The role of psychological and socio-demographical factors for electric bike use in Norway

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Abstract

The e-bike is emerging as a new sustainable transport mode in Norway and has the potential to lead to increased cycling among the population. However, little is known about psychosocial determinants of e-bike use. The aim of the study was to examine the role of normative and environmental beliefs, the perceived attributes of e-bikes, and innovativeness and demographical factors related to e-bike use in a Norwegian sample. An online survey was used to collect data from 910 respondents, including both e-bike users (252) and non-users (658). The respondents were recruited via a commercial panel (response rate 42.04%) and a Facebook post. A structural equation modeling analysis was used to analyze the data. The structural model had a good fit to the data. The results showed that attitudes towards e-bike use followed by innovativeness were the most important predictors of e-bike use. The normative processes measured within the Norm Activation Model activated positive attitudes towards e-bike use, which in turn predicted e-bike use. There was a negative relationship between e-bike use and conventional bike use, while a positive relationship was found between car use and e-bike use. The results are discussed with regard to their implications for interventions aiming to promote e-bike use.

Keywords: e-bike use; Norm Activation Model; attributes, innovativeness, Norway

1. Introduction

The electric bike (e-bike) is a newly emerging, sustainable urban transport mode that is increasingly used in many countries due to its benefits for both the environment and human health and mobility. The impact of e-bikes on the environment and people's health depends on which transport mode they replace, and often they are used as a replacement for conventional bicycles and cars (Cherry et al., 2016; Kroesen, 2017; MacArthur et al., 2014). A shift from use of conventional cars to e-bikes has been associated with a reduction in the use of energy resources and environmental problems, as well as increased health benefits due to increased physical activity and decreased traffic congestion (Berntsen et al., 2017; Cherry et al., 2009; Fishman and Cherry, 2016; Gojanovic et al. 2011; Hiselius and Svensson, 2017; Pierce et al., 2013; Plazier et al., 2017). Also, replacing a conventional bike with an e-bike leads to an increased number of bike trips and allows the cyclists to ride over longer distances and thus opens up new mobility options (Fyhri and Fearnley, 2015; MacArthur et al., 2014).

In Norway, increasing the share of cycling in the various transport modes is an important transportation policy strategy (Norwegian Public Roads Administration, 2003). Increasing the use of e-bikes may help to increase cycling activity among Norwegians by leading to increased numbers of bike trips (Fyhri and Fearnley, 2015) especially in regions that are perceived by many users as too hilly for conventional cycling. Although e-bike use is increasing rapidly in Norway, fewer people own an e-bike in Norway compared with most other European countries, such as Switzerland and the Netherlands (Figenbaum and Kolbenstvedt, 2013; Fyhri and Fearnley, 2015). This might be related to a low level of knowledge and familiarity related to e-bikes, since e-bikes were introduced relatively recently in Norway. In addition, geographical characteristics, harsh winter conditions, and differences in the cycling culture in Norway compared with other countries may account for the lower e-bike use. In order to have a better understanding of determinants of e-bike use and to promote e-bike use, more research is needed. The present study examined psychological and socio-demographical variables as well as the innovativeness of the user in relation to e-bike use in a Norwegian sample.

1.1 Personal and environmental characteristics related to e-bike use

Previous studies have shown that a number of demographic and personal characteristics are associated with e-bike use. Using an e-bike enables cycling for groups of people who tend to cycle less due to physical limitations. For example, older people and people with health problems cycle more with an e-bike than with a conventional bicycle (MacArthur et al., 2014; Wolf and Seebauer, 2014). Moreover, previous research has shown that the e-bike has led to women cycling considerably more than men (Fyhri and Fearnley, 2015), and e-bike users tend to have a higher education and income levels compared with the general population (MacArthur et al., 2014; Popovich et al., 2014; Wolf and Seebauer, 2014). In addition, environmental factors, such as landscape characteristics, weather conditions, and travel distances, and time influence the use of e-bikes. Challenging topography such as hills, bad weather conditions, and longer travel distances make riding a conventional bicycle less desirable for many (Heinen et al., 2010). However, using an e-bike instead of a conventional bicycle mitigates these barriers and makes cycling easier in difficult environmental conditions (Fishman and Cherry, 2016; Popovich et al., 2014).

1.2 Attributes of e-bikes

How people perceive the practicality and benefits of e-bikes is important for their use of e-bikes (Fishman and Cherry, 2016; Popovich et al., 2014). The possibility to maintain a higher speed with less physical effort with an e-bike compared with a conventional bicycle is one of the most frequently reported positive aspects of e-bike use (Fishman and Cherry, 2016; MacArthur et al., 2014; Popovich et al., 2014). Moreover, making more trips and having positive experiences associated with e-bike use have been reported as the motives for e-bike use (MacArthur et al., 2014; Plazier et al., 2017; Popovich et al., 2014). However, some negative aspects of e-bike use, such as safety and security risks, inhibit their usage. An increased risk of severe injuries in cases of accidents due to the higher speed compared with conventional bicycles and the increased risk of theft are among the negative aspects of e-bike use (Popovich et al., 2014). In addition, the higher weight of e-bikes and anxiety about their range on one charge, especially on long trips, have been reported as negative aspects of e-bike use (Popovich et al., 2014; Schepers et al., 2014).

