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Motives, perceptions and experiences of electric bicycle owners and implications for health, wellbeing and mobility

Tim Jones [a,*], Lucas Harms [b], Eva Heinen [c]

[a] School of the Built Environment, Faculty of Technology Design and Environment, Oxford Brookes University, Headington Campus, Oxford OX3 0BP, United Kingdom
[b] KiM Netherlands Institute for Transport Policy Analysis, PO Box 20901, 2500, EX, The Hague, The Netherlands
[c] MRC Epidemiology and UK CRC Centre for Diet and Activity Research (CEDAR), University of Cambridge, School of Clinical Medicine, Box 285, Cambridge Biomedical Campus, Cambridge CB2 0QQ, United Kingdom

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ABSTRACT

The sale of electrically assisted bicycles ('e-bikes') is growing at a rapid rate across Europe. Whereas market data is available describing sales trends, there is limited understanding of the experience of early adopters of e-bike technology. This paper investigates the motives for e-bike purchase, rider experience and perceived impact on mobility, health and wellbeing through in-depth interviews with e-bike owners in the Netherlands and the UK. Findings revealed that the motive for purchasing e-bikes was often to allow maintenance of cycling against a backdrop of changing individual or household circumstances. E-bikes also provided new opportunities for people who would not otherwise consider conventional cycling. Perceptions of travel behaviour change revealed that e-biking was replacing conventional cycling but was also replacing journeys that would have been made by car. There was also a perception that e-biking has increased, or at least allowed participants to maintain, some form of physical activity and had benefitted personal wellbeing. Technological, social and environmental barriers to e-biking were identified. These included weight of bicycle, battery life, purchase price, social stigma and limitations of cycle infrastructure provision.

Additional research is necessary to quantify actual levels of mode substitution and new journey generation among new e-bike owners and the impact of e-biking on promoting physical health and mental wellbeing.

1. Introduction

A significant contemporary phenomenon that may have a profound impact on mobility patterns is the emergence of the electrically assisted pedal cycle or what is more commonly known as the 'e-bike'. E-bikes typically incorporate a battery, which can be charged at an ordinary domestic power socket, linked to an electric motor in the bicycle transmission system. The rider controls the level of power assistance typically using a handlebar mounted computer display panel and controller. The term 'e-bike' is generic and includes a combination of different electrically powered two-wheelers some of which function by simply turning a throttle. The focus of this paper is the pedal assisted variety of e-bike (or 'pedelec') which only functions on condition that the rider also pedals. Pedelecs are the most common variety of e-bike within Europe and are regulated at 250 W maximum continuous rated power output and maximum speed up to 25 km per hour. They are permitted on cycle paths and other infrastructure specifically designed for pedal cycling (MacArthur et al., 2014).

There is evidence that e-bike sales are rising across Europe and are expected to continue to grow while sales of conventional cycles hold-steady(COLIBI/COLIPED, 2013; Pike Research, 2010). Authorities will need to consider where e-bikes fit within wider policies to promote sustainable mobility because this growth could have a significant impact on requirements for planning and designing cycle infrastructure. For example, e-bikes could replace short and medium distance car journeys and contribute to reducing traffic congestion and pollution in urban areas because they place less demand on road space and produce zero emissions whilst in operation (Ji et al., 2012). E-biking could also contribute to healthy mobility by enabling riders to incorporate moderate exercise into everyday travel routines. They could also help to increase accessibility for people unable or reluctant to use conventional cycles (e.g. older people and those with physical limitations) (Electric Bike Magazine, 2012; Gojanovic et al., 2011; Louis et al., 2012; Sperlich et al., 2012).

Despite this potential there are concerns that e-biking may wean people away from conventional cycling rather than tackling car use (Behrendt, 2013) and that promoting e-biking is distracting authorities from focusing on implementing good quality cycling infrastructure (Whitelegg, 2013). There is also concern about the potential risk of traffic injury to riders or other road users unaccustomed to their higher speeds (Du et al., 2013; Kahn, 2014; Papoutsi et al., 2014; Schepers et al., 2014;

* Corresponding author.
E-mail addresses: tjones@brookes.ac.uk (T. Jones), Lucas.Harms@minienm.nl (L. Harms), e.heinen@leeds.ac.uk (E. Heinen).

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Yang et al., 2014). Finally, although e-bikes produce no emissions at source, there are environmental challenges posed by the manufacture and disposal of batteries (Cherry et al., 2009; Weiss et al., 2015).

This paper focuses on the motives, perceptions and experiences of e-bike owners in the United Kingdom and the Netherlands, two very different cycling cultures, that to our knowledge, has not previously been investigated. The paper moves beyond quantitative analysis of market trends or online surveys of users and responds to calls for more in-depth understanding of the complexities of travel behaviour through qualitative methods (Clifton and Handy, 2001). It addresses the following questions: *What are the motives for purchasing e-bikes*? *What effect has this had on personal mobility*? *What are the personal experiences of e-bike use*? We conclude with a discussion on the implications for promoting e-biking as healthy and sustainable mobility within two regions with very different cycling cultures and policies towards promoting cycling.

