Summary

Effect of subvention program for e-bikes in Oslo on bicycle use, transport distribution and CO_2 emissions

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E-bikes contribute to an increase in peoples bicycle use by between 12 and 18 km per week, if they replace their usual bike, with an e-bike. This means that the bike share (cycling as a proportion of all travelled kilometres) could double compared with the current level, for people who get support for buying an e-bike. This is according to data from the largest ever survey done on e-bikes effect on transport mode, where a total of 669 freshly baked e-bike owners have been interviewed. This survey is also unique since the transport usage also was measured using a mobile app (measuring all trips). Overall, these data showed that CO_2 *emissions were reduced by somewhere between 440 and 720 grams per day for each participant that received support by the municipality to buy an e-bike.*

Background

The subvention program in Oslo was first announced quite shortly after the new city government took over offices in October 2015. The details about the program was announced via media in January 2016. Applicants were to submit their application online. The subvention amounted to 25 percent of cost of e-bike, max 500 €. The budget of the program was large enough to pay for 1000 e-bikes. The only conditions that had to be filled were that the applicant had to live in Oslo, the bike had to be an approved e-bike (PEDELEC), it had to be registered in an insurance registry (to locate bicycles based on their frame number in the case of theft) and they had to respond to a questionnaire prior to using the e-bike. The quota of 1000 applicants filled quite fast, and a stop in new applications was announced on the 1st of February.

A challenge with studying cycling activity in Norway is the large seasonal variation in cycling use. Figure S 1 shows monthly cycling share (of total kilometres travelled) the in Norway.

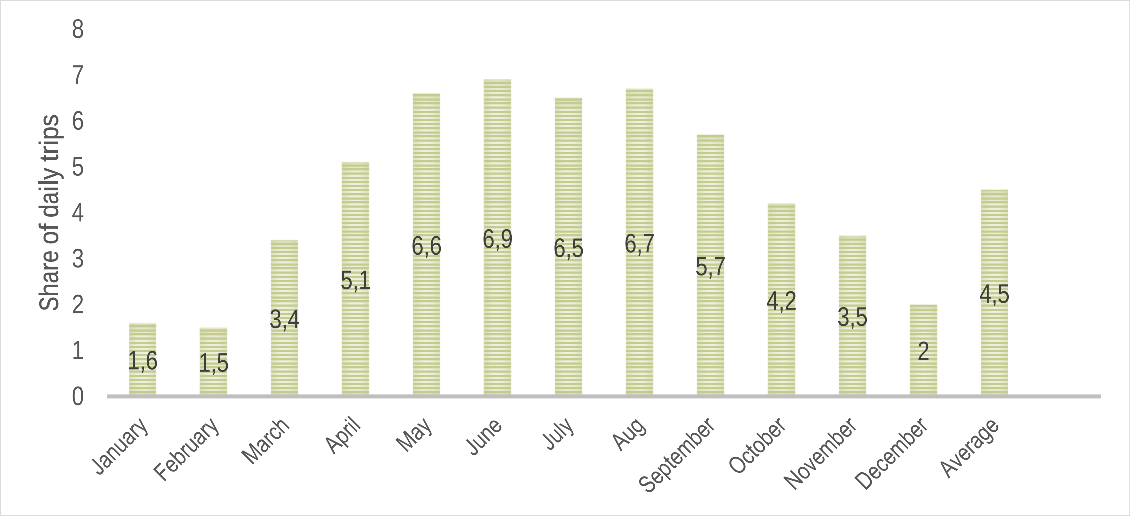

Figure S 1: Seasonal variation in bicycle use. Source National Travel Behavior Survey (Hjorthol et al. 2014).

As we see, the cycling share is as low as one percent in the winter months and then increases in April and May, with rising temperatures and decreasing snow, up to around six percent. Since the current study is conducted in the same time period as this natural seasonal variation, we need to take this into account when assessing the effect of the e-bike on cycling activity. In order to do this properly we need to have a control group that resembles the test group as much as possible, but that are not provided with an e-bike. The control group needs to be measured on the same variables, and at the same time as the test group.