1.3 Environmental and normative motivations for e-bike use

Despite several studies that examined the positive and negative attributes of e-bikes use, the role of normative and environmental motives for choosing e-bikes have been scantly examined. However, personal norms and environmental beliefs have been found important for the use of other sustainable transport modes, such as electric cars and public transportation (e.g., Lind et al., 2015; Nayum and Klöckner, 2014). The Norm Activation Model (NAM) (Schwartz, 1977) is a useful theoretical framework that has been commonly used for examining the role of normative and environmental beliefs related to sustainable transport mode choices. According to the NAM, the ultimate predictor of behavior is a personal norm (i.e., a person's sense of environmental obligations), which is activated by awareness of the consequences (AC) of a behavior and awareness of the need to take action (AN) (Klöckner and Matthies (2009). Although never formalized by the initial authors, there is a causal chain between these variables: AN triggers AC, which in turn activates the personal norm (Klöckner and Matthies, 2009). Despite of several studies applying the NAM to explain various transport modes choices, to our knowledge no studies to date have used it to explain e-bike use.

1.4 Consumer adoption stage

An e-bike can be considered a sustainable innovation because it is a sustainable transport mode that has been recently introduced to the consumer market. Therefore, in addition to social-psychological variables, such as beliefs, norms and motivations, the level of innovativeness as a characteristic of the potential buyer may be critical for their use of e-bikes. The diffusion of innovations theory by Rogers (2003) has been used to categorize consumers according to their characteristics and the timing of their adoption of innovations (e.g., Noppers et al., 2015). According to this theory, there are five consumer segments:

1. "innovators": consumers who adopt first and take risks in their decisions
2. "early adopters": consumers who anticipate the advantages of the innovation and adopt partly to gain respect from others
3. "early majority": consumers who adopt when they believe that innovation has certain advantages
4. "late majority": consumers who are skeptical and only adopt when the innovation has clear advantages
5. "traditionalists": consumers who avoids risk and change, and only adopt the innovation when the alternatives no longer exists

Previous research measuring consumer adoption stage in relation to the adoption of sustainable transport modes, such as electric cars (Noppers et al., 2015) and e-bikes (Wolf and Seebauer, 2014), has shown that earlier adopters are more likely to adopt electric vehicles than the late adopters, and early and late adopters of electric vehicles differ in their characteristics and motivations. Early adopters of e-bikes hold pro-environmental attitudes and they predominantly compromise older adults who use e-bikes especially for leisure trips (Dill and Rose, 2012; Wolf and Seebauer, 2014). The main reason for early adoption of e-bikes among older adults might be that the use of an e-bike has greater potential to increase their incidences of cycling since riding a conventional bicycle might be difficult due to some physical limitations (MacArthur et al., 2014; Wolf and Seebauer, 2014).

1.5 The present study

Compared with studies of other electric vehicles, there have been relatively few studies of e-bikes. The present study was conducted to examine the role of normative and environmental beliefs, the perceived attributes of e-bikes, demographic factors, physical fitness, car and conventional bicycle use, and consumer innovativeness for e-bike use in a Norwegian sample. Although some of these variables had been examined in relation to e-bike use previously (Popovich et al., 2014; Wolf and Seebauer, 2014;), they had not been examined comprehensively in a single study.

The comprehensive action determination model (Klöckner and Blöbaum, 2010) provides a useful theoretical framework to examine various factors in relation to pro-environmental transport mode choice. According to the model, intentional, situational and habitual processes have a direct effect on people's behavior, whereas normative processes affect their behavior indirectly through intentional and habitual processes (Klöckner and Blöbaum, 2010). Based on this model, we hypothesized that the evaluation of attributes related e-bike use and demographic variables will have a direct effect on e-bike use, whereas the effect of environmental and normative beliefs will be mediated by the evaluations of attributes. Additionally, we expected consumer innovativeness to be a significant predictor of e-bike use, in line with previous findings related to adoption stage and the adoption of e-vehicles (e.g., Noppers et al., 2015).

