeds City Council
- Sheffield City Council
- Bradford Metropolitan District Council
- Plymouth City Council
- Bath and North East Somerset Council
- West of England Combined Authority
- West Yorkshire Combined Authority
- Beryl, commercial partner
- Tier/Dott, commercial partner

2.2 PROJECT SUMMARY

Project Title	HEaLth iMpact of E-bikes and e-scooTers (HELMET)
Project Design	Seven inter-related work packages (WP1-7) WP1: Repeated cross-sectional quantitative survey with some repeated measures. WP2: Qualitative interviews. WP3: Observational metabolic study (energy expenditure assessment during e-scooter use). WP4: Cross-sectional carbon emission changes secondary data analysis. WP5: Quasi-experimental road traffic collision secondary analysis (controlled interrupted time series analysis). WP6: Economic evaluation secondary data analysis (cost-consequence analysis). WP7: Co-production and knowledge translation.
Intervention	Introduction of e-bike share hire schemes in Bristol and Leeds.
Project Participants	WP1: Residents of Bristol, Leeds (intervention sites; plus residents of Bath and Plymouth for triangulation only), Sheffield and Bradford (control sites) aged 16 years and over. WP2: Participants of WP1 survey who agreed to be re-contacted for interview. WP3: Bath resident e-scooter users who took part in WP1 survey and agreed to be re-contacted. Other potentially interested Bath residents (as required). WP4-6: N/A. WP7: Representatives from local authorities, combined authorities, and service providers who have implemented these schemes. Co-production team comprising policy makers, users, residents, and research team members. PPIE recruits for online participatory design workshops.

Planned Sample Sizes	WP1: n=1400-2400 (achieved n=2144 at baseline and n=2345 at resurvey) in intervention sites (Bristol and Leeds combined); n=1400-2400 (achieved n=1627 at baseline and n=2030 at resurvey) in control sites (Bradford and Sheffield combined); with n=1316 repeated measures. Sample size calculation included in survey data collection protocol (https://osf.io/gq9s8/). WP2: N=60 (n=18 e-bike scheme (only) users; n=12 e-scooter scheme (only) users; n=8 e-scooter and e-bike users; n=14 non-e-bike or e-scooter users where schemes are available; n=8 controls where no schemes are available). WP3: N=18-20 WP4-6: N/A. WP7: Interviews with n=10-16 representatives from local authorities, combined authorities, and service providers who have implemented these schemes. Co-production team of n=10-15 participants. PPIE participants for online participatory design workshops (n=6-8).
Planned Study Period	January 1st 2025 – December 31st 2026

2.3 PROJECT MANAGEMENT

2.3.1 FUNDER

This research is supported by National Institute for Health Research (NIHR) Public Health Research (PHR) Programme (NIHR163726).

2.3.2 PROJECT MANAGEMENT AND GOVERNANCE

Dr Armstrong will manage the project overall, including day-to-day project management and will line-manage Dr Garbutt at the University of Bristol. A part-time project administrator will be based at the University of Bristol and will be line managed by the Research Manager in the School for Policy Studies. Dr Sanghera will line-manage the Health Economics Senior Research Associate at the University of Bristol. Professor Jones will line-manage Dr Maryam Mani and Dr Nurgul Yardim Mericliler at Oxford Brookes University. Dr Philips will line-manage a quantitative transport data analyst at the University

of Leeds. Dr Armstrong and co-applicants will form the Project Management Team. The project management team will meet monthly during the project.

The Study Steering Committee (SSC) established during the PHR Rapid Funding Scheme (NIHR159622) baseline data collection phase will continue into this project. They will meet twice each year online. The SSC will be chaired by Dr Paul Kelly (Active Travel – Edinburgh). Members include Dr Anthony Laverty (Imperial College, London), independent local authority member Mr Ian Achurch (North Northamptonshire Council), Mr Tim Burns (Sustrans), and two Patient and Public Involvement (PPI) representatives, Ms Josephine Gyasi and Mx Ben Foley. Due to complex analyses in this project, Dr Jenna Panter (Quantitative Research Fellow, University of Cambridge) has also been added to the SSC.

2.4 PLAIN ENGLISH SUMMARY

Physical activity is important for physical and mental health. Walking or cycling between places is one way to be physically active. E-bikes are pedal bikes which have a battery to make cycling easier, especially on hills, whilst still maintaining a level of physical activity. Using e-bikes could be a good option to increase physical activity, but we need more scientific evidence. E-scooters run on batteries, meaning you don’t have to push them. E-scooters may decrease physical activity if people use them instead of walking or cycling.

The government has not yet decided whether to legalise the private use of e-scooters. The government has been testing e-scooter share hire schemes in some parts of the UK since 2020. People can pay to use them for trips within each of these areas. While certain types of e-bikes are currently legal in the UK, they can be expensive to buy and tricky to store safely at home. Being able to pay to use them only when they are needed may encourage greater use.

We don't know whether people’s travel choices change when e-bike and e-scooter share hire schemes are available. For example, do people who would have driven before or taken a bus, choose to take an e-bike or e-scooter instead? Do people who would have walked before, choose to take an e-scooter instead? This would impact on physical activity levels. We don’t know how much physical activity you get from using e-scooters. We also do not know the impact of e-bike and e-scooter schemes on the environment and if they reduce the amount of carbon dioxide emissions, which affects climate change. E-bike and e-scooter share hire schemes may increase or decrease road accidents. Having this information would enable local and national governments to make better choices. Information about value for money could also help them to decide whether to encourage e-bike and e-scooter use.