The main objective of this project is to document the effect of aid for e-bikes on market share and emissions. In order to achieve this main goal the following research questions need to be answered:

- What is subvention scheme's impact on people's desire to buy an e-bike?
- How big increase in bicycle use can we find among those who have access to an e-bike through the program compared to a control group that did not have access to e-bike?
- How big a shift do we get from motorized to non-motorized transport for the trial group compared with the control group?
- What are the climate effects of the program?
- What are the implications of a continuation of the scheme?

In this project we have used two methods to examine participants' transport mode, a series of surveys, and a separate app that measures all journeys.

Methods

Survey

Data was collected during a series of surveys and using two applications that measured transport mode in the period. The design of the study plan was quite complex. This section outlines briefly the most important parts of the procedure, as well as a brief description of the participants in the sample.

Three rounds of data collection with questionnaires were conducted: A preliminary study (T0), a mid-term survey (T1) and an after study (T2). T0 lasted from January 5th to May 5th 2016, T1 lasted from April to May, and T2 lasted from May 26th to June 3rd.

In the first questionnaire (T0), respondents were asked questions including:

- Bicycle use for transport and training
- Scope of daily physical activity
- Intentions for increased bicycle use, increased physical activity and reduced car use
- Perceived behavioral control for cycling (self-efficacy)
- Background variables

The survey also contained a travel diary, which started with a text explaining the participant about how to define a trip, meaning that it should have a given purpose. The first question was whether the participant had some travel outside the home yesterday. They were then asked to describe transport, purpose, distance cycled and time spent in a question matrix. Transport mode could be walk, bike, e-bike, moped / motorcycles, public transport and private car. 14 categories of purpose were used, obtained from the National Travel Survey (RVU).

The second questionnaire (T1) was a shortened version of the questionnaire from T0, where the main focus was bicycle use last week, and travel diary.

In the last questionnaire (T2) respondents conducted the travel diary anew, and answered the same questions about intentions, etc. that they had received in T0. In addition, there were questions to those who had purchased (and used e-bike) concerning:

• Date of purchase (and use) of e-bike

• How they exploited the extra power of the engine

• How expectations had been met regarding the use of the e-bike

As a control group 10 000 cyclists from Oslo were drawn from Falck national registry of bicycle owners. These received invitation to participate in a survey on daily travel and bicycle use. In the questionnaire there was a question about the desire to buy e-bike - to have a comparable control group to the trial group. Also those who had no desire to buy an e-bike were involved in further assessments. The response rate for the preliminary study (T0) were 23 percent for the control group and 78 percent for the trial group.

There are about 60 percent men in the trial group which has been granted an e-bike (F1). This is somewhat higher than the control group consisting of those who are interested in electric bicycle (K1) where 49 percent are men, but comparable with the entire control group. The age distribution is roughly equal between the control groups and the trial group F1, but the average age is higher in the trial group.

Most of the control group samples have answered the preliminary study at week 11 and the subsequent weeks, while most in F1 have responded at week 14 and the following weeks. This bias in response time could affect the results, and is something we must take into account when we look at the impact on bicycle use for the different groups later.

To see what effect the measure has had on bicycle use and transport distribution, we need to know how those who applied for support would have travelled without the measure. Which groups we choose to compare, effect how we can interpret the results (Table S 1).

Table S 1: Different groups for comparison.

Short name	Description	Number
F1	Those who applied for subvention at T0	884
F2	Those from F1 who had bought an e-bike between T0 and T2	669
K1	Those in the control group who wants to buy an e-bike	993
K2	Those in the control group who not wish to buy an e-bike	1237
K3	All in the control groups	2230
Kf4	Those from F1 who has not bought an e-bike at T2	215
EL	Those from F1 (142) and K3 (177) who already had an e-bike at T0	319

In this context, it is reasonable to compare this entire group (F2), with a similar group, i.e. K1. However, we know that many of the participants have not had time to buy the e-bike yet (31 percent had not bought an e-bike in the trial period). To include all of these in the trial group will therefore dilute the effect of the measure, compared to what it will be in the longer term. By using this group (KF4) as a separate control group we therefore have a second control group that basically is somewhat similar to F2, and who have been just as motivated to buy an e-bike.

App data

Parallel to this, we also used the app Sense.DAT, and for some respondents the app Moves. At the end of the questionnaire (T0), we recruited people to use Sense. DAT. Overall, it was 377 in the test group and 926 in the control group who said yes to participate by using Sense.DAT (in addition 21 said yes to use Moves)[1]. Not all who said yes to participate followed up.