2. Method

2.1 Sampling and procedure

An online survey was sent out to 1903 persons drawn from a commercial panel and 800 of them responded, resulting in a response rate of 42.04%. Although there is limited information about the overall proportion of e-bike users in the Norwegian population, local-level statistics from some areas indicate that the share is very small. According to the results of a cycling survey in the Oslo area, only 3% of the cyclists used an e-bike (Tretvik, 2015); this percentage is likely to have increased. Hence, in order to reach a sufficiently large number of e-bike users, the commercial panel used Facebook to recruit e-bike users in addition to the panel data. Respondents who used Facebook for searching and liking e-bike related information were invited to participate in the survey. Initially, 154 e-bike users responded to the survey, but since this was fewer than the targeted number, a Facebook post about the study was used too. In addition, 110 people (98 e-bike users and 12 non-users) responded to the survey via Facebook post, thus bringing the total number of respondents to 910: 252 e-bike users and 658 non-users. The commercial panel recruited respondents who were representative of the Norwegian population in terms of demographic characteristics and regional distribution. However, the e-bike users recruited mainly via Facebook were less likely to be representative of the general population. The main objective of our study, however, was not to draw a picture of the Norwegian population, but rather to identify factors that affected the use of e-bikes. In order to gain enough power for such a comparison, the proportion of e-bike users was therefore oversampled, while acknowledging the impact this would have in terms of representativeness. The data collection was completed between November 2016 and January 2017. The characteristics of the study sample are listed in Table 1.

2.2 Measures

The online questionnaire included five sections. In the first section, the respondents were asked whether they used an e-bike (1 = yes, 0 = no), conventional bicycle (1 = yes, 0 = no), and whether they had access to a car within their household (1 = yes, 0 = no). They were also asked how long (1 = less than 1 year, 2 = 1–2 years, 3 = 3–4 years, 4 = 5 years or more) and how frequently during a normal week (1 = never, 6 = 5 days or more) they used their e-bike. In the second section of the questionnaire, environmental beliefs and personal norms were measured using the Norm Activation Model (NAM) as a framework. Based on previous studies using the NAM to explain sustainable transport modes (e.g., Lind et al., 2015; Nayum and Klöckner, 2014), we adapted the model items to e-bike use for our study. Awareness of need (e.g., “Car use leads to serious environmental problems”) and awareness of consequences (e.g., “I can contribute to a better environment by using an e-bike”) were measured by three items, while personal norms (e.g., “I feel morally obliged to use an e-bike”) were measured with two items. In the third section of the questionnaire, the attributes of e-bikes were measured using 14 items related to health (e.g., “Use of an e-bike is good for my health”), ease of use (e.g., “I can reach my destinations faster using an e-bike than a conventional bicycle”) and self-image (e.g., “Using an e-bike says something positive about me”). Items measuring attributes and NAM components were rated using a 7-point Likert-type scale (1 = completely disagree, 7 = completely agree). In the fourth section of the questionnaire, the innovativeness of the respondents was measured based on the five adopter segments (innovators = 1, early adopters = 2, early majority = 3, late majority = 4, traditionalists = 5) proposed by Rogers (2003). The adopter segments used in our study are described in Table 2. The respondents were asked to choose the category that described them best. The final section of the questionnaire included several questions related to demographic information (age, gender, income, and education), household size (number of family members), and one question related to the respondents' physical fitness (1 = poor, 5 = excellent).

2.3. Statistical analyses

The analysis was conducted using a structural equation modeling (SEM) approach with the MPLUS software package version 7.4 (Muthén & Muthén, 2012). Initially, a measurement model for the latent constructs awareness of need, awareness of consequences, personal norms, "self-image related e-bike aspects," "health related e-bike aspects," and "ease-of-use related e-bike aspects" was tested. After establishing a well-fitting measurement model, the structural model was specified (Figure 1). Awareness of need was expected to predict awareness of consequences, which in turn would predict personal norms. Based on the three components self-image, health, and ease-of-use, a second order construct "general attitudes towards e-bikes" (ATT) was established to capture the shared variance of the three separate facets of perceived e-bike attributes. In other words, the latent variable "attitude" represented the overarching evaluation of e-bikes across all three components. These general attitudes were expected to be predicted by personal norms. Finally, e-bike use, which was measured by one item asking whether the respondents used an e-bike or not (1 = yes, 0 = no), was expected to be predicted by attitudes towards e-bikes, age (because of the expected non-linear relation also age^2 was included in the model), gender, income, conventional bike use, car use, fitness and innovativeness. Due to the non-normal distribution of many items, a mean and variance adjusted weighted least square estimator was used (WLSMV). In addition, due to the (intended) overrepresentation of e-bike users in the sample, their impact in the sample was weighted down according to their increased sampling probability. Furthermore, we adjusted the analysis for potential effects of having two different samples joint into the full sample by using a stratification adjustment in MPLUS.

3. Results

3.1 Reliability of the measures

The items and reliability coefficients (Cronbach's alpha) for each latent variable are listed in Table 3. All of the measured constructs had a Cronbach's alpha value above 0.70, which is considered satisfactory for reliability (Nunnally, 1978).