2. Background

Increased level of research interest in e-bikes has paralleled growth in sales. Over the past decade studies have focused on e-bike design and performance; sales trends; user demographics; safety; and environmental impact, but only recently has attention turned to motivations for purchase and impact on travel behaviour and personal health and wellbeing (Fishman and Cherry, 2015). Early adopters of e-bike technology in California are reported to be older, better educated and with higher than average income than the US population (Popovich et al., 2014) corresponding with the demographic profile of a study of Australian e-bike users (Johnson and Rose, 2015) while a study of Austrian e-bike users has shown that they were more likely to have lower educational and income levels than the general population (Wolf and Seebauer, 2014). The desire for increased speed and reduced physical exertion is reported to be the main motivation for the purchase of e-bikes(MacArthur et al., 2014; Johnson and Rose, 2015) particularly among those with physical limitations (Langford, 2013; MacArthur et al., 2014; Rose, 2012). A few studies also suggest that the desire to substitute car journeys is also a driver (Johnson and Rose, 2015; MacArthur et al., 2014; Popovich et al., 2014).

The limited evidence that is available on the impact of e-bikes on travel suggests that e-bikes may increase participation in cycling, increase the number of trips and distance cycled (Fyhri and Fearnley, 2015) and encourage users to replace car trips (Fyhri and Fearnley, 2015; Johnson and Rose, 2015; Popovich et al., 2014). Wolf and Seebauer (2014) reveal, however, that early adopters of e-bikes in Austria were mainly car owning older people for who the only shift from car trips to e-bikes seems to take place for leisure trips with no discernable effect on commuting or shopping trips. Questions remain, therefore, about the magnitude of effect of e-biking in substituting car journeys and indeed whether they are impacting household car ownership (Fishman and Cherry, 2015).

There is also growing interest in the role that e-bikes can play in promoting health and evidence that they can confer positive health benefits (Gojanovic et al., 2011; Hendriksen et al., 2008; Louis et al., 2012; Sperlich et al., 2012; Theurel et al., 2012). Although energy expenditure per unit time for e-biking is lower than conventional cycling (Langford, 2013) it can contribute to providing minimum physical activity requirements (Simons et al., 2009; Sperlich et al., 2012) and have positive influence on physiological parameters in untrained men and women (de Geus et al., 2013). Evidence is less clear on the psychological benefits of e-bikes although some studies have reported the sense of enjoyment conferred on their users (Fyhri and Fearnley, 2015, Popovich et al., 2014).

Few studies have investigated the barriers to e-bike use and those that do are mainly focused on users in the USA and Australia. Dill and Rose (2012), for example, conducted interviews with e-bike users in Portland, Oregon, and identified relative cost, weight of the bicycle, fear of theft, road danger, lack of supportive infrastructure and 'range anxiety' (i.e. the fear that the e-bike has insufficient battery power to reach its destination) as significant barriers to e-bike use. Popovich et al. (2014) also highlight stigma associated with riding electric bicycle versus conventional pedal cycles in California which could be inhibiting more widespread adoption of e-bikes.

3. Cycling in The Netherlands and the UK

The Netherlands and the UK are European regions with very different cycling cultures. Levels of cycling in the Netherlands are much greater than in the UK (1% of all trips in UK versus 27% in NL) largely a result of the Netherlands having a long history of implementing a 'multifaceted and mutually reinforcing' set of policies focused on supporting and promoting cycling (Harms et al., 2015; Pucher and Buehler, 2008). Dutch owners of e-bikes therefore benefit from favourable conditions for cycling and are able to use the existing network of approximately 35,000 km of cycle paths. Regional authorities are also investing in 'bicycle highways', which offer direct connections between urban centres (e.g. Arnhem and Nijmegen — see http://www.fietssnelwegen.nl) and there is a strong push to encourage e-bike use for commuting through the 'Beter Benutten' ('Optimizing Use') programme — see http://www.beterbenutten.nl/en). This includes providing employees with an e-bike free of charge for a trial period.

In the UK, where cycling infrastructure is much less developed, the government is developing a Cycling Delivery Plan (CDP) that will outline long-term investment programme for cycling. Under section 21 of the Infrastructure Act 2015 it is now obliged to produce a Cycling and Walking Investment Strategy (CWIS) specifying objectives, and more importantly, the financial resources that will be made available, and to review this every five years. The UK Department for Transport is starting to consider the potential of e-bikes as part of an overall strategy for sustainable transport. In September 2015, The Electrically Assisted Pedal Cycle Sharing Pilot Scheme awarded £700 K of funding to various cycle-hire schemes across the UK to enable them to expand their fleet with electric bikes (UK Department of Transport, 2015).

The Netherlands is now one of the biggest markets for e-bike sales in Europe (Fig. 1). Around 1 million e-bikes are now in ownership out of a total stock of 22 million cycles (Fishman and Cherry, 2015) and e-biking now accounts for around 12% of total distance travelled by cycle — roughly equivalent to 1.5 billion kilometres per year (KiM, 2014). Average journey distance covered by e-bike is 5.5 km—one-and-a-half times further than conventional cycling (3.6 km) (KiM, 2015). In terms of use by different age groups, e-biking accounts for one third of all cycling kilometres travelled by adults age 65 and above, 6% for adults aged up to 50 years and only 1% for adults aged up to 35. Older riders report using e-bikes for leisure and shopping whilst for younger adults commuting plays a more significant role (Fig. 2).

In the UK sales of e-bikes have also been increasing, though the absolute and relative numbers are much smaller compared to the Netherlands. A total of 30,000 e-bikes were sold in the UK in 2012 (compared to 175,000 in the Netherlands) roughly equating to 0.5 sales per 1000 population and only 0.8% of total cycle sales (COLIBI/COLIPED, 2013). Unfortunately, unlike the Dutch National Travel Survey, the UK National Travel Survey does not discriminate journeys by e-bike and therefore usage characteristics are difficult to assess.