Information about the application and login-information was sent through e-mail. There were also a web-site for support[2]. Dates of recruitment and the number in the control- and trial groups (e-bike) are given in Table S 2.

Table S 2: Dates of recruitment and the number in the control- and trial groups.

Date	Control	E-bike
31.03.2016	681	68
08.04.2016	16	138
18.04.2016	229	15
26.04.2016		62
02.05.2016		37
03.05.2016		46
20.05.2016		11
Total	926	377

The users (and non-users) received an e-mail May 12th. The purpose of the mail was to give our users information about of what data we had to this point, as well as a call for more to sign up.

1 Responded to the questionnaire prior to Sense.DAT being an option

2 www.toi.no/sensedat

Results from survey

To what extent did the scheme motivate people to buy an e-bike?

Everyone who had applied to the scheme were given the question "To what extent did the following factors influence your decision to buy an e-bike?

Figure S 2 shows how peoples responses are distributed, on a scale from to a large degree to no degree.

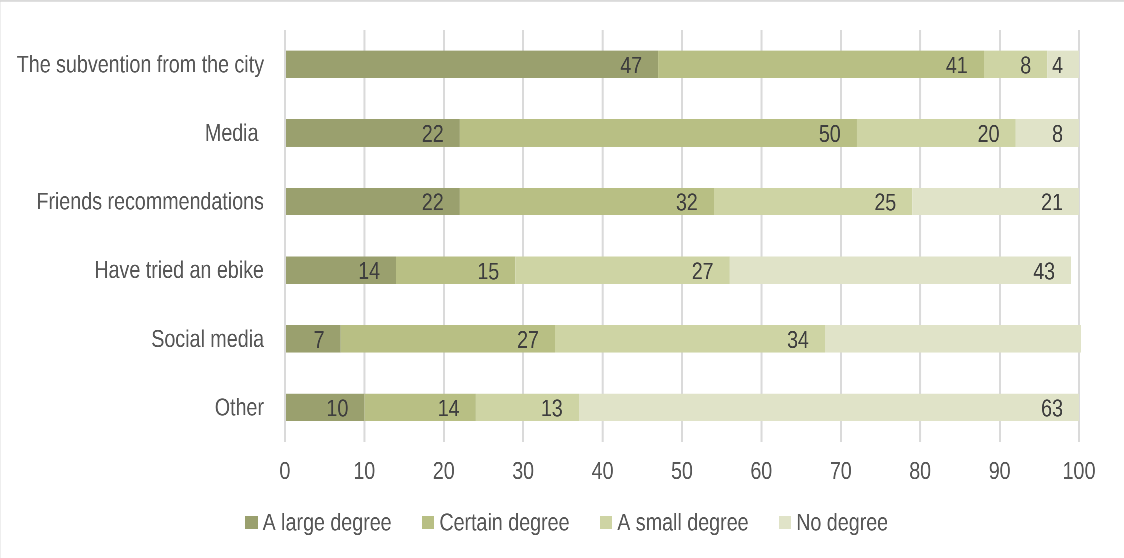

Figure S 2: Factors that influence decision to purchase an e-bike. Degree of influence. Percent. N=830.

The most important single factor is this funding from the municipality. About half felt that this had affected them to a very large extent, and a further 41 percent thought that it had influenced them to some extent. There were only 4 percent who believed that this support had not affected them. Also mention of e-bikes in media was seen as a major influence.

Weekly cycling activity before and after e-bike purchase (kms)

In order to better compare the two samples, we must control for start date. In addition, we test whether the changes are statistically significant, and the difference in changes between groups are significant. We therefore performed a pairwise ANOVA, with start date as a covariate.

Figure S 3 shows number of km cycled for transport and exercise (one week) before the trial (T0) and at T2 for the trial group (F1) and control group (K1).