3.2 Demographic differences between the e-bike users and non-users

A comparison of demographic characteristics between the e-bike users and the non-users is shown in Table 1. Compared with the non-users, e-bike users were significantly older, had higher education levels, and larger households. In addition, the e-bike users reported less use of conventional bicycles and higher use of cars compared with non-users.

3.3 Structural equation modeling

The structural model with standardized estimates is shown in Figure 1 (see Table 4 for full details of the non-standardized and standardized model estimates). In total, 890 respondents provided enough data for inclusion in the analysis, while 20 responses with too many missing values were excluded. The model fit indices showed it had a good fit according to a common standard (Hu and Bentler, 1999): $Chi^2 = 1212.545$, df = 406, $Chi^2/df = 2.99$; RMSEA = 0.047 (0.044, 0.050); CFI = 0.943; TIL = 0.938.

The results showed that the three facets of the assumed attitudes towards e-bike attitudes (self-image, health, and ease-of-use) were more or less equally reflected in the attitudes, which meant that to about the same degree the attitudes consisted of beliefs about how much e-biking led to increased health, contributed to improved self-image, and was functional in everyday life. Furthermore, the norm-activation chain contributed to activating positive attitudes, as expected: awareness of need triggered awareness of the consequences of the respondents' own travel mode choices, which activated a feeling of obligation to use environmentally friendly transport modes, which in turn triggered attitudes that were more positive. The links in this chain are strong. While positive attitudes were the most important predictor of e-bike use[1], innovativeness was the second most important predictor: the less innovative a person was, the less likely he or she was to own an e-bike. Of the demographic impacts, conventional bicycle and car use as well as age and income had an impact when we controlled for the other variables: car users were more likely to use e-bikes and conventional bicycle users were less likely to use e-bikes. The age effect was non-linear: the likelihood of e-bike use increased up until about 60 years of age and then reduced. In addition, e-bike use increased with higher income.

4. Discussion

The present study examined the role of various psychological variables, innovativeness, and demographic variables for e-bike use comprehensively using a large Norwegian sample. The variables in the norm-activation chain (awareness of need, awareness of consequences, and personal norms) predicted attitudes towards e-bikes, which in turn predicted e-bike use. Additionally, innovativeness and some of the demographical variables, such as age, had a direct effect on e-bike use. These findings confirmed our hypotheses.

Comparison of the demographic characteristics of the e-bike users and non-users showed that the mean age and proportion of people with higher education levels was significantly higher among e-bike users than non-users. Although the differences were not significant, the e-bike users tend to have higher incomes compared with the non-users, also

[1] The relation between attitudes and e-bike use for reciprocity was tested by specifying a modified model with an impact of attitudes on e-bike use and vice-versa at the same time. The influence of attitude on e-bike use was about three times stronger (standardized coefficient: .269***) as the influence of e-bike use on attitude (.091*). For model parsimony, we decided to stick to the model only assuming an impact of attitudes on e-bike use. The full model results for this additional model test can be obtained from the authors.

higher income was positively related with e-bike use in the SEM model Relatively high purchase prices for e-bikes is shown as a potential barrier for adoption of e-bikes (e.g. Popovich et al., 2014). Hence, it is likely that high purchase price for e-bikes hinders adoption of e-bike for those with a lower income. These findings are in line with those of previous studies showing that e-bike users tend to have a higher education and income levels compared with the general population (MacArthur et al., 2014; Popovich et al., 2014; Wolf and Seebauer, 2014). In the structural model, age had a non-linear effect on e-bike use, which meant that the likelihood of e-bike use increased until about 60 years of age and then decreased. In Norway, it is common for people to reduce their working hours or to retire after the age of 60, and therefore reduced mobility needs after the age of 60 years might be a reason for reduced e-bike use for those over the age of 60 years, although deteriorating health conditions might be a reason too. It may be argued that decreasing physical fitness initially leads to increased e-bike use, but eventually makes even e-biking too challenging.

Not surprisingly, the proportion of users of conventional bicycles was significantly lower among the e-bike users than the non-users. Also, in the structural model, conventional bicycle use had a negative effect on e-bike use. It is very likely that when people have the possibility to use an e-bike, they will make less use of a conventional bicycle less since e-bikes are more beneficial in many respects. However, the results could also indicate that conventional bicycle users are satisfied with their modal choice and do not consider using e-bikes (anecdotal evidence from conversations with users of conventional bicycles indicated that many of them considered e-biking as “cheating”). Some previous studies (e.g., Fyhri et al., 2017) pointed out that conventional cyclists who cycled the least are more interested in using an e-bike than those who cycled more with a conventional bicycle and thus it might be that the e-bike users in our study had already had a low level of willingness to use a conventional bicycle before they started to use an e-bike. In contrast to conventional bicycle use, car use was significantly higher among the e-bike users than the non-users, and car use had a positive effect on e-bike use in the structural model. In line with previous findings, (e.g., Kroesen, 2017), these findings suggest that instead of replacing cars, e-bikes were often used as an additional transport option. It is likely that instead of using e-bikes as their only transport option, people want to use e-bikes as an additional transport option in certain conditions, such as when they perceive the benefits of e-bike use as higher than the costs. Since the data we analyzed is correlational, the results could, however, also indicate that e-bikers recruit more from the population of car users than conventional bikers and since not all car trips are substituted, the rate of car use is still higher in this group.