4. Approach and methods

In the following sections we draw on evidence from interviews with e-bike owners living in the Randstad (Amsterdam and Utrecht) and Groningen in the Netherlands and also Oxford in the UK— characteristics of the case areas presented in Box 1. The approach to recruiting participants was through opportunity sampling — posting advertisements on noticeboards in public places and using social media — during May and June 2013. A total of 22 adult e-bike owners (12 in NL and 10 in UK) responded and were invited, to take part in the study. Participants

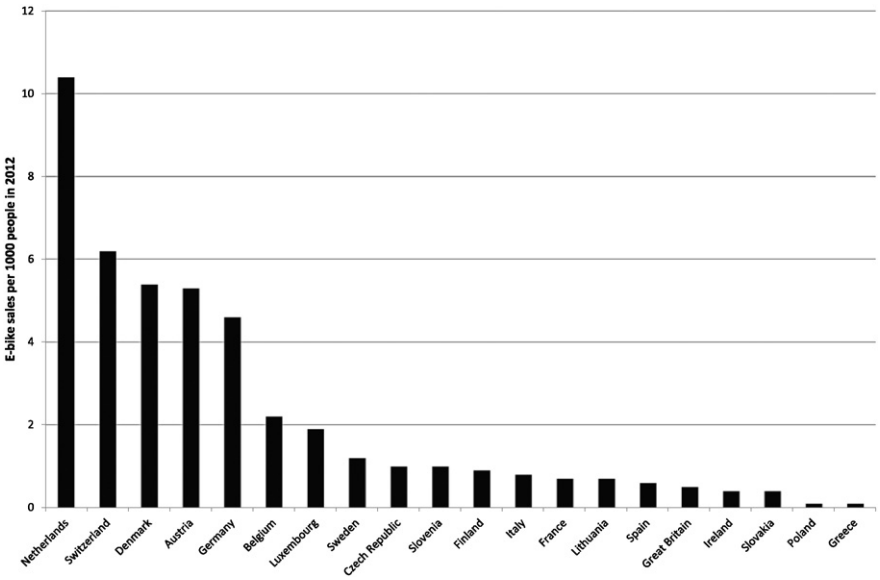

Fig.1. European e-bike sales per 1000 people in 2012. Source: (Fishman and Cherry, 2015; 7).

were evenly balanced between sexes and the average age was 56 years (age range of 43–70 years) — see Table 1. Most were in full or part time employment. Nearly all held a full driving licence and only five lived in households without access to a car. It should be kept in mind when interpreting results that this is a small sample within geographically limited areas and potentially biased towards those more pre-disposed to cycling and therefore may not be generalizable.

Semi-structured interviews of approximately one-hour and focused around three themes — motives for purchase, perception of impact on travel behaviour and user experience — were conducted with participants during June to October 2013. Interviews with Dutch participants were conducted in English by the lead author — a native English speaker. Although most Dutch participants were proficient in speaking English, one of the co-authors— native Dutch speakers — was present at interview to provide additional language support and to assist with vocabulary and nuances of meaning. After completing the interview participants were asked to complete an online exit survey. This confirmed basic demographic information as well as providing an estimate of the total number of journeys (defined as, 'one-way course of travel with a single main purpose') by mode during a typical week and perceived changes in personal travel behaviour since acquiring an e-bike.

Interviews were digitally audio-recorded and transcribed for analysis using the qualitative analysis data package NVivo10. Cross sectional coding was applied first to a sample of three transcripts by the three authors. Comparisons were made between the three and then an initial theme-based analytical framework developed to guide the analysis of remaining transcripts (Ritchie and Lewis, 2003). The framework was broadly in-line with the over-arching themes used to drive the semi-structured interviews (i.e. motivations, perceptions and experiences) but included sub-themes that emerged during analysis. (e.g. 'stigma', 'barriers'). The lead author took overall responsibility for manually checking inter-rater coding reliability of sub-themes and ensuring that data coding was consistent. Ethics approval was received from Oxford Brookes University Research Ethics Committee (Registration No: 130,749) prior to commencing the study. All quotes reproduced in this paper have been anonymised to protect participants' identity.

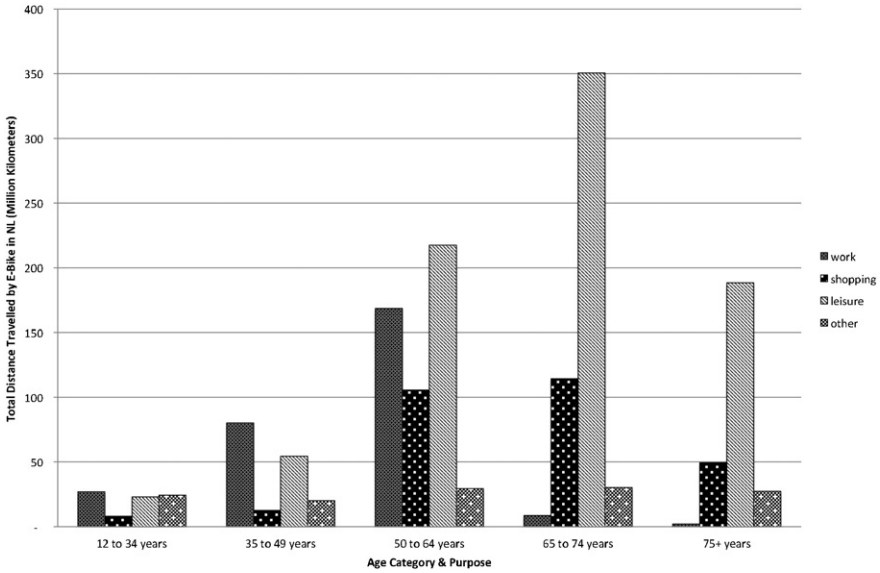

Fig.2. E-bike use in the Netherlands by age category and purpose. Source: KiM (2015).

