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Behavioural effects of a health-related cycling campaign in Denmark: Evidence from the national travel survey and an online survey accompanying the campaign



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ABSTRACT

Introduction: With the overall aim to improve people's health through increased physical activity, an extensive cycling campaign was conducted in Denmark from 2015–2017. The campaign included local activities concentrated in four partner municipalities across the country and national campaign activities. After one year, the “cycling coach”, a customised smart phone application to support cyclists in goal setting and goal achievement, was launched and promoted. This paper describes the campaign, how it was evaluated, and which behavioural effects it generated.

Methods: We measured the behavioural effects of the campaign based on two datasets: the Danish National Travel survey and a survey that was conducted as part of the project evaluation and monitored the cycling frequency before, during and after the campaign. Regression analyses modelling the likelihood of cycling based on travel survey data (logistic regression) and cycling frequency based on the project survey (linear regression) were conducted. In the analyses, the accumulated campaign activities in the respondents' municipality at time of measurement was included as the independent variable, while controlling for socio-demographic, spatial and time-related factors.

Results: Both regression analyses showed a significant effect of the campaign intensity on cycling. We assessed that at least 21 million cycling trips were conducted because of campaign activities.

Conclusions: Based on the project experience, we discuss ways to improve future cycling campaigns and their evaluation, for example by allocating sufficient resources for establishing a strong partnership among cross-sectional partners and for a more detailed documentation of campaign activities.

1. Introduction

Although Denmark shows high levels of cycling compared to most other European countries (Haustein and Nielsen, 2016), problems from individualised motorized transport persist and cause serious environmental and health-related problems. Especially cities suffer from air and noise pollution and urgently require actions that make urban life more healthy and liveable. An increased share of cycling is regarded as part of the solution to the social, economic, and environmental problems that many cities face and local cycling policies play an important role in achieving this increase (Lanzendorf and Busch-Geertsema, 2014; Pucher et al., 2010).

Policies that increase active travel are likely to result in population-wide benefits through the reduction of air and noise pollution

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(e.g., de Nazelle et al., 2011; Rabl and de Nazelle, 2012). According to an assessment based on commuting data from Stockholm county, a shift from the car to the bicycle for commuting of all people living in a 30 min cycling distance from work, would result in more than 449 years of life saved annually for that area based on reduced vehicle emission and related exposure (Johansson et al., 2017). Additionally, increased numbers of cyclists reduce the risk of collisions with motorists, as the visibility of cyclists improves (e.g., Jacobsen, 2003; Pucher et al., 2010).

A shift from passive to active transport modes like cycling has also been shown to result in individual health benefits through increased physical activity that clearly outweigh potential risk from traffic accident involvement and inhaled air pollution (e.g., Deenihan & Caulfield, 2014; de Hartog et al., 2010; Mueller et al., 2015; Pucher et al., 2010; Rabl and de Nazelle, 2012). More specifically, research identified negative relations between active travel and cardiovascular risk (e.g., Laverty et al., 2013; Millett et al. 2013) and diabetes and obesity (e.g., Pucher et al., 2010).

To increase cycling levels, various intervention studies have been carried out and assessed in terms of achieving modal shifts and related health effects. Reviews on the achievable effects by intervention studies show mixed results. A review study that assessed the effectiveness of different behavioural change techniques to promote walking and cycling found that the inclusion of self-monitoring and intention-formation techniques is most promising (Bird et al., 2013). This is also in line with recommendations derived from behaviour theory, which moreover stresses the need to support people differently, depending on their current stage of behaviour change (e.g., Bamberg et al., 2011; Gatersleben and Appleton, 2007): People who have no intention to start or increase cycling first need to be informed about the potential benefits of cycling (and/or the negative effects of not cycling), while people who have already formed this intention rather need assistance in formulating specific personal goals and information on how to achieve these goals. Finally, people who have already started to increase cycling need feedback and social support to maintain the new behaviour and transfer it into a new habit.

When differentiating between interventions that either promote cycling specifically or a change of travel behaviour more generally, clearer evidence was found for cycling specific interventions (Yang et al., 2010). For interventions applied at population level, net increases of up to 3.4 percentage points could be identified (Yang et al., 2010). Addressing larger populations (e.g., whole cities) instead of individuals or groups is also supported by a review with special focus on how to increase commuter cycling: even when population-wide interventions have only small effects, the overall effect is larger as they reach out to more people (Stewart et al., 2015). Pucher et al. (2010) stresses the need of comprehensive efforts and integrated packages of interventions instead of individual, uncoordinated interventions. As other review studies, they also point to methodological deficits of many existing intervention studies (Arnott et al., 2014; Bird et al., 2013; Pucher et al., 2010; Scheepers et al., 2014; Yang et al., 2010), where robust evidence for the success of cycling campaigns is still missing (Stewart et al., 2015).

On this background, the aim of this study was to evaluate the behavioural effects from a population-wide cycling campaign in Denmark that was inspired by theory and evidence on which measures appear most promising in achieving a modal shift to cycling.