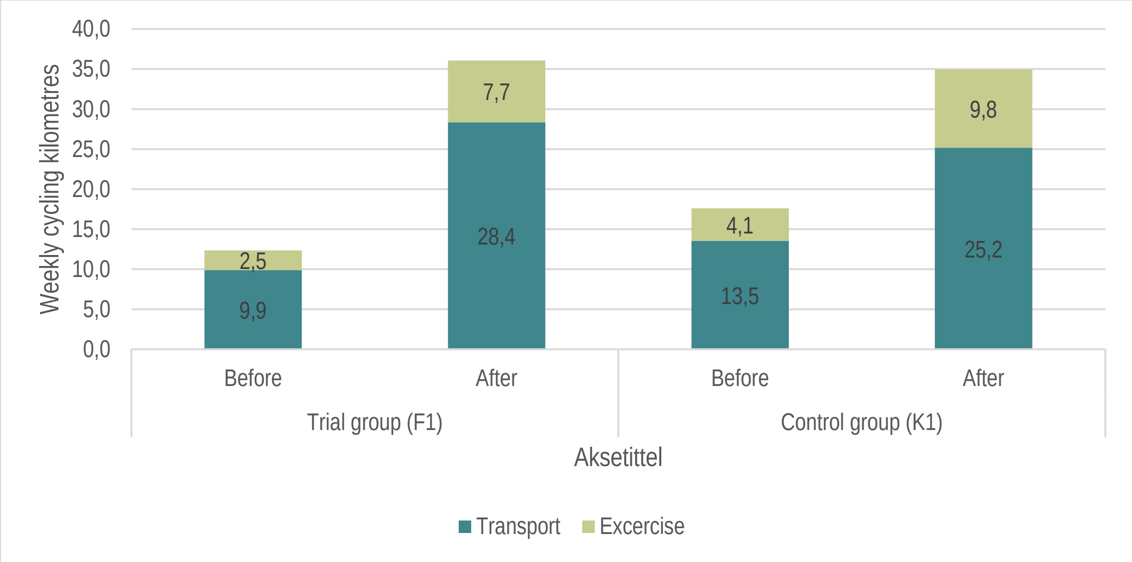

Figure S 3: Bicycle activity (km) for exercise and transport for trial group (F1) and control group (K1) at T0 and T2. Estimated means (start date as covariate).

Both groups had a statistically significant increase in bicycle use in the period. This applies both to transport and training. The increase is, however, significantly greater for trials group than for the control group (F(1,1514)=15,871, *p*=0,01). In this case the effect is calculated to be an increase in bicycle use of 37 percent (6.4 km x 100 / 17.3 km).

Figure S 4 shows the change in the number of kilometres cycled for transport and training from before to after for experimental group (F2) and control groups (K1, K2 and Kf1).

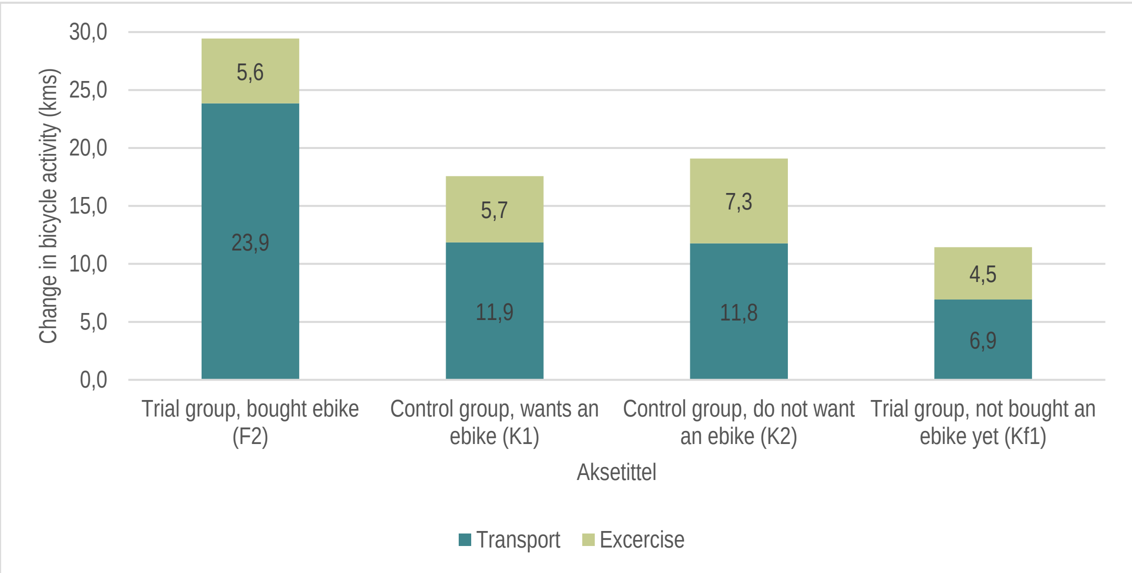

Figure S 4: Change in bicycle activity (kilometres) for exercise and transport for trial group (F2) and control groups (K1, K2 and Kf1) from T0 to T2. Estimated means (start date as covariate).