Bristol added e-bikes to their e-scooter share hire scheme in the autumn of 2023. At the same time Leeds introduced an e-bike only share hire scheme. We conducted a survey of residents in Bristol and Leeds during the summer of 2023, to understand if these hire schemes changed how active people were or how they travelled. We asked residents of Bradford and Sheffield the same questions so we could compare to cities without these share hire schemes. We repeated the survey in summer 2024. This will allow us to compare the answers and see if the share hire schemes changed how active people were or how they travelled. We will also ask people how they feel about such share hire schemes. We will check how much activity people get when using a share hire scheme e-scooter. We will look at whether the number of accidents change when these share hire schemes start or stop. We will assess the costs and benefits, and their environmental impact. Finally, we plan to work with a range of groups to create guidelines to help councils and the government make decisions on how to promote e-bikes and e-scooters in the future.

We have worked with members of the public and local Councils to design this study. Members of the public and local authority-based colleagues' have been involved in all parts of the project. We plan to continue working with these groups. This will help project findings to be as useful as possible to the public and to policy makers.

2.5 BACKGROUND AND RATIONALE

The car is still the dominant mode of transport in the UK for all journeys of 1 mile or more (1). However, harms associated with cars are well-established, including ill health and environmental damage (2). E-bike and e-scooter share hire schemes offer sustainable ways of travel (3) and may have health impacts for the user (4), but these are unclear (4–6), particularly in the UK context. When referring to e-bikes, we mean cycles which the user has to pedal for assistance to be provided; throttle-powered electric bicycles are not considered in this project (7). The maximum power for an e-bike in the UK is 250W with a top speed of 25km/hr (8). Under UK law, e-bikes are considered bicycles and are therefore legal (8). E-scooters are a more recent addition to the transport 'family' and are classed as motor vehicles in the UK (9). Currently in the UK it is illegal to use privately-owned e-scooters on the roads [(9). However, the Department for Transport (DfT) began e-scooter pilot schemes starting in 2020 involving 32 UK regions (10). However, the UK government is yet to make a decision about legalising the use of e-scooters outside of trial areas (11), with trials recently extended for a fourth time until May 2026 (11). Reasons cited for the extension include the need for more evidence on "usage, safety and environmental impacts and to explore changing travel patterns since the coronavirus pandemic and as e-scooters become more embedded in public life" (11). Understanding

the health, social, economic, and environmental impact of e-bike share hire schemes and combined e-bike and e-scooter share hire schemes is, therefore, urgently needed to inform policy.

E-bike and e-scooter share hire schemes extend travel options, which may affect physical activity (4,12,13) depending on the transport mode they replace. Physical activity reduces the risk of chronic diseases and (14) all-cause mortality (15). The UK Chief Medical Officer recommends that adults engage in 150 minutes of moderate-to-vigorous-intensity physical activity (MVPA) per week (16). In the UK, 37% of adults do not meet these guidelines (17). Increased active travel is associated with a corresponding increase in overall levels of physical activity (18). Further, walking and cycling are associated with 11% and 10% reductions in all-cause mortality risk, respectively (19). E-bikes are considered a form of active travel (20–22). The level of physical activity associated with e-scooter use is unclear (23). However, it may affect active travel behaviour by way of both substitution and complementary effects on active travel (10,24).

E-cycling provides at least moderate intensity physical activity (20–22) and can improve health (4). Individuals ride an e-bike for longer and further than a conventional bicycle and therefore experience similar physical activity gains to conventional cyclists (4,12). Improved mental health has also been reported with e-cycling (25). There is some evidence that e-cycling improves cardiorespiratory fitness (4). The precise energy expenditure associated with e-scooter use within share hire schemes is unclear with insufficient evidence available for them to be included in the 2024 compendium of physical activities (23). A laboratory-based study (n=42) using an e-scooter mounted on a treadmill found that e-scootering provided significantly less energy expenditure than walking for the same duration (26). A small study (n=8), using commercial activity trackers suggested e-scootering may provide none or light activity (13). Further, individuals reported disproportionately replacing walking and bike journeys with e-scooters (13).

E-scooter and e-bike share hire schemes could help connect people with public transport (27). This is important as there is often a lack of options for transport to and from public transport (end-to-end solutions). Few studies have explored how access to an e-bike or e-scooter impacts access to employment, education, or other societal opportunities (28). This may offer scope for reducing inequalities, as ethnic minority and low-income users were more likely to report being regular e-scooter users in UK e-scooter trials (10).

It is important to note that climate change has been identified as the greatest threat to global public health in the 21st century (29). Cycling can aid in tackling the climate crisis, while also providing health co-benefits for the individual (30). E-bikes and e-scooters are more environmentally friendly than cars (3,10), with peri-urban and rural areas likely to have the greatest potential for individual carbon

savings (3). However, charging-related emissions make both less environmentally friendly than conventional scooting or cycling (5) and share hire schemes may have greater life cycle emissions due to fleet management (31).

Several qualitative studies have found that individuals report using their car less once they have access to an e-bike (32). However, quantitative survey data from the PASTA project exploring e-bike use in 9 EU countries found that the primary mode for which the e-bike substituted depended on the primary mode of transport used in the city at the time (12). Chang (33) reported that e-scooter trips replace walking and bicycling trips as often as they do car trips.

A Swedish naturalistic cycling study found that on average, e-bikes were ridden at a faster speed than standard bicycles (34). However, a US naturalistic cycling study suggested e-bike and standard bike users showed similar safety behaviours (35), with average e-bike speed higher than standard bikes on roads but slower on shared use paths (35). A Dutch retrospective survey study reported that e-bike users were more likely to be involved in traffic collisions requiring emergency department treatment than standard bike users (36). It is thus not clear whether regulation to prevent traffic collisions should differ between e-bikes and standard bikes.