The following section describes the cycling campaign in more detail. Section 3 presents the database of the effect assessment as well as the applied method of data analysis. Section 4 provides descriptive results on cycling in Denmark before, during, and after the campaign. Subsequently, the results of the effect analyses are shown. Section 5 discusses results and limitations and draws conclusions on how to improve future campaigns and their evaluation based on the experience from the project process and results.

2. The cycling campaign

The cycling campaign this paper focusses on was conducted in four partner municipalities in Denmark: Frederiksberg, Aarhus, Odense, and Middelfart. The cities vary considerably in size and cycling levels and are located in different regions of Denmark, as shown in Table 1.

The overall goal of the campaign project was to increase cycling in Denmark by one percentage point, which equals circa 50 million additional cycling trips per year. In particular, this was expected to be achieved through a shift from the car to the bike for short trips (up to 5 km). The increased level of long-term physical activity was expected to contribute to the prevention of non-communicable, lifestyle related diseases and medical conditions including diabetes, coronary heart diseases, and four types of cancer. Accordingly, the partnership behind the project included the Danish Cancer Society (project owner), the Danish Diabetes Association, and the Danish Heart Foundation. The other partners were two transport organisations (DSB, Movia), the Danish Cyclist Federation, and the above-mentioned partner municipalities.

The campaign activities included different elements: national media activities (e.g., press releases, national campaign promotions, flyers distributed to households), social-media campaigns on Instagram and Facebook (e.g., campaign sites, quests, photo contests), and local events such as cycling services, lotteries, and the distribution of small incentives (e.g., bicycle bells, oil, coffee cups) along

Table 1
Description of partner municipalities.

Partner municipality	Inhabitants	Region	Residents' modal split: cycling, walking, public transport, car	Average trip length
Frederiksberg	104.410	Zealand	32%, 28%, 14%, 25%	10 km
Aarhus	340.421	East of Jutland	21%, 23%, 8%, 48%	13 km
Odense	202.348	Southern Denmark	24%, 19%, 4%, 51%	12 km
Middelfart	38.210	Funen	10%, 13%, 3%, 70%	20 km

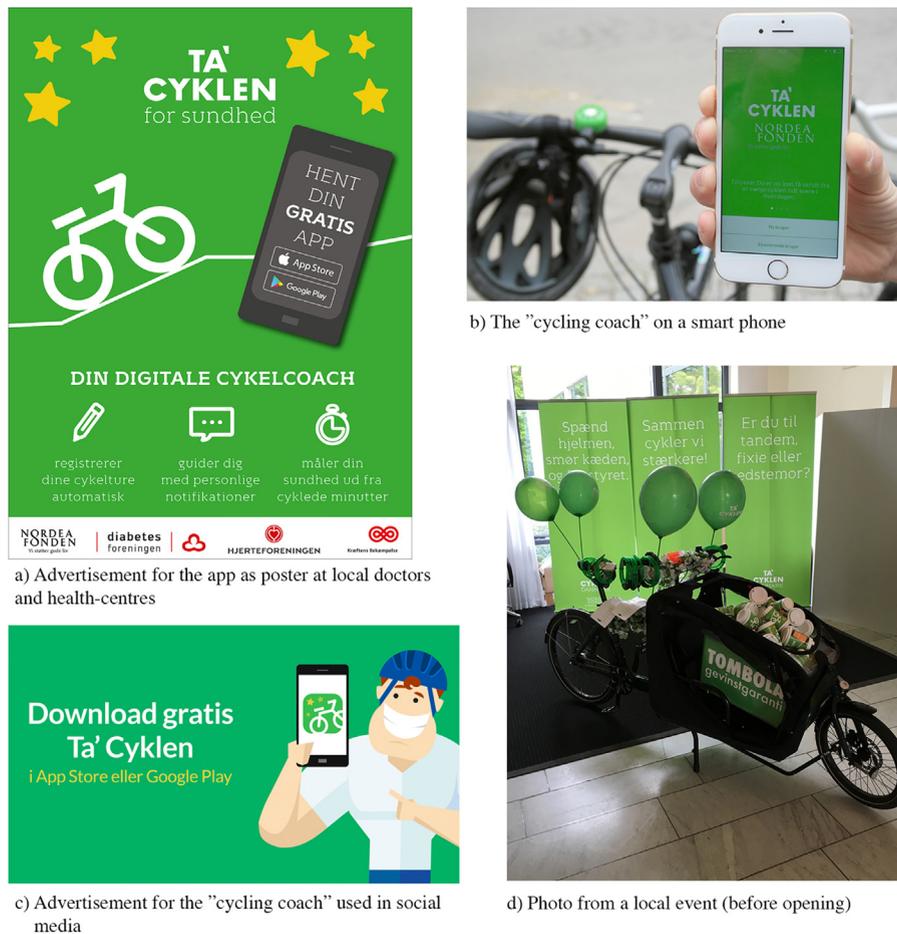


Fig. 1. Examples of material used in the campaign.

with project flyers and personal information. Fig. 1 provides some examples of campaign material. The main argument used to motivate people to cycle was the positive (physical and mental) health effect of cycling. The project's communication guideline included – among other aspects – that all communication should be positive, supportive, motivating, concrete, personal, and evidence-based.