Bicycle Support applicants who have purchased an e-bike (F2) has by far the largest increase in bicycle use in the period (23.9 km in transport cycling and 5.6 km in exercise cycling). Only the increase in transport cycling differs between the different groups, and contributes to the relative change in favour of the bicycle support applicants.

In the comparison with the control group Kf1, the effect could be calculated to be an increase in bicycle use of 157 percent (18 km x 100 / 11.4 km). Compared with the control sample wishing an electric bicycle (K1) the change is 67 percent.

Effects of e-bikes- cycling share (km's) before and after

The participants answered a travel diary. The first question was whether the participant had some travel outside the home yesterday. They were then asked to describe transport, purpose, distance cycled and time spent in a matrix. Mode of transport could be walking, bike, electric bicycle, moped / motorcycles, public transport and private car.

Those who have applied for a subvention have increased their bicycle usage by 30 percentage points, at the expense of both walking (- 4 percentage points), public transport (-10 percentage points) and car use (- 16 percentage points) from T0 to T2. The control group also increased their cycling share (15 percentage points). Most of this has happened at the expense of public transport (-11 percentage points).

Figure S 5 shows the change in cycling shares at T0 and at T2 for the test group (F2) and the control groups K1 and Kf1.

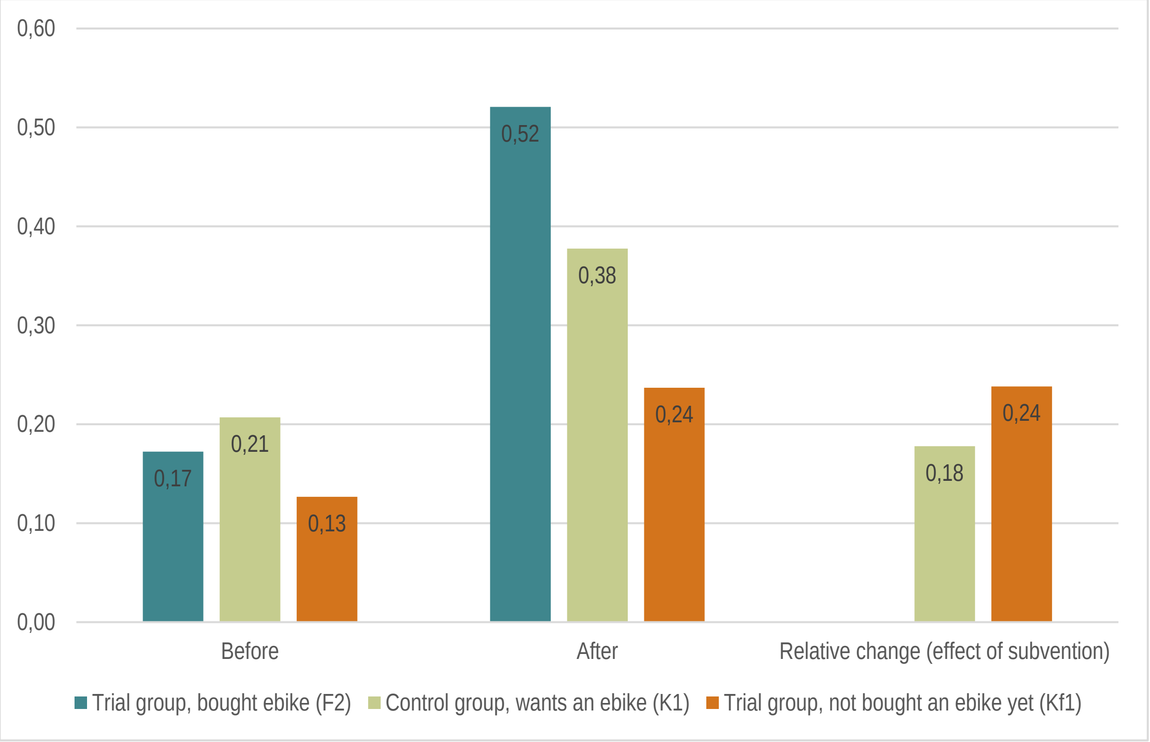

Figure S 5: Cycling share at T0 and T2 for those who have applied for subvention (trail group) (F2) and the control group (K1 and Kf1). Not adjusted for start date.