European data from six countries found an increase of 8.6% in police-reported traffic collisions associated with e-scooters following the introduction of e-scooter share hire schemes (37). However, in cities with high bike-lane density, no effects were found (37), highlighting the potential important role of transport-related policy for e-scooter safety. While evidence on e-scooter traffic collisions in the UK is limited (10), early data found 5% of survey respondents reported a collision in the preceding year, with less experienced users reporting the most collisions (10). A recent study reported severe injuries were more common in e-scooter users than in conventional cyclists (38).

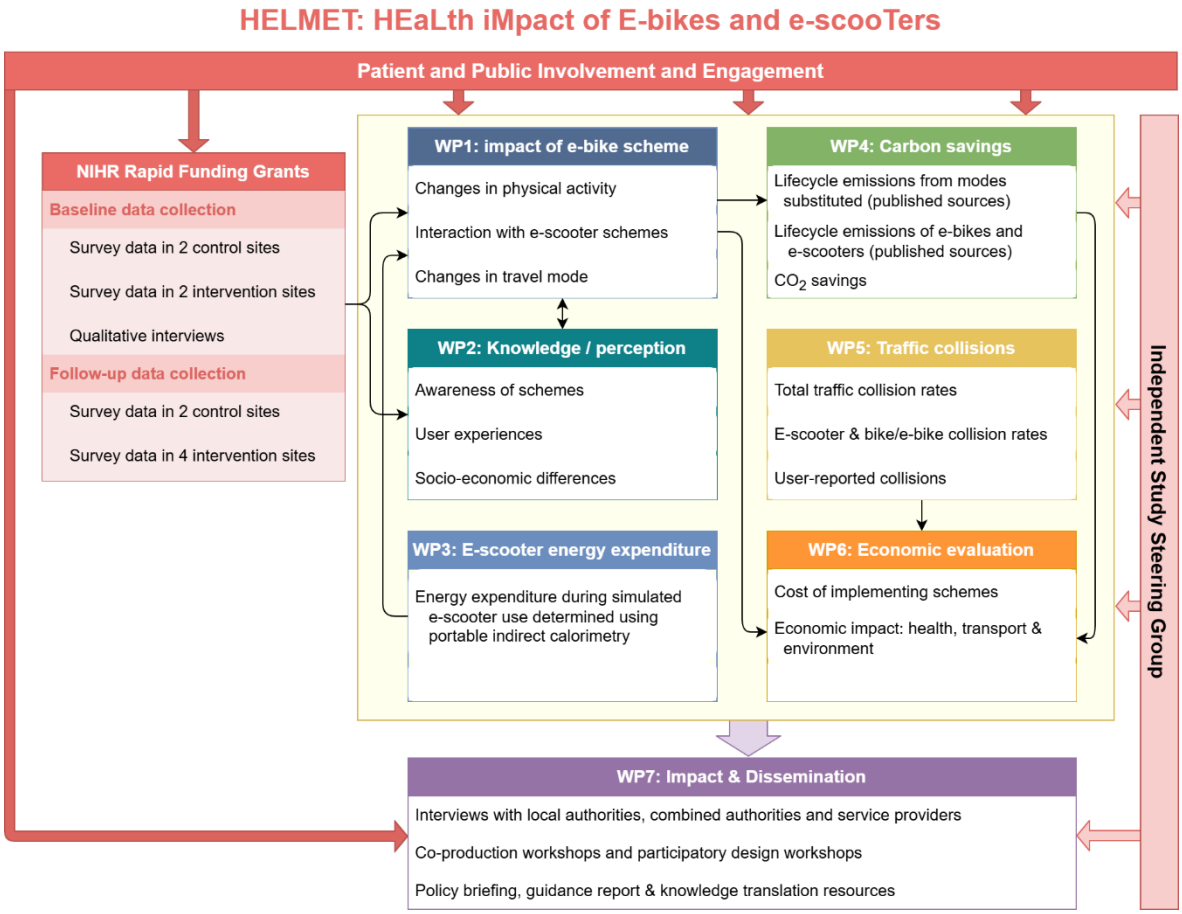
Thus, while it is evident that e-bike (EB) and combined e-bike/e-scooter (ES+EB) share hire schemes could impact on public health, social, economic, and environmental factors, numerous research gaps still remain.

2.6 RESEARCH AIMS AND OBJECTIVES

The overall aim of the HELMET project is to understand the impact of EB and combined ES+EB share hire schemes on public health, social, economic, and environmental factors. The project will use a natural experiment design to evaluate these schemes, using controlled before-after cross-sectional data collection, with some repeated measures, along with qualitative interviews. The project has the following research objectives (see also Figure 1):

1. Examine changes in physical activity and travel mode (modal shift) resulting from the introduction of an e-bike share hire scheme into cities with and without prior e-scooter share hire schemes (work package 1 (WP1)).
2. Explore users' knowledge, perceptions and use of EB and ES+EB share hire schemes and what strategies could be put into place to increase use across all socio-economic groups (WP2).
3. Understand average energy demand in adults associated with e-scooter use in the context of a share hire scheme (WP3).
4. Estimate potential carbon savings associated with EB only and combined ES+EB share hire schemes (WP4).
5. Understand collision risks associated with EB only, ES only and combined ES+EB share hire schemes (WP5).
6. Assess costs and benefits of EB share hire schemes from a public sector perspective (WP6).
7. Co-produce guidance for policymakers and service providers on EB and ES+EB share hire schemes (WP7).

Figure 1. HELMET work packages: inputs and research aims



2.6.1 RESEARCH QUESTIONS

Project objectives aim to be achieved through addressing the research questions stated in Table 1; each linked to one of the seven inter-related work packages.

Table 1. HELMET project work packages and the research questions each will address.