The events and media campaigns were also used to promote one central element of the campaign – the “cycling coach” (launched in April 2016, see Fig. 1). The cycling coach is a smartphone app, developed as part of the project, to motivate people to cycle (more). The app asked users to set a specific goal for the number of days per week that they would like to cycle. In addition, app users were requested to provide their present cycling frequency and their motivation to increase cycling. This information was used to profile users and defined the personalised content of the ‘coaching’ that each user received. Each user could monitor his/her personal cycling goal with the app. Goal fulfilment was ‘celebrated’ by the app, including an opportunity to post successes on social media (Facebook and Instagram).

The cycling coach automatically registered cycling trips based on GPS and accelerometer data, which was used as a basis for feedback on personal goal achievement. Depending on the level of goal achievement, personalised messages were sent to the users to increase their motivation and eventually adjust their personal goal.

The different elements of the campaign were created to support people at different stages in the process of behaviour change (e.g., Bamberg et al., 2011; Bamberg, 2013; Gatersleben and Appleton, 2007) and provided through various channels. More general information about cycling and health were provided via different media channels and at doctors and health centres aiming for awareness raising among people who had not formed an intention to increase cycling yet. For people who already had an intention to increase cycling, the cycling app should help to set a realistic goal, while the app supported goal achievement by feedback, self-monitoring and social support.

Being a national campaign that specifically focused on increasing cycling and that used awareness raising, feedback, self-monitoring and goal-setting techniques as techniques of behaviour change, the campaign was built upon assumptions derived from behaviour theory (Bamberg et al., 2011) and evidence from evaluation studies (e.g., Bird et al., 2013; Yang et al., 2010) on what is most useful in increasing cycling. Still, each campaign partner was free to add elements according to own possibilities and interests as long as they fitted within the overall strategy and communication guidelines. Frederiksberg municipality, for example, used the info

screens in local health centers for promotion of the app. In Odense, campaign material was sent to all households.

Project partners were asked to document what kind of activities they conducted and when (year and month), which material they distributed, and how many people they approximately reached.

3. Material and methods

3.1. Survey data

The effect assessment is based on two different independent data sources: the National Travel Survey of Denmark (Transportvaneundersøgelsen, TU, see [Christiansen and Skougaard, 2015](#)) and a representative survey that monitored the awareness of the campaign and its single elements, cycling levels, and factors that may affect cycling before, during, and after the campaign (Kendskabundersøgelsen, KU).

TU contains a one-day travel diary of Danish residents aged 10–84 years. Besides details on travel activities the day before, the survey asks about a variety of background variables (e.g., gender, age, place of residence, income, education, car and bike ownership). TU is based on a combination of web and telephone interviews. Each respondent receives an introductory letter, including a personal link to the web survey. Respondents who do not complete the web interview within two days are selected for telephone interviews. The survey's response rate is on average 58%, data is collected continuously ([Christiansen and Skougaard, 2015](#)).

For this study, we used a TU dataset covering the period from July 2010 to August 2017 including 280,000 trips by survey respondents (age 10–84) with all modes of transportation, so that we could analyse the impact of the campaign on the use of a bicycle on a trip, based on the place of residence and the campaign intensity in the place of residence.

KU was conducted as an online survey with six waves of data collection from February 2015 to June 2017. Data were collected based on an online panel of the market research institute EPINION. The panel (“Danmarkspanelet”) consists of approx. 240,000 members covering all regions of Denmark. The first survey was completed before the first campaign activities began (baseline measurement), the last one was conducted circa one month after the last activity. In each wave, a national representative sample of about 1000 participants was included and an additional data collection among residents in each partner municipality of about 200 per municipality. The complete KU dataset comprises 11,798 participants.

The questionnaire covered the following topics: awareness of the campaign and its elements (e.g., the cycling coach app); cycling and driving frequency, considerations about changing cycling and driving habits, attitudes and norms related to cycling and driving, socio-demographic factors. The cycling frequency was included as a question on the number of cycling days per week or month. Questioning the occurrence of cycling days was based on the experience from previous questionnaires ([Olafsson et al., 2016](#)) and provided an approach to cover cycling frequency without the ambiguity associated with asking respondents to account for their trips. The question was implemented as an ordinal scale with categories: ‘never’, ‘no cycling in the past month’, ‘1–2 days in the last month’, ‘2–3 days in the last month’, ‘1–2 days in the last week’, ‘3–4 days in the last week’, ‘5–6 days in the last week’, and ‘every day’. The scale was adapted to increase sensitivity towards changes in low-frequency cycling as this was thought to be a likely outcome of the campaign.

3.2. Measurement of campaign intensity

To measure and quantify the development and impact of the campaign, a campaign log was developed. Originally, campaign partners were asked to register all campaign activities in terms of date, municipality, duration, activity, resources employed, target group, number of sites involved, as well as number of handouts and/or attendance in the campaign log. However, it was not possible to collect this information in a comparable format on all occasions. Instead, we operationalised the campaign intensity for each partner municipality as the number of sites with activities per month. This operationalisation has the advantage of allowing for a scale measure of the increase in campaign intensity over time and it provides large differences in the volume of campaign activities between the participating municipalities.