Box 1
Characteristics of case study areas.

Randstad & Grongingen, NL— Amsterdam, Utrecht and Groningen are cities with the highest levels of cycling in the Netherlands and indeed Europe (Rietveld and Daniel, 2004). Amsterdam and Utrecht are part of the so-called north wing of the Randstad, the urbanized belt of cities in the western part of the Netherlands. The distance between Amsterdam and Utrecht is roughly 40 km. The Amsterdam conurbation has a resident population of 1.1 million, whereas the Utrecht conurbation counts almost 500,000 inhabitants. In Amsterdam and Utrecht cycling accounts for roughly 35% of journeys (Statistics Netherlands, 2014). Groningen is a medium-sized town located in the north east of the Netherlands. Groningen has almost 200,000 inhabitants (CBS StatLine), and a large student population (over 50,000). The city centre is largely car restricted and prioritizes pedestrian and cyclist movement. There is extensive dedicated cycling infrastructure including large cycle parking facilities in the city centre and at the main central railway station. Groningen municipality has the highest cycling share of all Dutch municipalities at around 40% of all journeys and 59% solely within the city centre (Handy et al., 2012).
Oxford, UK— Oxford is regarded as one of the UK's 'cycling cities'. The university-city is located approximately 100 km from London in the south of UK, and is renowned for being an important educational centre and tourist destination. It has a resident population of around 150,000 and a temporary population of around 40,000 students. Around 17% of journeys to work are by cycle compared to the England and Wales average (excluding London) of around 3%(UK Office for National Statistics, 2014). The local authority describes provision for cyclists in Oxford as: "One of the most comprehensive in the country with cycle lanes on many main roads, traffic speeds generally less than 30 mph and 20 mph on all side roads and many quiet routes away from the main radial roads" (Oxfordshire County Council, 2012).

5. Results

5.1. Perceived impact on personal travel behaviour

The online exit survey revealed that just over half of all participants (n = 12) used conventional cycling as their main method of travel before purchasing an e-bike(Table1). The remainder reported using cars (n = 4) or a combination of car and conventional bicycle (n = 4) or public transport (n = 2) — one participant (#12) reported previous use of an e-bike. Over half of all participants (n = 13) reported using their e-bike for the majority of their overall weekly journeys. Walking was reported as the second most commonly used method of local travel. E-bikes were used for multiple purposes including accessing local shops, commuting and for leisure.

More detailed observation (Table1) highlights that over half (n = 12) of all participants for whom conventional cycling was their main mode of transport before purchasing their e-bike perceived that they had reduced their conventional cycle use. Half of all participants (n = 13) also indicated that they had reduced their car use and this was particularly evident among those for whom driving was their main method of moving around prior to purchasing an e-bike. Some participants also reported a reduction in their use of public transport (n = 8) and walking (n = 3).

The selection of quotes below illustrate how those who mainly cycled prior to purchasing an e-bike might have given up cycling altogether and transferred to the car. Moreover, those who would not have previously contemplated conventional cycling have been able to replace car use with e-biking for at least some journeys.

> "*I use the e-bike so much more than I imagined and if I have to go to town* [8 km] *then it doesn't enter my head to use the car* [*which was the previous method*]." Natascha, 70, Groningen.

> "[*If I hadn't purchased an e-bike*] *I wouldn't have got back on my bike, no.* [*Beforehand*] *I drove every day, that's what I was doing.I was driving every day, parking over the road, so I would have carried on doing that.*" Helen, Oxford.

> "*My mother lives in Abingdon* [*6 miles away*]. *Whereas before I probably wouldn't have tackled the journey on my ordinary bike, I feel that I can easily get there and back by using the e-bike.*" Bradley, 61, Oxford.

> "*It's not possible to travel by regular bike four days a week, so I can choose metro or car* [*laughs*]*…then I would not travel by bike.*" Ellis, 57, Amsterdam.

> "*How am I going to get to work after dropping my daughter off?'One option is to buy another car, one option is to use an ordinary bike and the other …the electric bike; and I went down the electric bike route because I thought five days a week on an ordinary bike, it was doable but pretty tiring,* [*and*] *I'm not getting any younger.An electric bike takes a lot of the effort out of it, it allows me to get into work quicker than an ordinary bike and it saves me having to buy another car.*" Jonathan, 43, Oxford.

5.2. Motives for e-bike purchase

The most common reason among our participants for purchasing an e-bike was a personal sense of decline in physical ability often bought about by a health condition. Those who used a conventional bicycle for most of their journeys prior to purchasing an e-bike regarded e-biking as a solution to maintaining their cycling.

> "*I got some health problems… I didn't have the strength anymore.*" Ramona, 49, Utrecht.

> "*Two years ago the DVLA* [*UK driving agency*] *would not renew my driving licence because my eyesight's not good so I was thinking of well I don't want to be stuck at home too much. Knowing that electric bikes existed, I investigated and took it on from that as a means of getting me from A to B where it's more difficult* [*by pedal cycle*]." Carl, 76, Oxford.