In addition to environmental factors, (e.g., weather and road conditions) contextual factors such as travel distances to common destinations and cycling infrastructure are important for the choice to use e-bikes. Although we did not focus on the factors hindering e-bike use in this study, insufficient cycling infrastructure, not feeling safe when cycling, and bad weather conditions have been reported as the most common barriers to cycling in Norway (Fyhri et al., 2017). Thus, although e-bikes mitigate some of the barriers to cycling, other barriers such as insufficient infrastructure and bad weather conditions potentially limit the use of e-bikes in Norway. Since we did not compare the amount of car use before and after the respondents acquiring access to an e-bike, we cannot draw conclusions about the effect of e-bike use on car use, but it is very likely that e-bike trips replaced some of the car trips. Higher car use among the e-bike users compared with the non-users might be indicative of higher mobility needs among the e-bike users. The percentage of households with five or more people was almost twice as high among the e-bike users compared with the non-users, which is likely to have increases their mobility needs. It is possible that in large families e-bikes are used in addition to cars to cover the various transport needs of the family members.

In terms of the Norm Activation Model components, awareness of need predicted awareness of consequences related to travel mode choices, which in turn strongly predicted personal norms related to the use of environmentally friendly transport modes. Thus, our findings confirm the causal order of the variables in the Norm Activation Model. In line with previous studies showing personal norms as an important predictor of sustainable transport mode choices, such as electric car and public transportation use (Lind et al., 2015; Nayum and Klöckner, 2014), in our study personal norm significantly predicted attitudes towards e-bikes, which was the strongest predictor of e-bike use.

Attitudes towards e-bikes were established based on the three measured aspects of the e-bikes, which were related to self-image, health, and ease-of-use. The results show that these three aspects are almost equally strongly reflected in the attitudes, which means that beliefs about how much e-bike use increases health, contributes to improved self-image, and is functional in everyday life are almost equally important elements of attitudes towards e-bike use. In particular, attributes of e-bikes related to positive self-image and status gained by using an e-bike were the strongest component in attitudes towards e-bike use. In common with previous studies that have shown the important role of perceived attributes and usefulness of e-bikes for the adoption of e-bike use (Fishman and Cherry, 2016; MacArthur et al., 2014; Popovich et al., 2014; Wolf and Seebauer, 2014), our findings showed that attitudes towards e-bikes were the strongest predictor of e-bike use. The second most important predictor of e-bike use was the innovativeness of the respondents. As expected, respondents who described themselves more innovative were more likely to own an e-bike. This finding adds to previous research showing a positive relationship between innovativeness and use of newly emerging sustainable transport modes, such as electric vehicles (Noppers et al., 2015; Wolf and Seebauer, 2014).

Although majority of the present findings are in line with the international findings related to e-bike use, they should be interpreted with caution with regard to their transference to other contexts. There are considerable differences between countries in terms of built environments, natural environment, psychological and cultural factors that might influence cycling frequency of individuals (e.g., Heinen et al., 2010). For example, both in Netherlands and Denmark, a flat terrain, good cycling infrastructure, relatively short distances within the cities and strong social and cultural norms favoring cycling lead to a high level of bicycle use (Heinen et al., 2010; Pucher and Buehler, 2008). Previous research points out that e-bike use is especially high in countries where use of conventional bikes is traditionally high (Fishman and Cherry, 2016). Therefore, it is not surprising that European countries with highest levels of conventional bike use, such as Netherlands and Denmark, are also leading countries in terms of e-bike use. On the other hand, in Norway, harsh winter conditions, hilly landscape and insufficient cycling infrastructure make cycling less desirable compared to some other northern European countries. Although some of these barriers such as hilly landscape can be overcome by use of e-bikes, there are still some factors, such as harsh winter conditions, which might reduce use of e-bikes as well as conventional bikes. Also, there are some aspects of Norwegian cycling culture, which might also influence e-bike use. For example, involving in physical activity by cycling is an important aspect of cycling culture in Norway. However, use of e-bikes requires less physical activity; therefore, some people might avoid using e-bikes because it is contradicting with the traditional view of cycling.