The ideal campaign intensity measure could have involved a more direct measure of contacts or exposure, or measures of resource spending. This was not possible due to the open nature of the campaign and its development, which also included use of unpaid volunteers. However, with the operationalised measure we do achieve a substantial improvement compared with simpler binary representations of campaign participation, which would otherwise have been the alternative. We also achieve a measure, which is independent from the behaviour data that is used to measure the campaign effect.

Local campaign activities were launched with events in local supermarkets of the same food store chain in all partner municipalities by March 2015, later events targeted cycling to public transport hubs (September 2015). In 2016, the local campaign activities diversified and intensified, based on local cycling teams, events and communication channels. Activities included distribution of campaign material to all households (Odense, April 2016), bicycle repair/assistance to promote the cycling coach and the campaign message (Aarhus, April 2016), and digital-banners on urban arterials (Aarhus, October 2016). To a lesser degree, the locations for campaign activities also spread to municipalities beyond the four original partner municipalities. The highest campaign intensity was reached in April and October 2016 – the beginning and end of the cycling season. Parallel to this, a number of national activities were carried out based on nationwide media or the networks of the partner organisations. These activities cannot be compared to local activities. They included the launch of the cycling coach on Facebook supported by the web channels of the partner organisations, a national press release, distribution of campaign material by volunteers to bike-shops and health-centres, as well as infographics and animations in public transport media in the Capital region. These activities have been summed up as a variety of events

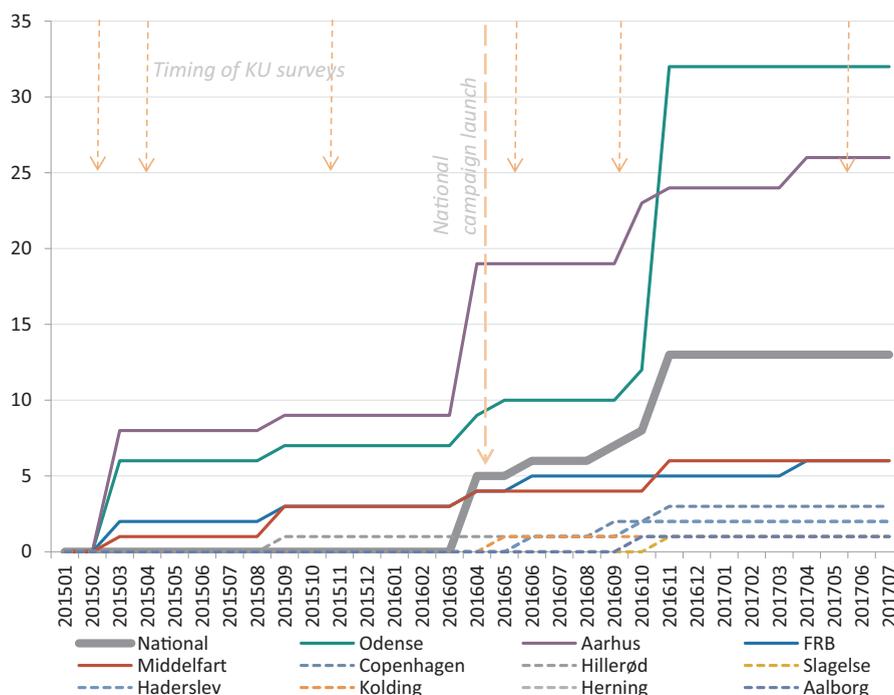


Fig. 2. Cumulated national and local campaign activities during the project period. *Notes:* Timing of KU survey waves and the beginning of the national part of the campaign is indicated with arrows. Local campaign activities are summarized from the number of locations with activities in each municipality. The continuous lines relate to partner municipalities, the interrupted lines to non-partner municipalities with local campaign activities.

/ activities at different times, but with no specific geography. Fig. 2 shows the cumulated national and local campaign activities during the project period. The local campaign activities are shown separately for each municipality with local events or activities.

3.3. Analysis of behavioural effects

Behavioural effects were estimated based on regression analyses. We used two independent datasets to estimate the effects – TU data and KU data (see Section 2.1). We expected that the real effect lies within the range of both estimations and that similar values based on both datasets would indicate high reliability of the results.

The regression analysis based on TU data was a logistic regression using the information whether a trip was a cycling trip or not as dependent variable. In the regression analysis based on KU data, the number of cycling days per month for each survey participant was the dependent variable. In both analyses, the campaign effect was estimated based on the cumulated local campaign activity, which varied between 6 and 32 among partner municipalities, and between 0 and 3 for non-partner municipalities. We also used the same (when available) or similar (when not available) control variables in both regression analyses.

Based on the estimated campaign effects from the regression analyses, we estimated how many additional cycling trips were conducted because of the campaign. Based on information from TU data on average number of cycling trips per day and cycling trip length within the partner municipalities, these numbers were transferred to cycling trips and kilometres per persons per month. Descriptive statistics presenting the TU and KU datasets are included in Table 2 and Table 3.