However, many participants offered multiple reasons of which health or declining physical ability was part. Helen's quote exemplifies the complex personal and household circumstances and changing travel scenarios that, for her, made conventional pedal cycling challenging.

> "*I was trying to get back into cycling but with that health issue in place as well as the constraints of being a single parent and having to only leave the house at a certain time and be home at a certain time.So I was faced with a number of factors so I needed to speed up but I couldn't speed up because of my health, so I started to look at e-bikes as a dual thing. I thought it would get me fit, it would enable me to speed up my journey on a bicycle and it would have all the added benefits of lowering costs. I don't have to worry about parking and all those sort of things but it was the first two of I want to cycle, how do I speed up my journey and how do I address the fitness issue…?*" Helen, Oxford.

Table 1
Participant characteristics and their reported travel behaviour.

	Person	Age	Sex	Location	Household composition	Economic status	Driving licence	No. cars	No. cycles	Main method of travel pre-e-bike purchase	Travel behaviour change since purchasing e-bike			
											Cycle [not e-bike]	Walk	Drive	Take transit
1	Anton	37	M	Ams, NL.	C + ch < 18	FTE	Y	2+	3	B	−2	0	−2	−1
2	Ellis	57	F	Ams, NL.	C	FTE	Y	1	4	PT (Metro)	−2	0	0	−2
3	Jeanet	66	F	Ams, NL.	S	RTD	Y	0	1	C	−2	−2	dk/ns	dk/ns
4	Jos	57	M	Ams, NL.	C + ch < 18	FTE	N	1	6	B	0	0	0	0
5	Suzanne	62	F	Ams, NL.	S	USC	Y	1	1	B	−2	1	1	dk/ns
6	Karlijn	54	F	Utr, NL.	C + ch < 18	PTE	Y	0	4	B	0	0	0	0
7	Ramona	49	F	Utr, NL.	S	USC	Y	1	1	B	−2	1	−1	−1
8	Erwin	58	M	Gron, NL.	C	FTE	Y	1	2	B	0	0	1	0
9	Juliette	63	F	Gron, NL.	S	PTE	Y	0	2	PT (Train)	2	0		−2
10	Marcel	56	M	Gron, NL.	C	FTE	Y	1	1	C-B	0	0	−2	0
11	Marjolijn	43	F	Gron, NL.	C + ch < 18	PTE	Y	1	4	C	−1	0	−2	0
12	Natascha	70	F	Gron, NL.	C	RTD	Y	2+	1	C-eB	−2	0	−2	−2
13	Andrew	46	M	Oxf, UK.	C + ch < 18	USC	Y	2+	2	C	0	0	−1	0
14	Bradley	61	M	Oxf, UK.	S	FTE	Y	2+	4	B	−2	0	−1	−1
15	Calvin	70	M	Oxf, UK.	S	RTD	Y	0	0	C-B	2	−2	−2	−2
16	Carina	48	F	Oxf, UK.	C + ch < 18	PTE	Y	1	3	C-B	−2	−2	−2	0
17	Carl	76	M	Oxf, UK.	S	RTD	N	0	1	B	−1	0	dk/ns	0
18	Claire	56	F	Oxf, UK.	S	PTE	Y	0	1	B	−2	0	−1	−1
19	Helen	ns	F	Oxf, UK.	C + ch < 18	FTE	Y	1	1	B	0	0	−2	0
20	Jonathan	43	M	Oxf, UK.	C + ch < 18	FTE	Y	1	2	C	−2	0	0	0
21	Roberta	50	F	Oxf, UK.	S	FTE	Y	1	0	B	dk/ns	0	−1	0
22	Sam	57	M	Oxf, UK.	C + ch < 18	PTE	Y	2+	3	B	1	0	−1	0

Household composition: C = co-habiting couple (no children at home); C + ch < 18 = co-habiting couple (with children under < 18 at home); S = single occupant.
Economic status: FTE/PTE = Full/part-time employed; RTD = retired; USC = unemployed/sick/carer. Main method of travel: C = car; B = bicycle; eB='e-bike'; PT = public transport.
Travel Behaviour Change: −2 = decreased a lot; −1 = decreased a little; 0 = stayed the same; +1 increased a little; +2 = increased a lot; dk/ns = don't know/not stated.

Participants who did not cycle, or who did very little cycling prior to purchasing an e-bike, typically described critical junctures that forced them to reflect on their lifestyle and travel behaviour. Marcel in Groningen, with a self-confessed aversion to physical activity, described how the turning point for him was the breakdown of his car, coupled with reflections on his own personal health when he reached his 50th birthday.

> "*When I turned 50 I decided it was time to change something about my health habits, I did not have time to do any physical activities, so Idecided that e-biking to work might be a reasonable idea.*" Marcel, 56, Groningen.

Andrew began working for a new employer in Oxford and had never really cycled and did not class himself as a 'cyclist'. His continual frustration when driving to work on congested roads around the city, and seeing colleagues cycle, had encouraged him to invest in an e-bike.

> "*I got into e-biking when I first moved to Oxford in 2007, I had never really been a cyclist at all, just a bit of casual summer cycling…I worked for a company just in Oxford and lots of people used to cycle to work.*" Andrew, 46, Oxford.

Participants recounted first becoming aware of electric bicycles through friends and acquaintances that already owned one or by noticing an increasing number of people on the street using them. Having had their interested piqued, they would find out more information using online sources and consumer magazines before making enquiries at cycle retailers and trying-out different models.