Some implications of our study may be helpful for interventions aiming to promote e-bike use. Since attitudes towards e-bike use was the most important predictor of e-bike use, forming positive attitudes towards e-bike by emphasizing their ease-of-use (e.g., easy to use and fast), health enhancing (e.g., increased physical exercise for people who are otherwise inactive), and especially self-image related attributes (e.g., status-enhancement) of e-bikes could be effective for increasing e-bike use. The positive association between e-bike and car use indicates that e-bikes are often used in addition to cars or at least by car-focused households. If people are made more aware of the environmental and health benefits of e-bike use over car use, it might help to increase e-bike use as preferable to car use. It is promising that car users made more use of e-bikes than did cyclists. The respondent's innovativeness was the second most important predictor of e-bike use, since the less innovative he/she was, the less likely he or she was to use an e-bike. Since late adopters of innovative products need to see the obvious advantages of an innovation before they start to use it, increasing knowledge and emphasizing the advantages of e-bikes through information campaigns might be helpful in order to increase e-bike use, especially among late adopters. Increased visibility in later stages of market diffusion might also contribute to convince late adopters, and the exponential growth of e-bike sales in Norway would be favorable in this respect.

The present findings contribute to understanding of the determinates of e-bike use since we examined a wide range of psychological and demographical variables in relation to e-bike use using a large sample. However, our study had some limitations. For example, in order to reach more e-bike users, the commercial panel mainly recruited the e-bike users via Facebook, which is likely to have reduced the representativeness of the e-bike users group in the sample, since e-bikers who were especially active on Facebook might have been overrepresented. Also, using two different methods for recruiting the respondents may have been a limitation of the study. Since the proportion of e-bike users was low in the panel data, more respondents were recruited through a Facebook post about the study, which helped us to reach more e-bike users in total but also created a biased sample. Some differences between the e-bikers recruited by the two different methods should be taken into account when interpreting the results: e-bike use, the proportion of respondents with higher education, and males were higher among the respondents recruited by Facebook compared with the respondents recruited by the panel, which might have potentially biased the results. A further limitation of the study might have been the use of a cross-sectional survey design, which made it difficult to draw conclusions about the causal order between the variables. Measuring conventional bicycle use and car use before and after the use of an e-bike could have been useful for understanding the effect of e-bike adoption over conventional bicycle and car use more clearly. Finally, although our findings related to the predictors of e-bike use, we did not focus on the willingness to buy or use an e-bike among the non-users. Examining factors related the e-bike use intention among the non-users might have provided better insights that could be useful for increasing the share of e-bike users in the future.

Conclusions

E-bike use is increasing in Norway and has the potential to increase the share of cycling among the other transport modes. Positive attitudes towards e-bike use, which were based on evaluations of functionality, health benefits, and self-image related aspects of e-bikes were the most important predictor of e-bike use. Thus, in order to increase e-bike use, it is important to emphasize the benefits and functional aspects of e-bikes. Awareness of need, awareness of consequences, and personal norms, which were measured within the Norm Activation Model, activated positive attitudes towards e-bike use, as expected. The second most important predictor of e-bike use was innovativeness showing that the more innovative people were, the more they used an e-bike. Regarding the use of other transport modes, conventional bicycle use was negatively related and car use was positively related to e-bike use, thus suggesting that e-bikes replace conventional bicycles rather than cars.

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Tables and Figures

Table 1. Sample characteristics

	E-bike users (n=252)	Non-users (n=658)	t-value	χ2
Age mean (SD)	54.07 (14.07)	50.89 (16,33)	2.73**	
Gender (%)				1.55
Male	54.8	50.2		
Female	45.2	49.8		
Education (%)				15.52**
Elementary school	4.8	5.2		
Secondary school (vocational)	19.8	20.1		
Secondary school (general)	13.5	12.8		
University/college (≤ 3 years)	26.6	38.8		
University/college (>3 years)	35.3	24.0		
Income (%)				15.66
Under 200 000 kroner	9.1	15.8		
200 000 - 299 999 kroner	13.0	11.1		
300 000 – 399 999 kroner	18.8	14.2		
400 000 - 499 999 kroner	16.9	20.7		
500 000 – 599 999 kroner	19.5	15.5		
600 000 – 699 999 kroner	5.2	8.7		
700 000 – 799 999 kroner	3.2	5.0		
800 000 – 999 999 kroner	8.4	4.5		
Over 1000 000 kroner	3.9	2.3		
Household size (%)				5.93*
1-2 persons	74.0	71.5		
3-4 persons	18.2	24.5		
5 persons or more	7.8	4.0		
Conventional bike use (%)				39.69***
Yes	42.1	65.0		
No	57.9	35.0		
Car use (%)				8.14**
Yes	93.3	86.5		
No	6.7	13.5		