4. Results

4.1. Descriptive results

4.1.1. Campaign awareness

In each KU survey wave, people were asked if they had ever seen or heard about the campaign. On a national level, the awareness increased from a base level of 16% before the campaign, to 21% in the third survey wave, and decreased again to 19% at the end of the campaign. In the partner municipalities, awareness partly reached values around 40% (Middelfart & Odense), as can be seen in Fig. 3.

The high level of awareness before the campaign represents ‘false positives’ as the campaign was not public at the time. Such responses are common when respondents are asked about their knowledge of a specific item. The changes over the survey waves does, however, indicate real increases in the awareness of the campaign over time.

Table 2
Descriptive statistics for the TU dataset.

Variable	Distribution or mean and SD values	
Survey year	2010: 14%	2014: 11%
	2011: 22%	2015: 10%
	2012: 12%	2016: 11%
	2013: 10%	2017: 8%
Survey month	Jan: 7%	Jul: 9%
	Feb: 7%	Aug: 9%
	Mar: 8%	Sep: 9%
	Apr: 8%	Oct: 9%
	May: 8%	Nov: 9%
	Jun: 8%	Dec: 8%
Daytype	Weekdays: 57%	Saturday: 13%
	Friday: 15%	Sunday: 11%
	Weekday in holiday: 2%	Public holidays: 2%
Gender	Men: 49%; Women: 51%	
Handicap	No: 96%; Yes: 4%	
Familytype	Single: 19%	Couple: 31%
	Single with children: 7%	Couple with children: 44%
Education:	7th–10th grade: 23%	Short further education: 22%
	High school level: 11%	Medium length further education: 6%
	Vocational training: 2%	Long cycle higher education: 25%
		Other: 12%
Occupation	Student: 18%	Free-lancer: 5%
	Employee: 51%	Other: 26%
Age	Mean: 43	SD: 19
Family income	Mean: 63,000 EUR/year	SD: 45,000 EUR
City density	Mean: 26 pop/Ha	SD: 21 pop/Ha
City size (population)	Mean: 273,000	SD: 482,000
Cycling grants	Mean: 1.5 million EUR	SD: 3.1 million EUR
Cycling grants for national roads	Mean: 0.11 million EUR	SD: 0.4 million EUR
Local campaign activities	Mean: 0.5	SD: 3
National campaign activities	Mean: 1.5	SD: 3.5

Notes. The TU sample included trips from June 2010 to June 2017, a total of 234,352 trips.

Table 3
Descriptive statistics for the KU dataset.

Variable	Distribution or mean and SD values	
Survey wave	Wave 0: 16%	Wave 3: 17%
	Wave 1: 16%	Wave 4: 16%
	Wave 2: 18%	Wave 5: 18%
Region	Region North Jutland: 6%	Region Southern Denmark: 35%
	Region Mid Jutland: 24%	Region Zealand: 7%
		Copenhagen Region: 28%
Gender	Men: 43%; Women: 57%	
Household type	Single person 29%	Household with children 23%
Education:	Higher education (Medium or long cycle higher education): 54%	
Occupation	Student: 11%	
Age	Mean: 49	SD: 15
City density	Mean: 34 pop/Ha	SD: 15
Jobs/inhabitants	Mean: 0.4	SD: 0.1
Local campaign activities	Mean: 4.5	SD: 7.4

Notes. The KU sample included 11,798 respondents surveyed in six separate survey waves between February 2015 and June 2017. Fig. 2 shows the timing of each wave.

4.1.2. Cycling frequency

This section provides descriptive results for the two dependent variables that we used in the regression analyses in Section 3.2. Fig. 4 shows the percentage of cycling trips in three of the four partner municipalities compared to the rest of Denmark for the time period that was included in the regression analysis (2010–2017) based on TU data. Middelfart is not included here, as the data base is too small. The figure shows diverse trends between the three municipalities which is also likely to be related to the high uncertainty that is associated with producing an annual estimate for each municipality. A trend can be established with the highest degree of certainty for the municipalities that were not partners of the campaign. Here the trend is negative and the cycling share of trips is declining over time ($p < 0.001$). By contrast, the municipality of Aarhus displays a slight positive trend towards an increasing cycling share over time ($p < 0.001$), but trends for Frederiksberg and Odense remain insignificant.