5.3. User experience — perceived benefits

The perceived benefits of e-biking included the ability to cover greater distances and complete more activities in the same time over conventional cycling. There was also a perception that it construed positive benefits to health and wellbeing, and as noted previously, that e-biking was replacing journeys that would have been made by car.

There was a strong feeling among participants that the e-bike had provided opportunities to cycle for journeys that would not have otherwise been contemplated by pedal cycle because of journey distance. General benefits of e-biking versus conventional cycling focused around being able to go further in less time and with less effort. Participants whose commute was around 10 km or more discussed how the e-bike allowed them to overcome the issues that can be inherent in longer distance commuter cycling (i.e. 'tiredness', 'sweating').

> "*I know sporty people can do it [ride 14 km] with a normal bike but I really hated to come to my work sweaty and then you have to change, or you have a red head for 45 min and then you go to work.*" Marjolijn, 43, Groningen.

The e-bike also provided the opportunity to complete more activities in the same time period, whether escorting children, running errands to the shops, or creating more leisure time, for example, to go recreational rides in the countryside.

While a few of participants did express dissonance over whether 'addiction' to e-biking had impacted overall physical activity achieved through conventional cycling, the consensus was, that overall it had made a positive impact to personal activity and wellbeing. The majority of participants spoke about how e-biking had allowed them to maintain or increase their level of personal fitness even in cases where conventional pedal cycling had been reduced. The e-bike was widely regarded as a tool for continuing to cycle and therefore to keep active, and furthermore, to actually increase the frequency and range of cycling activity. The positive sensation derived from riding an e-bike was also described and contrasted with other methods of travel (e.g. sitting in a car or using public transport).

> "*I broke my foot a couple of years ago* [*but*] *I've managed to keep* [*my regular Sunday ride*] *going and I find that I've been able to go further*

afield with the e-bike…I've explored parts of Oxford that I've never really seen before." Bradley, 61, Oxford.

"Well for me I think I lost weight now just…just because I'm now going with E-bike, because I move more." Marjolijn, 43, Groningen.

"[On my regular pedal cycle I made]…three or four trips in the whole summer, and with my e-bike I do it three times a week. I just started doing more exercise because I'm taking much more trips outside the city — which I never did before." Suzanne, 62, Amsterdam.

"…I think that when you get older and you've got a life that is very demanding I find that I can't keep up my fitness and there's a constant battle, I've got to go to the gym, I've got to look after my son, I've got to cook food, I've got to do a job.There's a constant battle." Helen, Oxford.

"I always feel happy [when e-biking]. I liked it so much better than sitting in a car. Like if you have a glass of wine — it [e-biking] feels good! So it's a kind of warmth…a nice feeling inside." Natascha, 70, Groningen.

5.4. User experience — perceived barriers

The issues that emerged during analysis in relation to experience were related to barriers to e-biking and these centred around three themes: technological (bike and equipment), social (stigma and safety) and environmental (infrastructure).

5.4.1. Technological

The high purchase price of e-bikes and associated technology was emphasized by all participants and particularly those in the UK. The heaviness of e-bikes was also seen as problematic. Participants described difficulties manoeuvring their e-bike when parking, lifting it over obstacles, or for example, trying to placing it on public transport or on the back of a car.

"*It's a big, heavy thing and it's, well you know, it's just the main weight of it. That is the one disadvantage. If you've got to lift the bike over a threshold or something it's a bit of a hassle.*" Calvin, 70, Oxford.

Some parents also highlighted the difficulty they had in finding electric bicycles that are designed to enable the carriage of children.

"*I think most e-bikes are made for women aged 60 and over or something and they don't think about it how you can move your child on it.*" Marjolijn, 43, Groningen.

There was also concern about battery performance in terms of range —so-called 'range anxiety' — and also longevity and the potential expense of replacement. Participants had generally experienced a much more limited range than that specified by manufacturers and it was noted that this was particularly problematic during the winter months.

"*I have worries about my battery — if it's charged and if I can get far enough. So I would love to have an e-bike that can go 80 km without worrying.*" Ramona, 49, Utrecht.

"*There is no information about cycling with an e-bike in the cold. But it's terrible…in winter the battery is terrible.*" Jos, 57, Amsterdam.

"*Like most things with a battery there's a sort of honeymoon period, and then after a couple of years you're looking at it declining in efficiency… and financially it's quite expensive [to replace].*" Carina, 48, Oxford.

Participants discussed the need to plan ahead to ensure e-bike batteries are sufficiently charged before travelling because of the time it can take to fully load the battery. Charging was often performed by removing the battery from the bike and connecting it to an electric socket at home or at the workplace. Some participants also reported carrying a spare charging cable with them when making some longer journeys for fear that they might need it at their end destination.

"*That's the only hassle, remembering to charge it because if you've got back and you've only got a range of five or ten miles then I can't get to work.*" Sam, 57, Oxford.

"*The annoying thing about that is if you're doing a long journey you actually have to remember to take the charging cable with you if you think you might run out and the charging cable is really heavy.*" Roberta, 50, Oxford.

5.4.2. Social — stigma

Participants in both the Netherlands and UK often highlighted the stigma attached to e-biking. That is, e-biking is in some way 'cheating' vis-à-vis conventional pedal cycling. There were general accounts of teasing by work colleagues and comments received from members of the public.

"*I guess the initial reaction is that it's cheating, partly because I'm part of the cycling group/culture and [they] think it's cheating…[and that] anyone who is capable of cycling above* 15 miles *an hour without too much effort and is fit probably doesn't need an electric bike …*" Sam, 57, Oxford.