Work Package	Research Questions
1	1.1: Does the introduction of an e-bike share hire scheme (EB or ES+EB) impact physical activity behaviour, and is this moderated by e-scooter provision? 1.2: Does the introduction of an e-bike share hire scheme (EB or ES+EB) impact mobility patterns, particularly active travel, access to goods and services, and modal share?
2	2.1: What is the level of awareness and knowledge of EB and ES+EB share hire schemes and perception of their users? 2.2: What are the pathways to personal use of share hire schemes and how is this perceived to have affected travel behaviour and health? 2.3: What is the experience of share hire scheme users and how does this vary between different groups and in different geographical contexts? 2.4: What strategies could be put in place to increase share hire scheme use across all socio-economic groups?
3	3.1: What is the physical energy demand of using an e-scooter within the context of a share hire scheme?
4	4.1: What are the potential carbon savings of an e-bike share hire scheme? 4.2: What are the potential carbon savings of adding e-bikes to an e-scooter share hire scheme?
5	5.1: What are the collision rates associated with EB, ES and ES+EB share hire schemes?
6	6.1: What is the cost of implementing EB share hire schemes? 6.2: What is the economic impact of EB share hire schemes?

7	7.1: What guidance can be co-produced to guide policymakers and service providers when considering the introduction of an EB or ES+EB share hire scheme? 7.2: What messages should be included when co-producing knowledge translation resources for a range of stakeholders?

2.7 PROJECT PLAN

2.7.1 DESIGN AND THEORETICAL/CONCEPTUAL FRAMEWORK

The HELMET project (WP1-7) is underpinned by a socio-ecological theoretical framework which acknowledges the interplay that exists between individual behaviours, environmental contexts and broader systemic factors in shaping health, social, economic, and environmental outcomes. A natural experiment methodology (39) will be implemented to evaluate the introduction and impact of EB share hire schemes (irrespective of existing ES share hire schemes). Baseline survey data were collected in August/September 2023 and follow-up survey data collected in August to the first week of October 2024, i.e. prior to main project start (data collection funded via rapid funding scheme NIHR159622). This was a controlled before-after, repeated cross-sectional study design with some repeated measures. Survey data will be analysed during WP1 and results used to inform later WPs.

The natural experiment includes three levels of exposure for the evaluation of the impact of an EB share hire scheme (irrespective of existing ES share hire schemes):

1. No provision of an e-bike and/or e-scooter share hire scheme (NP);
2. Addition of an e-bike share hire scheme where there is no e-scooter share hire scheme (EB);
3. Addition of an e-bike share hire scheme to an already implemented e-scooter share hire scheme (ES+EB).

With survey data collection sites and their share hire scheme exposures at baseline and follow-up as follows:

1. Leeds: NP to EB only during baseline (launch 15th September 2023). EB only at follow-up.
2. Bristol: E-scooter only (ES) at baseline. Combined ES+EB at follow-up (launch 14th October 2023).
3. Bradford: non-intervention control area (NP) at baseline/follow-up.
4. Sheffield: non-intervention control area (NP) at baseline/follow-up.

And including data collected from two additional cities at follow-up for triangulation only:

5. Plymouth: EB only at follow-up (launch 21st March 2023) for triangulating with Leeds.
6. Bath: Combined ES+EB at follow-up (launch 11th September 2023) for triangulating with Bristol.

In this project, open science principles will be followed to ensure transparency by uploading time-stamped protocols for each work package on the 'Open Science Framework' (http://osf.io). The current protocol provides an overview of the project as a whole (WP1-7); more-detailed protocols for each individual work package will be uploaded during the course of the project, prior to each work package start/analysis. Each work package will report progress and findings at monthly management team meetings to ensure learning is shared and applied across the project as a whole. The NICE real world evidence framework will be used to guide the planning, conducting and reporting of the project (40).

2.8 WORK PACKAGE 1 (WP1): IMPACT OF THE INTRODUCTION OF E-BIKE SHARE HIRE SCHEMES ON PHYSICAL ACTIVITY

This work package will focus on quantitative analysis of survey data previously collected under NIHR PHR rapid funding grant NIHR159622, which has been cleaned but not yet analysed. The online survey included questions on demographics, physical activity, usage and mode of transport, quality of life and access to goods and services (see https://osf.io/gq9s8/ for baseline and follow-up data collection protocols). Baseline data from adults aged 16+ in two control sites (Bradford and Sheffield) and two intervention sites (Leeds and Bristol) were collected in August/September 2023 with follow-up data collected in the same four sites in August to the first week of October 2024; one year after the introduction of EB and ES+EB share hire schemes in Leeds and Bristol respectively. This design provides the following exposure gradient:

1. no change in exposure – control site (Sheffield and Bradford) without e-bike or e-scooter share hire scheme, i.e. no provision (NP);
2. an e-bike share hire scheme only (EB) (Leeds);
3. an e-bike added to e-scooter share hire scheme (ES+EB) (Bristol).

Post-intervention data (only) was also collected in Plymouth (EB) and Bath (ES+EB), to allow for triangulation (Plymouth with Leeds; Bath with Bristol). Recruitment targeted all those aged 16+ that reside in the remit of the intervention and control site local authorities. A survey question was also

included to determine possible contamination effects to ensure people could be identified who, for example, live in Bradford but commute into Leeds and therefore were exposed to the e-bike share hire scheme intervention. The surveys were distributed through various local authority channels, relevant local equality and stakeholder groups, and local social media groups aimed at seldom heard voices. Given lower response rates to the survey in Bradford at baseline, at follow-up, we also partnered with CNet in Bradford; a local charity trusted by the community, to boost participation.