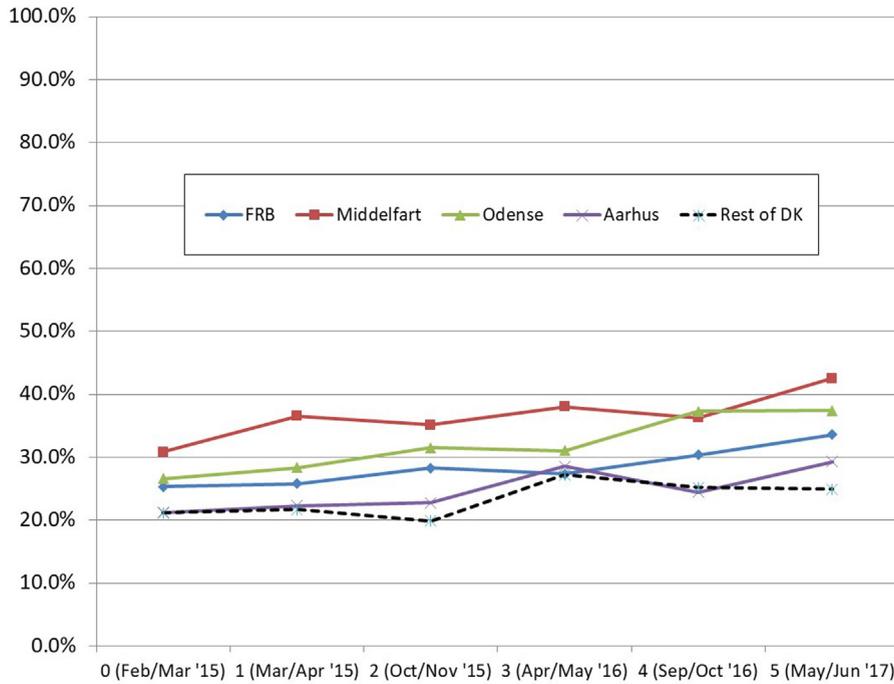


Fig. 3. Percentage of people aware of the campaign during the project period.

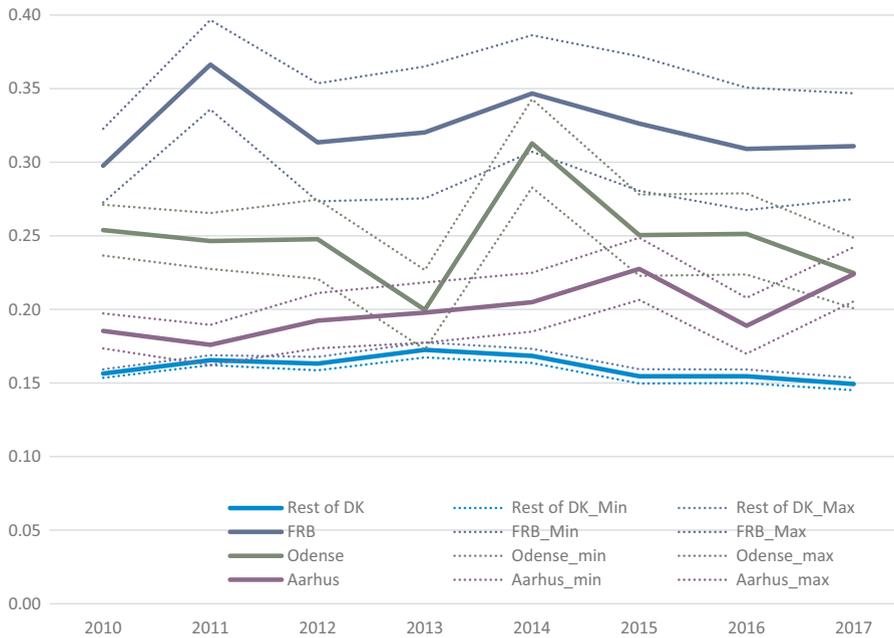


Fig. 4. Share of all trips that involves the use of a bicycle calculated from TU data 2010–2017 by municipality and survey year. Notes: ‘Min’ and ‘Max’ refer to the 95% confidence interval of the mean.

Fig. 5 shows the self-reported monthly number of cycling days in the four partner municipalities compared to the rest of Denmark for all six waves of data collection based on KU data. The differences between the six survey waves might partly reflect seasonal effects and partly campaign effects. Based on the descriptive results alone, it is not possible to estimate the campaign effect.

4.2. Behavioural effect assessment

To estimate the behavioural effects from the cycling campaign, we calculated two regression analyses, one logistic regression