"*…at work some people were laughing about it because … they still had that idea of an e-bike [for old or disabled people].Others would react more because they travelled the same distance but by sport bike. They would say 'Why do you need an e-bike, you can just go by road bike'. So that was the responses I get from my colleagues.*" Anton, 37, Amsterdam.

"*People close to you, say, 'oh, it suits you' … and they understand. People who are not so close joke that, 'e-bikes are for older people'… I do not mind*! [*laughs*]" Ellis, 57, Amsterdam.

"*…in my department there are quite a few older ladies, and their line is you know, 'You're young and fit, you don't need that do you?'*" Carina, 48, Oxford.

Some participants explained how they had actively investigated models of e-bikes that were almost identical to regular pedal cycles. Ramona explained how she had even attempted to 'camouflage' her e-bike with accessories to disguise the fact that it was electrically assisted.

"*…I camouflage it [e-bike] with the big bags on the back, and with the plastic flowers on the front, just to camouflage the electric part—you don't see it.*" Ramona, 49, Utrecht.

5.4.3. Social — safety

Participants in both the Netherlands and UK reported experiencing minor incidents that they felt compromised their safety whilst riding their e-bike. The general perception was that other road users do not anticipate the speed of e-bikes. Almost all participants recounted having to 're-adapt' to cycling by learning to moderate their speed and to anticipate the reactions of other road users particularly in more populated areas of the city. In the Netherlands this was more of an issue given the higher level of cycling. Dutch participants described the strategies they employ to avoid interaction with

other roads users including planning routes that offered the least obstruction, avoiding busy interactions and minimizing complex manoeuvres. In UK reflections were more likely to focus on dealing with poor infrastructure and anticipating inattentive car drivers.

> "*In the beginning you have to get used* [*to the fact*] *that it goes very fast. After three months I also had an accident because I was going through the traffic lights and a car was going this way.* […] *I pulled the brakes, and the brakes are very strong, and so I just pulled myself over*". *Suzanne, 62, Amsterdam.*

> *"I don't really think cars really pay any attention to an e-bike or a non e-bike, they just see … because my bike looks like an ordinary bike in many respects, they probably don't even notice and if they do, I don't think I get treated any different to an ordinary cyclist." Jonathan, 43, Oxford.*

> *"The only times where it feels dodgy is when […] the cycle paths aren't wide enough and/or car drivers or van, bus, lorry drivers, anyone are just not considerate of cyclists". Roberta, 50, Oxford.*

> "*Outside the city I have it on maximum acceleration, maximum support, because that is just one straight road ahead and you can just move it. But in the city I normally put it down a notch or two, because all the other cyclists…if you go too fast then there will be accidents and you have to brake all the time, so it doesn't work anyway.*" Anton, 37, Groningen.

5.4.4. Environmental (infrastructure)

UK participants often expressed dissatisfaction with the condition of traffic infrastructure and the lack of dedicated space for cycling compared to their Dutch counterparts. However, paradoxically, the benefit of e-bikes in allowing riders to 'keep up with the traffic flow' was appreciated — in the UK cycling on-road sharing with other vehicles ('vehicular cycling') is more common than in the Netherlands where dedicated provision for cycling is abundant and traffic speeds are reduced to walking/cycling pace in more populated areas.

> "*Sometimes those supposedly quicker routes, the cycle paths, are not wide enough or they're muddy or they're not as well cared for and things like that, so sometimes you're better off being on a road than on a cycle path.*" Roberta, 50, Oxford.

> "*I mean the big resistance to cycling is…a lot of people just feel … don't feel safe cycling. Now I think electric bikes can help that a little bit because it enables someone to feel a bit more confident but a lot of people simply say, 'no, I'm not going to cycle on that main road' whatever … 'I need a cycle track', so that has to go hand in hand.*" Sam, 57, Oxford.

Participants in both countries reported that parking e-bikes was problematic particularly at major transport hubs such as rail stations because of lack of space or issues with design. There was a strong desire for more secure long-stay valet style parking in city centres and at transport hubs with provision to charge batteries.

> "*The lack of bike stands in Oxford is sometimes infuriating. I think you've got to be a bit more careful with an e-bike, cos there's a lot more cost involved. You want to park it somewhere good, you don't want things stolen off it or whatever.*" Carina, 48, Oxford.

> "*…in the station, if I park it there and someone else parks it next to me I can't get it out... So I have to lift it up over the other bikes which I don't have the strength for. Or if the bottom rows are full, you need to park it on top. I don't know, you haven't ever tried an e-bike, tried to lift it—it's about 20 to 25 kg.*" Ramona, 49, Utrecht.

6. Discussion

Across Europe the sale of e-bikes is rising. This paper, as far as we are aware, has provided the first detailed insight into the motives, perceptions and experiences of e-bike owners in the Netherlands and the UK. In-depth interviews with e-bike owners in two separate geographical and cultural contexts reveal common motives, perceptions and experiences of owning and operating e-bikes and also issues specific to each region.