2.8.1 STATISTICAL ANALYSIS

This study is a controlled before-and-after design, with a primary outcome of self-reported minutes of MVPA per week. As this is a highly skewed variable, data will be analysed on the log scale and back-transformed to give estimates of percentage increase in MVPA. Primary analyses will employ a difference-in-differences model to estimate the intervention effect of the introduction of an EB share hire scheme, with adjustment for repeated measures and using propensity scoring to account for sample differences between sites. Data has been collected at the same time of year and so no adjustment for seasonality is necessary. Due to the nature of the evaluated share hire schemes, this will estimate the average effect of introducing an EB scheme irrespective of ES schemes.

Secondary analyses will disaggregate this further by:

1. Comparing all three arms (NP (Bradford and Sheffield), NP to EB (Leeds), ES to ES+EB (Bristol));
2. Exploring whether the average EB effect is moderated by the presence of an ES share hire scheme (comparing effects in Leeds and Bristol);
3. Exploring the effect of an ES-only scheme estimated from a cross-sectional comparison of baseline data from Bristol (ES) and control/NP sites (Bradford and Sheffield).

Changes in MVPA will also be explored by subgroup (gender, age, socio-economic status) where sample sizes allow. Generalisability of results will be explored by triangulating post-intervention patterns in Leeds and Bristol with data from Plymouth and Bath respectively. Further analyses will look at changes in use of different transport modes/'modal shifts' (self-reported change in travel mode over the previous year, specifically for e-bikes, e-scooters and active modes of travel) using logistic models. A subset of data on repeat respondents will also be used to explore longitudinal changes in travel mode and induced trips directly.

2.9 WORK PACKAGE 2 (WP2): KNOWLEDGE, PERCEPTIONS AND USE OF E-BIKE AND COMBINED E-SCOOTER AND E-BIKE SCHEMES

Building on interviews conducted at baseline (n=8; see https://osf.io/gq9s8/), N=60 interviews will be carried out across the intervention sites that have implemented EB (Leeds and Plymouth) or ES+EB (Bristol and Bath) schemes and at the control sites without EB or ES share hire schemes (Sheffield and Bradford). The aim will be to gain insights into how schemes impact on health, social, economic, and environmental factors. WP2 will have a similar data collection methodology to the qualitative component of baseline data collection (see https://osf.io/gq9s8/) but with a different interview guide. Participants will be recruited from survey participants who indicated their interest in being contacted for interview. Interviews will be conducted either at participants' homes, a mutually agreed third space, or online and will take place during Year 1 of this project.

In Leeds and Plymouth, interviews will be conducted with n=12 users of an EB scheme and n=8 non-users (n=20); in Bristol and Bath interviews will be conducted with n=8 users of ES+EB schemes; n=6 users of only the EB scheme; n=12 users of only the ES scheme; and n=6 non-users of either scheme (n=32). Finally, interviews in Sheffield and Bradford will be conducted with n=8 control participants who have never used EB or ES schemes. The total sample (N=60) will therefore represent n=18 EB scheme (only) users; n=12 ES scheme (only) users; n=8 ES+EB users; n=14 non-EB or ES users where schemes are available; and n=8 controls where no schemes are available. A variety of user and non-user types will be selected who differ by gender identity, age, geographic location, and ethnicity as well as reported health and mobility. This will provide a qualitative dataset that is practicable for identifying commonalities, as well as any points of divergence, between and within users and non-users of schemes for building a strong analytical narrative based on richness, complexity and detail (41).

Two skilled interviewers based at Oxford Brookes University will be responsible for administering interviews across all sites. Following transcription by an approved supplier and confirmation of accuracy by interviewees, data will be analysed in NVivo v14 (by both field researchers responsible for collecting data; overseen by Prof Jones) using constant comparison to identify themes and points of convergence and divergence (42). Data collection and analysis will be concurrent to enable emerging themes and avenues for further investigation to be developed as the field research unfolds. Pseudonymised vignettes of participants will be produced of those participants who exemplify key themes and trajectories.

2.10 WORK PACKAGE 3 (WP3): E-SCOOTER RELATED ENERGY EXPENDITURE

This metabolic study will examine the physical activity energy expenditure related to the use of e-scooters that are a part of ES share hire schemes. We will recruit 18-20 participants drawn from survey respondents in the Bath area (where the University of Bath laboratory is situated) who report using an ES and have given consent to be contacted about this sub-study, and other potentially interested participants (as required). Similar energy expenditure studies conducted with e-bike users have included 8-18 participants (20–22).

Following consent, participants will complete a brief medical screening questionnaire. Their height and weight will also be measured. Laboratory resting metabolic rate (RMR) will be derived to provide an accurate estimate of metabolic equivalent energy expenditure. Study participants will each complete the same marked route whilst wearing a portable gas analysis system (Cosmed K5, Italy) to determine energy expenditure via indirect calorimetry. This route will include a simulated walk from their starting destination to where the e-scooter is parked (500 m), the use of the e-scooter over a standard-length route (2.5 km), and the walk from parking the e-scooter to the final destination (500 m). A member of the research team will follow behind the participant on foot during walking sections and on e-bike/e-scooter during e-scooter sections to ensure a researcher is easily available if there are any problems during the testing. In UK ES share hire schemes, an average e-scooter journey is 2.2 km with an average duration of 14 minutes (10). The Rating of Perceived Exertion (RPE) will be assessed according to the Borg scale (43) on completion of the test condition, to assess each subject's personal perception of their exercise intensity. On completion of testing, participants will be compensated for their time with a £40 Love2Shop (or similar) voucher. Estimated energy expenditure (total) and Metabolic Equivalents of Tasks (METs) will be calculated by dividing measured RMR by energy expenditure during simulated e-scooter use and walking.