Those who have purchased an e-bike have increased their bicycle share from 17 percent to 52 percent of all travelled kilometres, while control sample K1 showed an increase from 21 to 38 percent, and Kf1 showed an increase from 13 to 24 percent. The relative difference between the change among F2 and the other two groups can be interpreted as the effect of the measure (far right in figure S 5). Depending on which group we compare this effect is an increase in bicycle share of 18 percentage points (compared to K1), or 24 percentage points (compared to Kf1). This again represents an increase in bicycle share of between 47 (18 km x 100/38 km) and 100 (24 km x 100/24km) percent.

Results from the mobile app Sense.dat

All in all, 619 participants had used the app, of these 153 were from the trial group, 233 were from the control group who wanted an e-bike (K1) and 233 were from the control group who did not want an e-bike (K2). The number of trips recorded in the period (May and June) ranged from 1 trip to 471 trips, with a median value of 174 trips. The lower 10th percentile was 106 trips the 90th percentile was at 254 trips.

In the following, data are analysed with trips as unit of measurement (and not respondents as we did in the previous sections).

The total number of trips recorded was 863 201. We divided the trips into seven groups, according to the e-bike ownership status of the user at the time of recording (see figure S 6). The no e-bike group is by far the largest, with 677 253 of all the trips (78 percent), and the Not bought yet and E-bike <10 days are the smallest with some 12 000 trips each (1 percent).

Figure S 6 shows how the total amount of kilometres travelled can be distributed for these different user groups.

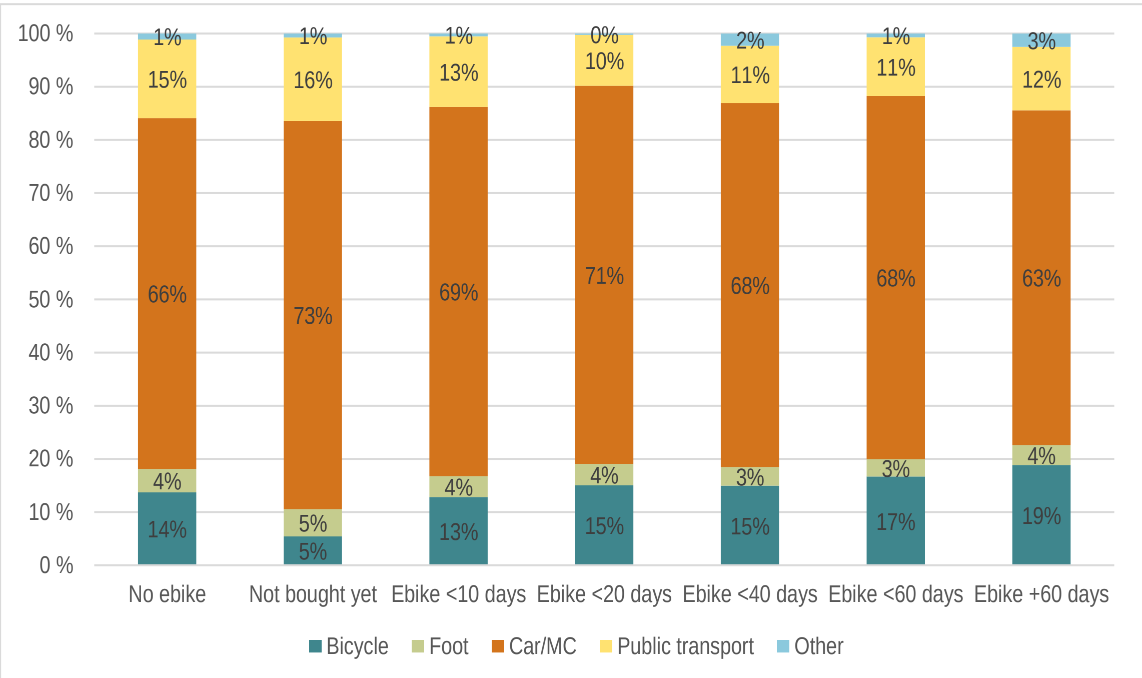

Figure S 6: Mode share (kilometres) for trips by different user groups. Percent. N=863 201.