Among users in both the UK and the Netherlands there is a sense that e-bikes offer the opportunity to maintain or increase levels of cycling for non-car based everyday travel and recreation, particularly when faced with reduced physical capacity or complex travel patterns that makes conventional cycling more challenging. Our findings corroborate previous studies (MacArthur et al., 2014; Johnson and Rose, 2015) that suggest that the main motivation for engaging with e-biking in both the UK and the Netherlands is the option it provides for overcoming longer or more complicated journeys (typically 10 km or more) that would otherwise preclude conventional cycling because of the time and physical exertion required. Furthermore, and in line with previous studies (Dill and Rose, 2012; Fyhri and Fearnley, 2015; Johnson and Rose, 2015; Popovich et al., 2014) our study also revealed that there is a perception that personal e-bike use is replacing personal journeys that may have otherwise been made by car.

We also revealed the common perception in both regions that e-biking has increased personal physical activity or at least enabled previous levels of cycling to be maintained. E-bikes are perceived to promote engagement in cycling by encouraging more frequent and longer journeys (Fyhri and Fearnley, 2015) and also allow participants the confidence to discover geographies previously untapped by conventional cycling. Similar to the US study by Popovich et al. (2014), positive effect on personal wellbeing was evident in participant narratives around the 'joy of riding'— videoing interviews would have allowed us to reveal the positive non-verbal gestural and facial expressions demonstrated by our participants. E-biking could therefore have positive benefits for personal wellbeing and although we present no measurable outcomes, our qualitative findings perhaps elaborate the positive cognitive response attributed to e-biking in other quantitative studies (Theurel et al., 2012).

Despite these positive attributes significant barriers to e-biking remain in both the Netherlands and the UK and mirror those reported by e-bike riders in the USA (Dill and Rose, 2012). The initial financial outlay and the greater weight of e-bikes are most noteworthy but our study also identified the subsequent disappointment with manufacturers'publicized battery range and performance, and the unexpected ('hidden') cost of battery replacement. We also highlighted that minor accidents/incidents were commonplace but this had not deterred our participants from riding. Interactions seemed more problematic for riders in the Netherlands where most cycling takes place on purpose built cycle tracks typically among other cyclists. Oxford participants, whilst lamenting the lack of 'Dutch style' infrastructure, suggested that e-bikes allow them to 'behave like a vehicle', accelerate out of junctions and keep up with the flow of traffic. It is unclear, however, whether this perceived benefit is likely to encourage the wider uptake of cycling in the UK. Finally, the perceived social stigma associated with e-biking identified in West Coast USA(Popovich et al., 2014) was also raised in UK and the Netherlands. Whilst this had not acted as a deterrent to e-bike users in our study, it may deter those unwilling to deviate from 'mobility norms' particularly in the UK where there is a low share of cycling for transport and where e-biking is already a 'sub-culture within a sub-culture'.

6.1.1. Implications for policy; practise and for future research

E-biking could play an increasingly significant role in policies to promote low carbon transport and healthy cities. This potential could be tapped by officials involved in mobility policy and

planning. The e-bike could substitute journeys by car that are deemed too challenging for conventional pedal cycling, for example, because of distance and topography. Furthermore, e-biking could make an important contribution to promoting wellbeing through independent travel and expanding opportunities to engage in activities spread across wider geographical areas.

E-bikes require different demands for space and facilities vis-à-vis conventional pedal cycles meaning the impact of existing infrastructure/facility design on e-biking requires further investigation. Policy makers and designers could develop policy guidance on the provision of e-bike parking and charging points. Public bike sharing schemes at municipal and organizational level (e.g. university campuses) could include e-bikes and remove the need for individual up-front capital investment (Ji et al., 2014; McLoughlin, 2012). There is also the potential to promote road safety awareness of e-bikes among all road users and for agencies to provide bespoke rider training.

With regard to the bicycle industry, improvements to battery design including size and weight, load time and range could further stimulate the e-bike market (Weinert et al., 2007). Design innovation may unleash a new wave of 'smart e-bikes' offering, for example, regenerative charging, integrate smart technology (e.g. satellite navigation, weather updates), internal security/immobilizing devices and the ability to carry children and goods (Behrendt, 2012). Extensions to tax-free saving on the purchase of more expensive e-bikes could provide an incentive for would-be-bike commuters, for example, through the UK Cyclescheme.

Officials wishing to promote e-biking as part of low carbon/healthy transport policy may find that developments in e-bike technology, coupled with infrastructural and fiscal stimulus, are insufficient in promoting e-biking. Though the stigma associated e-biking had not deterred owners in our study it may deter the wider public from considering it a 'normal' and 'acceptable' form of urban mobility. Publicity campaigns could therefore focus on representing e-biking as a normal part of the mobility landscape, particularly in the UK where cycling is regarded as abnormal (Aldred, 2012; Pooley et al., 2011). Social barriers may reduce as more diverse electric bicycles reach the market and a broader and more diverse section of the population is witnessed using them.

There is also the need for clarification by UK government on the role of e-bikes in transport policy and the routine collection of data on e-bike use. The Netherlands is already ahead of the game in this respect and other European states could be encouraged to follow suit. E-biking could also be more closely monitored in health surveys in order to monitor its impact on health and wellbeing and physical activity.

Future research could focus on new or returning cycle users from other geographical locations with differing cultures of cycling and levels of support. While the findings from this study are not generalizable to all e-bike owners they provide grounds for further investigation on a larger scale. For example, there is the need to try to quantify actual levels of mode substitution and new journey generation among e-bike owners and the extent to which this is enabling a reduction in ownership (or forfeiture) of other household motor vehicles. More insight is also required into the actual *in situ* use of e-bikes, for example interactions with other road users and infrastructure, through observational studies including mobile interviews and ethnography. Future studies should also investigate the role of e-bike mobility in promoting physical health and mental wellbeing.

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