2.11 WORK PACKAGE 4 (WP4): CARBON EMISSION CHANGES

This study will calculate and report the carbon dioxide (CO_2) emissions changes observed amongst survey respondents and extrapolate these changes across the population of the cities. We will also triangulate this against total scheme usage figures from each local authority.

To do this, we will first determine the CO_2 emissions for e-bikes and e-scooters. Life Cycle Assessments (LCAs) are used to calculate CO_2 emissions for different vehicles and consider emissions due to manufacture, use and disposal/recycling. These can be used to calculate the carbon emission changes relating to share hire schemes. Consistent with standard methods, we will use published documents

for the LCA component of this project (3,44). Operators in our study areas have, in other locations, conducted LCAs of their equipment and published results (45,46). We will compare these LCA results to peer-reviewed academic studies conducting LCAs of e-bikes and e-scooters (31,47) to ensure that values are in expected ranges. When we calculate the CO_2 emissions based on the operator's figures, we will also carry out sensitivity analyses to consider issues such as expected lifetime mileage of e-bikes/e-scooters using the most similar schemes described in the academic literature. Operators and local authorities will supply information such as the types of vehicles used to redistribute e-bikes and e-scooters (e.g. diesel or electric vans), as this can have a considerable effect on overall emissions of a share hire scheme (48). We will also gather data on the CO_2 emissions of different transport modes (e.g. car, bus) from the academic literature (3,49) and use this information in conjunction with CO_2 emissions data for the different transport modes to calculate potential carbon savings. We will combine these emissions factor data with survey responses giving the number of miles of travel substituted to estimate CO_2 emissions change.

Our CO_2 reduction calculations will report the potential savings observed amongst our participants. We will also estimate the scheme-wide CO_2 emission changes by extrapolating these changes amongst survey respondents to the population of each city. In addition, operators and local authorities have agreed to provide anonymised trip data from which we will calculate total distance travelled by the scheme EB/ES. This will give a second method to estimate the whole scheme CO_2 changes for triangulation purposes.

Findings from this WP will provide local authorities considering the introduction of share hire schemes with an estimate of potential carbon savings to aid in their decision making.

2.12 WORK PACKAGE 5 (WP5): TRAFFIC COLLISIONS

This study will look at the impact of share hire schemes on road traffic collisions. We will use STATS19 police-reported collisions data between 2018 and 2024 for 10-15 control cities and 10-15 cities that have implemented EB, ES or ES+EB share hire schemes. The STATS19 data capture ES separately from other micromobility options, but do not separate EB and standard pedal bikes. Thus, the primary outcome will be monthly city collision rates per 100,000 population, which combines both direct and indirect effects of share hire schemes (e.g. reduction in motor collisions due to modal shift). This is a similar approach to that used in a study considering data from six European countries (37).

Effects will be estimated based on a controlled interrupted time series analysis, with intervention status defined as the city-specific launch date of the share hire scheme provided by commercial

partners or local authorities. This staggered intervention timing, with control and different intervention combinations (EB, ES and ES+EB) overlapping provides a robust design. Secondary analysis will focus on (1) direct effects of ES schemes only using collision data involving ES; and (2) direct effects of EB and ES+EB schemes from comparing collision data on personal EB and pedal bikes under control conditions, with share hire EB, personal EB and pedal bikes under intervention conditions. While personal EB use may change over time, the use of cities with different share hire scheme implementation dates will help disentangle personal and share hire EB collisions and reduce bias due to confounding by time.

Data will be analysed via Poisson generalised additive models to include city random effects and allow for seasonal patterns in collisions as well as potential trends in intervention effects over time. Analyses will be adjusted for differences between cities. We will also conduct sensitivity analyses to explore the robustness of estimates.

2.13 WORK PACKAGE 6 (WP6): ECONOMIC EVALUATION

The economic evaluation will comprise a cost-consequence analysis of EB share hire schemes (irrespective of the presence of an ES scheme). This will provide a disaggregated summary of the costs and a range of different outcomes, thus allowing decision-makers to choose the costs and outcomes relevant to their perspective. A cost-consequence analysis is most appropriate for this analysis as share hire schemes have a wide range of effects beyond health which are therefore challenging to combine in a single metric. The cost-consequence analysis will take a public sector perspective to capture broader costs and benefits of EB share hire schemes on sectors including health, transport and the environment. There is growing evidence that this approach is preferred for public sector decision-making where outcomes of interventions fall across different public sectors (50). The approach also enables us to present information to decision-makers by socio-economic status, provided sufficient data are available.

Outcomes presented in the cost-consequences analysis will include those related to health, as overall physical activity levels (as measured by MVPA) and wellbeing-related quality of life (as measured by the ICECAP-A (51)); environment, as emissions estimated in WP4; and transport, as mode of travel. Where appropriate, each outcome will be presented at baseline and follow-up time point for each scheme type (EB or ES+EB) to illustrate change over time.

Setup, delivery and maintenance costs of the share hire schemes will be obtained from local councils and providers. In conjunction with findings from WP5, we will determine healthcare resource use

using road traffic collision data from STATS19. To obtain more detailed injury data and assign the associated national reference costs, we will supplement STATS19 data with CRaSH data. CRaSH: Collision Recording and SHaring system is a centralised system used by police forces in three of the four regions to record road traffic collisions (Leeds, Bradford and Sheffield). For the remaining region, Bristol, higher level data on injuries are available from STATS19 and a proxy resource-use estimation (based on proportion of cost for each injury category) will be taken based on detailed injury data from the other regions. A sensitivity analysis will be carried out to explore the impact on this cost. If sufficient data are available, the health equity impact will also be explored by presenting findings by subgroups of different populations, for example by socio-economic status.