Approximately two third of all transport (measured as kilometres) covered in the period is done by car. For trips conducted prior to having bought an e-bike, as much as 73 percent are done by car and 5 percent are done with a bicycle. The cycling share then increases with increased length of ownership up to a maximum of 19 percent for those who have owned a an e-bike for more than 60 days. The increase is mainly mirrored in a decreased share of car use.

A challenge with the analysis above, is that it does not take into account the seasonal variation in cycling use. Since the variable e-bike purchase is not independent of time of year (more people will own an e-bike at the end of the period), this might influence our results.

In order to account for this, we divided the trips into two: Those conducted by an e-bike owner, and those conducted by a prospective e-bike owner.

We then performed a univariate ANOVA, with week of recording as a covariate. Dependent variable was meters travelled, fixed factors were bicycle/non-bicycle trips. The actual ANOVA results were not of interest here, but the estimated marginal means can be recalculated into total metres travelled, and subsequently into cycling shares (Table S 3).

Table S 3: Distance per trip (meters), number of trips with and without a bicycle for users who have bought an e-bike, and for users who have not yet bought one. Cycling share, percent. Recording week as covariate.

		Not bought yet	Bought
Not bike	Distance per trip, meters	8 897	11 002
	Trips	1 270	14 345
	Total	11 299 222	157 826 588
Bike	Distance per trip, meters	2 937	4 667
	Trips	197	6 204
	Total	578 501	28 951 946
Sum	Total	11 877 723	186 778 534
	Cycling share	5 %	16 %

The average trip with a bicycle is 2.9 kilometre in the prospective group, and 4.7 in e-bike owner group. When we multiply the average trip length with the number of trips and divide with the total travelled distance, we find that prospective e-bike owners have a cycling share of 5 percent, and e-bike owners (mostly the same people) have a cycling share of 16 percent.

Climate effects

In order to estimate the possible effects of the e-bike subvention on greenhouse gas emissions, we look at the change in motorized traffic as a result of the trial. We make some assumptions to obtain CO_2 emissions, based on previous estimates:

- Cars emit 200g CO_2 / kilometre in Oslo
- Public transport in Oslo emits on average (regardless of type of transport) 35 grams of CO_2 per person-kilometres.

Note that we have not taken into account the type of public transport that people use. Electrified public transport emit less CO_2 than motorized (buses), but we assume that are participants' use of types of public transport has the same mix as the average population of Oslo.

When we calculate changes in travel by public transport and by car, our starting point is total amount of transport kilometres produces on the registration day of the diary. As mentioned, depending on which groups we use to compare, we get slightly differing estimates. We have therefore calculated the average of the values of the test group F1 and F2, and compare these with the average of control groups K1 and KF2. On average, participants in the trial group reduced their CO_2 emissions by 707 grams per day. Compared with a reduction of 270 grams per day in the control group, this gives an actual reduction resulting from the e-bike at 437 grams per day. The annual savings in CO_2 can be estimated to 87 kilograms of CO_2 per e-bike. We here assume that the bikes are in use 200 days per year.

Another way of estimating CO_2 reductions is by utilising the data from the app sense.dat. We have used the same assumptions as above, and have calculated the total CO_2 emissions from car and public transport resulting from all their trips recorded by sense.dat (Table S 4).

Table S 4: Total CO_2 emissions, total travelled kilometers and CO_2 emissions per kilometer travelled for prospective e-bike buyers and people who have bought an e-bike. Grams.

	CO_2 total	Travelled kilometres	CO_2/km
Prospective buyers	1 847 952	11 905 804	155
Have bought e-bike	23 898 137	174 041 966	137

The average CO_2 emission from transport is reduced from 155 to 137 grams per kilometres travelled (11 percent), as a function of owning the e-bike. Given that the average inhabitant of Oslo travels 40.2 kilometres per day (according to the national travel survey), this amounts to a potential saving of 720 grams of CO_2 per day, and 144 kilograms per year per person (given a cycling season of 200 days). A likely estimate for future e-bike purchasers is a therefore a reduction in CO_2 emissions in the region of 87 to 144 kilograms per year, based on the fact that they e-bike purchasers have a somewhat lower daily transport need than the average population.