*p<0.05, **p<0.005, ***p<0.001

Table 2. Adopter segments for e-bikes

	Adopter segment	Description
1	*Innovators*	I am a type of person who closely follows new technological developments and who dares taking risks by being the first to purchase an e-bike.
2	*Early adopters*	I am a type of person who envisions potential advantages in e-bikes and who is one of the first to make use of these advantages and to profit from those.
3	*Early majority*	I am a type of person who is interested in e-bikes but at the same time is pragmatic. First, I would like to take time and be persuaded by the advantages that an e-bike possesses. My decisions are (mainly) based on the recommendations of existing users.
4	*Late majority*	I am a type of person who is not thrilled by e-bikes, but who rather appreciates security. It is safe to purchase an e-bike when it has been on the market for some while and offers obvious advantages.
5	*Traditionalists*	I am a type of person who is traditional and has little affinity with e-bikes. I do not like changes in life and I purchase an e-bike only when the existing bike I use is not produced anymore.

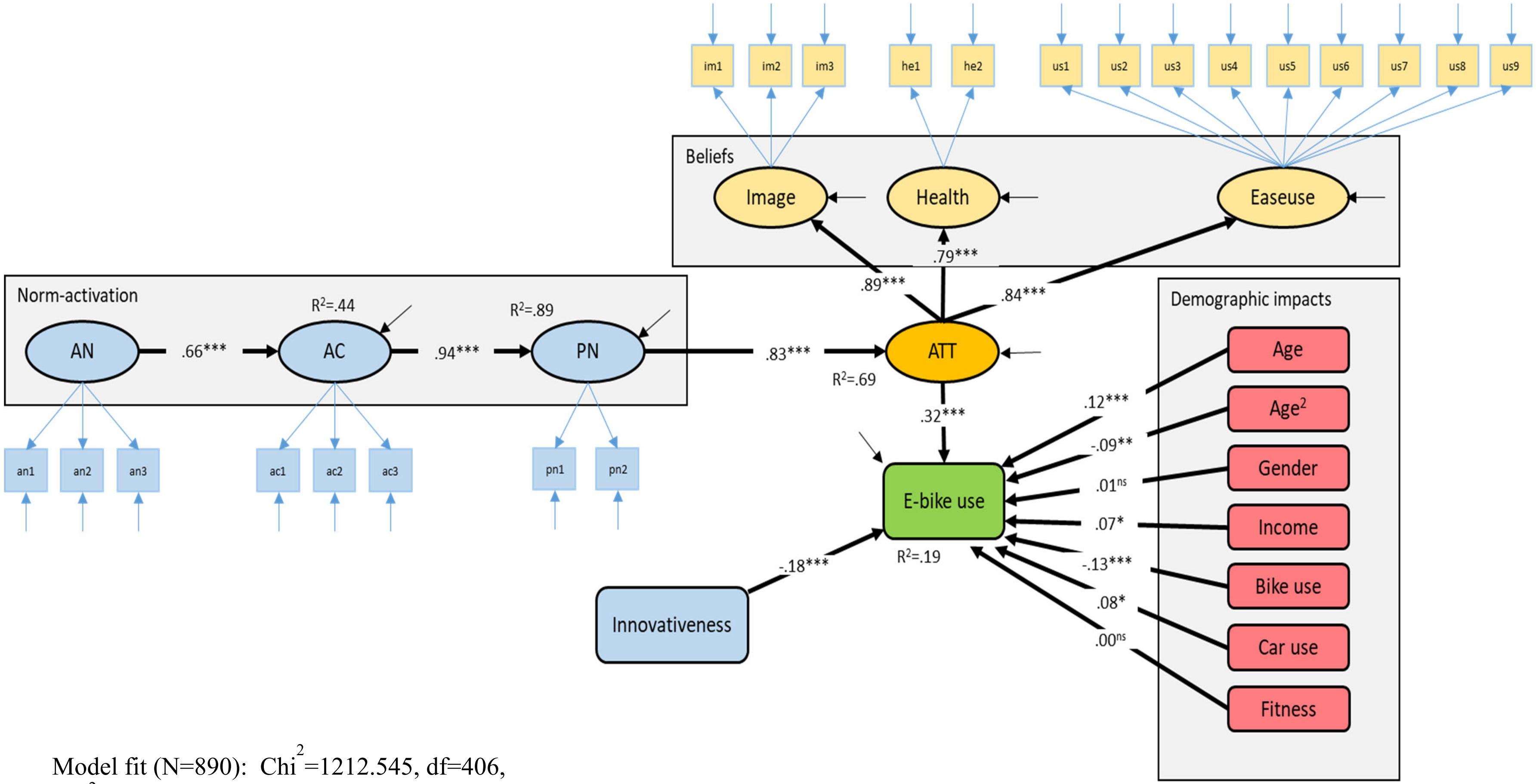
Adapted from Noppers et al. (2015)