2.14 WORK PACKAGE 7 (WP7): IMPACT AND DISSEMINATION

The final phase of this project will draw together findings from the previous WPs to co-produce guidance for policy makers and service providers considering the introduction of EB or ES+EB share hire schemes. To gain insight into perceived challenges, benefits and lessons learnt, including considerations related to regulation of EB and ES use, we will conduct up to 16 interviews with local authorities, combined authorities, and service providers who have implemented these schemes.

Once the interviews have been completed and analysed, we will form a co-production group comprising policy makers, EB/ES users, residents, and research team members. Collaboratively, we will distil policy implications and guidance for local authorities and service providers considering the introduction of a new EB or ES+EB scheme. These will be based on the study findings from WP1-6 and the WP7 interviews and co-produced at an in-person co-production meeting in Bristol. They will be used by the research team to produce a policy brief working with 'Policy Bristol', a guidance report for local authorities and service providers, and a list of key performance indicators. These will be shared with the co-production group for comment and refinement at a later online co-production meeting. The research team will then make revisions and circulate for final feedback and approval.

To ensure that the findings from our project are easily understandable to the wider population, we will co-produce (with PPI representatives) two infographics; one aimed at policy makers and another aimed at the study population/general community. We will also commission a professionally-produced dissemination video. We will use a participatory design based on the 'Bristol Approach' (52); a six-step cyclical framework. Four online participatory design workshops will be held with a group of six to eight Patient and Public Involvement and Engagement (PPIE) members over the course of three months. These workshops will distil the most important messages from our findings for inclusion in the video and infographics.

We will invite PPI participants to the co-production and participatory design workshops with the goal of achieving variety in a range of backgrounds such as gender identity, ethnicity, mobility, deprivation and age.

To ensure dissemination of our findings to practitioners, we will write articles for 'Local Transport Today' and 'TransportXtra', which are widely read by practitioners. We will also target briefings to the DfT, Active Travel England, Directors of Public Health and the Local Government Association.

2.15 PROJECT TIMETABLE

This project starts 1st January 2025. Funded work ends 31st December 2026 with a post-funding phase expected for an additional three months to 31st March 2027 (see Table 2 for detail).

Table 2. HELMET project timeline.

Phase	Main Setup Phase		Main Data Collection and Analysis Phase																		Main Dissemination Phase				Post-project Phase		
Project Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Calendar Month	Jan-25	Feb-25	Mar-25	Apr-25	May-25	Jun-25	Jul-25	Aug-25	Sep-25	Oct-25	Nov-25	Dec-25	Jan-26	Feb-26	Mar-26	Apr-26	May-26	Jun-26	Jul-26	Aug-26	Sep-26	Oct-26	Nov-26	Dec-26	Jan-27	Feb-27	Mar-27
Workpackage 1 - Survey data																											
Protocol WP1 writing and archiving																											
Statistical analysis																											
Workpackage 2 - Interviews																											
Protocol WP2 writing and archiving																											
Sample Selection, recruitment and interviews																											
Transcription and interview analysis																											
Workpackage 3 - E-scooter Energy Expenditure																											
Protocol WP3 writing and archiving																											
Participant recruitment and data collection																											
Data cleaning and Statistical analysis																											
Workpackage 4 - Carbon savings																											
Protocol WP4 writing and archiving																											
Collate Lifecycle Assessment data																											
Data preparation and analysis																											
Workpackage 5 - Collisions																											
Apply for STATS-19 and CRaSH data																											
Gather e-scooter & e-bike scheme info																											
Protocol WP5 writing and archiving																											
Data preparation and statistical analysis																											
Workpackage 6 - Health economics																											
Protocol WP6 writing and archiving																											
Data preparation & statistical analysis																											
Workpackage 7 - Co-production																											
Protocol WP7 writing and archiving																											
Stakeholder recruitment, interviews and analysis																											
Co-production workshops and material revisions																											
Participatory design workshops (PPIE) and material revisions																											
Dissemination																											
Manuscript WP1 (Milestone 1)																											
Manuscript WP2 (Milestone 2)																											
Manuscript WP3 (Milestone 3)																											
Manuscript WP4 (Milestone 4)																											
Manuscript WP5 (Milestone 5)																											
Manuscript WP6 (Milestone 6)																											
Manuscript WP7 (Milestone 7)																											
Conference presentations (WP1-7)																											
Policy Brief & Lay report, Video & Infographics (WP7)																											
Public Dissemination Events (WP7)																											
Articles for practitioners (WP7)																											
Final report (WP1-7)																											

2.16 DATA MANAGEMENT

The Principal Investigator and the research team will preserve the confidentiality of participants and collect and store research data in accordance with the General Data Protection Regulation 2018 (GDPR) and subsequent data protection laws that supersedes the Data Protection Act. All data will be handled according to the principles of the DPA and University of Bristol, University of Bath and Oxford Brookes University data protection/privacy policies, as necessary.

Survey data (WP1): The baseline survey was hosted by the JISC 'Online Surveys' platform (https://www.onlinesurveys.ac.uk) and the follow-up survey hosted by the Qualtrics platform (https://www.qualtrics.com). Both platforms are GDPR compliant and certified to ISO 27001 standard. Qualtrics was used at resurvey due to a loss of required functionality on JISC Online Surveys during platform revisions taking place at the time of resurvey data collection. The same survey content but different survey links were used for each local authority site. Data has been cleaned, and relevant new variables created to produce a dataset of baseline and follow-up survey data ready to be used in this full evaluation. Pseudonymised data will be stored on a secure University of Bristol server. Key data for any possible linkage between baseline and re-survey data will be stored in a separate area of the secure University of Bristol server. A master matching file will be created in which each name/contact details are assigned a participant ID (e.g. P1, P2, P3).