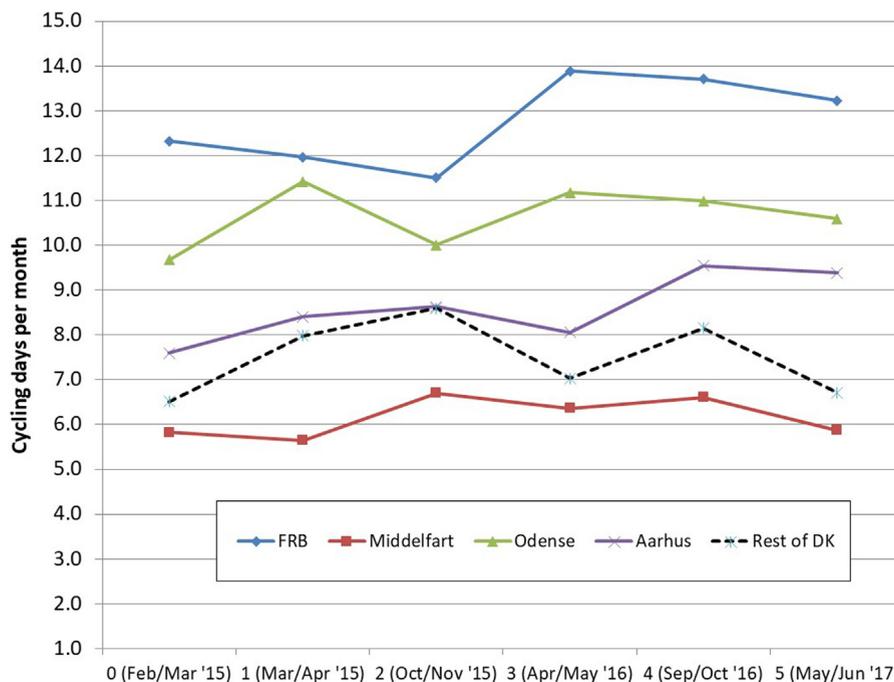


Fig. 5. Number of cycling days per month in the partner municipalities and the rest of Denmark based on KU survey data. In the survey, the number of trips were assessed in categories, which were afterwards transformed into cycling days per month (e.g., every day = 29.7; 3-4 days per month = 3.5) for the analysis.

analysis based on the trips registered in TU data (cycling trip or not, see Table 4), and one linear regression based on the self-reported number of cycling days per person that took part in the KU survey (see Table 5). In both analyses we controlled for demographic variables, spatial/regional effects, and time effects (TU: month/ KU: wave of data collection).

The regression in Table 4 is based on 154,817 trips conducted between July 2010 and July 2017. The model controls for the

Table 4

Logistic regression analysis modelling whether or not a trip was a cycling trip.

Variable	B	Sig.
Survey year (2010–2017, df=7)		0.000
Month (January–December, df=11)		0.000
Type of day (Weekdays Mon–Thur, Friday, Weekdays in holidays, Saturdays, Sundays, Holidays or Sundays preceding weekends or holidays, df=5)		0.000
Gender (Woman = 1, Man = 0)	0.107	0.000
Age	-0.008	0.009
Age squared	0.000	0.041
Type of education (< 7th grade, 8th, 9th, 10th, high school, higher tech. exam, vocational training, short-, medium, or long (university) further education, other; df=10)		0.000
Handicap (0,1)	0.684	0.000
Type of housing (df=5)		0.160
Family type (df=3) single, single w. child(ren), couple, couple w. child(ren),		0.000
Children below 6 year of age in the household (0,1)	0.092	0.000
Type of occupation (student, employee, free-lancer, unemployed, df=3)		0.000
Family income per adult (in thousands year 2000 DKK)	-0.001	0.000
City density (persons/Ha of city area)	0.007	0.000
Cycle path density (km path/lane /square metre city area)	0.122	0.000
Capital region (0,1)	-0.257	0.000
East Jutland (the urban region from Randers to Haderslev, 0,1)	-0.256	0.000
City size (LN population)	0.123	0.000
Sum in million DKK for local cycling projects granted 2010–2015. Grants expected to have an effect with 2-years delay	0.004	0.000
Sum in million DKK for national cycling projects granted 2010–2015. Grants expected to have an effect with 2-years delay	0.007	0.034
Cumulative campaign intensity in each municipality 2015–2017	0.010	0.000
Cumulative national campaign intensity 2015–2017	-0.003	0.688
Constant	-5.610	0.000

Notes: DKK = Danish kroner. Empty cells: Betas for categorical variable with more than two categories are not provided but can be found in the appendix.

Table 5
Linear regression analysis modelling cycling days per month.

Variable	B	Stand. coefficients β	Sig.
Gender	0.092	-0.003	0.620
Age	-0.109	-0.152	0.023
Age squared	0.001	0.063	0.046
Longer higher education (0,1)	1.065	0.015	0.000
Occupation: student (0,1)	3.528	0.070	0.000
Family type: single (0,1)	0.687	0.023	0.003
Family type: with children (0,1)	0.006	-0.016	0.981
Wave 1: Apr. 2015	1.084	0.034	0.001
Wave 2: Nov. 2015	1.293	0.013	0.000
Wave 3: May 2016	0.041	-0.013	0.898
Wave 4: Sep. 2016	1.033	0.010	0.002
Wave 5: June 2017	-0.478	-0.020	0.143
Region North Jutland	-0.042	0.017	0.916
Region Mid Jutland	-0.267	0.004	0.464
Region Southern Denmark	0.829	0.052	0.028
Region Zealand	-0.584	-0.013	0.111
City density (persons/Ha)	0.152	0.257	0.000
Jobs/inhabitants	3.923	0.027	0.000
Cumulative campaign intensity in each municipality 2015–2017	0.077	0.032	0.000
Constant	1.914		0.118

survey year and month and thereby for general changes in the probability of cycling as well as seasonal variation. In addition, the model controls for regional effects, population density, density of bicycle infrastructures, and city/municipality size, which can also be relevant for the probability of cycling.

To control for other ‘competing’ efforts to increase cycling, which may also have contributed to changes in cycling, we included a measure of the project volume that had been funded by the national ‘Bicycle fund’ (Transportministeriet 2009, 2010, 2011, 2012, 2013, 2014, 2015) in each municipality. As only knowledge on the time of funding was provided (and not the project duration etc.), we assumed a two year lag from grant to ‘effect’ as these projects generally have changes to the infrastructure as a core component.