Table 3. Items and reliability coefficients for the latent variables

Latent variables	**Cronbach's α**
Awareness of need (AN)	0.86
I am worried about CO_2 emissions due to car use.	
Car use leads to serious environmental problems.	
Use of fossil fuels in cars is an important cause of climate change.	
Awareness of consequences (AC)	0.88
I could contribute to a better environment by using an e-bike.	
I could help reducing environmental problems by using e-bike as much as possible.	
By using an e-bike, I could help reducing CO_2 emissions.	
Personal Norm (PN)	0.73
I feel morally obliged to use an e-bike.	
I (would) feel guilty because of not using an e-bike.	
Health-related attributes (HEALTH)	0.84
Using an e-bike is good for health.	
Using an e-bike promotes physical activity.	
Self-image-related attributes(IMAGE)	0.78
Using an e-bike enables me distinguish myself from others.	
Using an e-bike fits me.	
Using an e-bike says something positive about me.	
Ease-of-use attributes (EASEUSE)	0.84
It is easy to reach many places with an e-bike.	
Using an e-bike is useful for everyday mobility.	
It is possible to reach your destinations faster with an e-bike than a conventional bike.	
One can save time by using an e-bike instead of a car, especially in short trips.	
E-bike is a more practical transportation mode than public transportation.	
It is simple to use an e-bike.	
Using an e-bike is a cheap way of transportation.	
It is safe to use an e-bike.	
E-bike is an environmental-friendly transport mode.	

Table 4. Unstandardized and standardized model estimates (WLSMV estimation, *N*=890)

	B	*SE*	*Beta*	*p*	R^2
Measurement model					
Awareness of need					
AN → AN1	1.000	-	.890	-	
AN → AN2	.979	.027	.871	<.001***	
AN → AN3	1.047	.024	.932	<.001***	
Awareness of consequnces					
AC → AC1	1.000	-	.900	-	
AC → AC2	1.013	.019	.911	<.001***	
AC → AC3	.972	.017	.875	<.001***	
Personal norm					
PN → PN1	1.000	-	.781	-	
PN → PN2	.871	.054	.680	<.001***	
Health benefits					
HEALTH → HEALTH1	1.000	-	.958	-	
HEALTH → HEALTH2	.908	.029	.870	<.001***	
Self-image					
IMAGE → IMAGE1	1.000	-	.652	-	
IMAGE → IMAGE2	1.386	.077	.904	<.001***	
IMAGE → IMAGE3	1.328	.071	.867	<.001***	
Ease-of-use					
EASEUSE → EASEUSE1	1.000	-	.719	-	
EASEUSE → EASEUSE2	1.126	.048	.809	<.001***	
EASEUSE → EASEUSE3	.814	.049	.585	<.001***	
EASEUSE → EASEUSE4	.909	.047	.654	<.001***	
EASEUSE → EASEUSE5	.886	.047	.637	<.001***	
EASEUSE → EASEUSE6	.969	.054	.696	<.001***	
EASEUSE → EASEUSE7	.929	.047	.667	<.001***	
EASEUSE → EASEUSE8	1.002	.047	.720	<.001***	
EASEUSE → EASEUSE9	1.050	.051	.754	<.001***	
Attitudes					
ATT → HEALTH	1.000	-	.792	-	
ATT → IMAGE	.765	.047	.890	<.001***	
ATT → EASEUSE	.796	.043	.841	<.001***	
Structural model					
PN → ATT	.808	.046	.832	<.001***	
ATT					.692
AC → PN	.817	.034	.942	<.001***	
PN					.887
AN → AC	.671	.033	.664	<.001***	
AC					.441
E-BIKE USE → ATT	.441	.046	.320	<.001***	
E-BIKE USE → INCOME	.042	.019	.072	.026*	
E-BIKE USE → Gender (1=male, 0=female)	.012	.059	.006	.883	
E-BIKE USE → Age	.008	.002	.124	<.001***	
E-BIKE USE → Age^2 (squared centered age)	-.000	.000	-.089	.018**	
E-BIKE USE → Bike use (1=yes, 0=no)	-.283	.060	-.132	<.001***	
E-BIKE USE → Car use (1=yes, 0=no)	.222	.104	.079	.033*	
E-BIKE USE → Innovativeness (1=innovator, 5=traditionalist)	-.216	.035	-.180	<.001***	
E-BIKE USE → Fitness (1=poor, 5=excellent)	.004	.033	.004	.905	
E-BIKE USE					.192



Model fit (N=890): Chi^2=1212.545, df=406,
Chi^2/df=2.99;RMSEA=.047 [.044 .050]; CFI=.943; TIL=.938

Figure 1. Results of the structural model with standardized estimates