Interview data (WP2): Qualitative interviews will be audio recorded using an encrypted recording device. Interview transcription will be conducted by an approved Oxford Brookes University supplier with a data sharing agreement in place. Interview recordings will be deleted following transcription and analysis, and interview transcripts will be edited to remove identifying details. As interviews will be conducted by qualitative researchers at Oxford Brookes University, interview data will be stored securely in a password protected file at Oxford Brookes University. Once analysis has been completed, anonymised interview transcripts will be securely transferred to the researchers at the University of Bristol and stored securely in a password protected file on the University of Bristol server. Interviews will be transcribed and all identifying information anonymised within six weeks of the interview. The interview data will be linked to the original survey data and anonymised using the master matching file.

E-scooter energy expenditure data (WP3): As data collection and analysis will be conducted by a researcher at the University of Bath, WP3 data will be stored on a secure University of Bath server. Once analysis has been completed, anonymised data will be securely transferred to the researchers at the University of Bristol and stored securely in a password protected file on the University of Bristol server.

Scheme operator data (WP4): Beryl and Tier/Dott are our commercial partners running the EB share hire scheme in Leeds and the combined ES+EB share hire scheme in Bristol respectively. Beryl own their own share hire scheme data whereas the West of England Combined Authority (WECA) own the Tier/Dott data. Both Beryl and WECA will provide additional user data necessary for this evaluation. Individual users will not be identifiable but shared data will be stored securely and analysed on a secure University of Bristol server. Scheme operator data is third party data and cannot be shared on data.bris for reuse. Other researchers wanting to access this data would need to apply directly to the scheme operators.

STATS19 and CRaSH data (WP5-6): As STATS19 and CRaSH data can include sensitive/personally identifiable information (e.g. collision locations, home postcodes), data will be stored and analysed within a secure University of Bristol server. STATS19 and CRaSH data are third party data and cannot be shared on data.bris for reuse. Other researchers wanting to access this data would need to apply directly to the Department for Transport.

General: Wherever transfer of data is required between the University of Bristol and the University of Bath or Oxford Brookes University, transfers will be made using password protected files transferred via the University of Bristol Facility for the Upload of Large Files (FLUFF) system. Passwords will be communicated separately to ensure data security. The University of Bristol research data repository, data.bris will be used to store anonymised data for reuse. Interview data will have all possible identifying information redacted. Reuse will be permissible under a Creative Common Share Alike 2.0 licence. Anonymised analysed data and summaries of data will be held for 10 years after the project is finished.

2.17 ETHICAL AND REGULATORY CONSIDERATIONS

2.17.1 ETHICAL APPROVAL

Ethical approval has been granted by the School for Policy Studies Research Ethics Committee at the University of Bristol for all aspects related to WP1 (survey) and WP2 (interviews) (SPSREC/2223/362). As WP5 (traffic collision assessment) is a secondary data analysis, ethics approval with be sought from the University of Bristol as an amendment to SPSREC/2223/362. Any subsequent protocol amendments will be submitted to the Research Ethics Committee for approval. Separate ethics approval will be sought from the University of Bath for WP3 (understanding average energy demand in adults associated with ES use in the context of a share hire scheme). Separate ethics approval will

also be sought from the University of Bristol for WP7 (co-production of guidance for policymakers and service providers on EB and ES+EB share hire schemes).

While we are not aware of any conflicts of interest relevant to the research team or project, we will follow the NIHR Conflict of Interest Policy for Funding and Awards as necessary.

2.17.2 PATIENT AND PUBLIC INVOLVEMENT AND ENGAGEMENT (PPIE)

We are embedding PPI throughout this project with the inclusion of PPI representatives on the research team, the steering committee, co-design workshops and participatory workshops. In WP7, we will also run a series of four online participatory design workshops with a group of six to eight PPIE members over the course of three months to refine the project messaging included in knowledge translation resources (a professionally produced video and two infographics).

The choice of work packages was also influenced by members of the NIHR Applied Research Collaboration (ARC)-West PPI panel and the independent local authority member on our Steering Committee.

2.17.3 INVESTIGATORS RESPONSIBILITY

The Principal Investigator, Dr Armstrong, will ensure that local research approvals have been obtained and that any necessary contractual agreements required have been signed off by all parties. All investigators will comply with this protocol. Investigators will allow access to study documentation or source data on request for monitoring visits and audits performed by the NIHR or any regulatory authorities.

2.17.4 PROJECT SPONSORSHIP

The University of Bristol is the sponsor of this study.

2.18 DISSEMINATION

Each WP will have individual outputs, but other outputs will be developed from findings across multiple WPs. Outputs will include both academic and non-academic publications.

Type	Details	WP
Journal articles	At least one journal article per work package, published in international peer-reviewed journals such as: BMC Public Health, IJBNPA, Journal of Transport and Health, Journal of Cycling and Micromobility Research	1-7
Participant vignettes	Pseudonymised vignettes of participants, to include those who exemplify key themes and trajectories	2
Conference abstracts	A minimum of 2 conferences, e.g. ISBNPA, DfT Analysis Guidance (TAG) conference	1-7
Policy brief and lay report	To communicate findings with local and combined authorities, service providers, the Local Government Association, DfT and other stakeholders	7
Dissemination video and infographics	To communicate findings in more accessible ways to policy makers, participants, and the general public	7
Public dissemination events	Two events to communicate the main findings with study participants and intervention area residents	7
Project webpage	On Bristol Blogs, to include policy brief, dissemination video, infographics, project updates etc.	7
Practitioner Articles	Articles for 'Local transport today' and 'TransportXtra', widely read by practitioners	7
Wikipedia page	Wikipedia Study results page, supported by the NIHR resident Wikipedian	1-7
Final report	Funder report (WP 1-7)	1-7

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