Measures of campaign activities were included in the regression analysis in form of the cumulated number of campaign activities in the municipality from the beginning of the campaign until the time of the survey. A similar approach was applied to the national campaign activities, but the same cumulated campaign activity would here apply to all municipalities as these activities cannot be assigned to a specific geography, but rather were accessible to all with Danish language skills.

The model shows a significant positive effect of the local campaign activities on the likelihood to cycle. The same does not apply to the national campaign activities. This variable has less variation and it is very likely that the national activities and communication channels easily ‘drowns’ in noise from other activities. It can also be argued that key elements from the national campaign efforts, especially the cycling coach, has been promoted through the local activities where volunteers and the local health sector has played a role in increasing awareness. Large parts of the national activities are therefore expected to be reflected in the local campaign activities.

The effect of local campaign activities reflected in the model can be interpreted as a small effect compared to many other variables. However, a small additive effect from campaign activities should generally be expected compared to the many well-established factors affecting cycling, including weather/season, income and urban density.

Other variables and effects in the model include positive effects from other investments in cycling, as well as positive effects from cycling infrastructures, urban density, city size, and negative effects from being part of the highly integrated urban regions where more trips exceed cycling range. The model additionally includes general differences from year to year, the seasons of the year, daytypes during the week, and socio-demographic variables that may see some change over the years or between the survey waves and therefore should be included as control variables in the analysis.

To test the overall results presented in Table 4, we prepared a number of alternative editions of the main regression model. As only few control variables (including general differences from year to year and the project volume in each municipality that has received support from the national cycling fund) are able to represent changes over time, it is a necessary speculation, whether the effect of the campaign variable reflected in the regression model, can be due to specific conditions or changes in the municipalities with campaign activities that are not related to the campaign. To challenge the campaign effect of the main model in Table 4, we first prepared an alternative model with a variable that indicated whether or not campaign activities had taken place in the municipality (0,1). This indicated that the campaigning municipalities generally have higher cycling rates than other municipalities, but only a smaller fraction of the correlation with the campaign variable can be attributed to this difference (B for local campaign activities = 0.008 compared to 0.01 in the original model in Table 4).

In a further step, we prepared a second alternative model to test whether considering time trends or differences from year to year that are specific to the group of campaigning municipalities could be important to the result (by including the variable: Year * local campaign activities 0,1). The assumption would here be that the municipalities with campaign activities could have a different development trend for cycling over the years, which may generate a spurious correlation between campaign activities and cycling if

not taken into consideration. The alternative model indicated that the campaigning municipalities do tend to have a higher cycling frequency in all years, with some variations, but also that taking this into consideration does not reduce the effect of the campaign variable in the model. As a final test, we prepared an alternative model to test how an assumption of linear time trends that are specific for each of the four partner municipalities, where most of the local campaign activities took place, influenced the campaign effect in the model (we included four new variables in the model, one time-variable for each municipality). This specification of the model assumes that there could be specific levels and itineraries/trends for the development in cycling in each municipality that could accidentally influence the correlation between campaign activities and cycling in the model and therefore should be accounted for before considering campaign effects. The regression results indicated significant trends in Odense, Aarhus (+) and Frederiksberg (-) but no significant trend in Middelfart. The joint recognition of level and trend differences among the partner municipalities that is included in this alternative model also removes effect from the campaign variable and increases uncertainty (controlling for specific trends in the four municipalities leads to a campaign effect parameter estimate (B) of 0.004 compared to 0.01 in the original model in Table 4). However, this alternative specification also represents the highest degree of endogeneity that can be handled if there is to be any room to estimate the campaign effect, and there is an obvious ‘conflict’ between the control variables being specific to municipalities and the magnitudes of difference in campaign activities between municipalities.

The linear regression in Table 5 models the number of cycling days of people participating in KU as a function of the campaign intensity, controlling for sociodemographic, regional/spatial and time-related factors. The highest effect on the number of cycling days is the city density, which is not surprising as Copenhagen – the capital of Denmark – is by far the city with the highest percentage of cycling trips. Like the TU model, also the KU models shows a small but significant positive effect of the cycling campaign intensity. Based on KU data it is not possible to examine the effect of the national campaign intensity as it is highly correlated with the wave of data collection, which is needed as a variable in the model to control for general changes and seasonal variations in cycling. The KU data is in this respect less ‘flexible’ than the TU data that samples the seasonal variation through the year.

Based on the estimates for the cycling campaign in each model, we calculated its equivalent in number of cycling days, trips and kilometres. The regression coefficient from the KU model provide a direct way to calculate the added number of cycling trips per person for each month and each municipality (converted from cycling days), which were then summarized across the months in the campaign period and ‘scaled’ based on the populations of the municipalities with campaign activities.

The TU based model supported a calculation of the probability of cycling in each municipality and month, with and without (simulated) campaign activities, which was then applied as a change in probability of cycling to the total number of trips. Changes to the total number of cycling trips related to the campaign were finally summarized across all campaign months and municipalities with campaign activities. Cycling days (KU) and trips (TU) were converted into trips and kilometres by applying the averages of the municipalities that could be derived from the TU dataset. Thus, one day with the use of a bicycle corresponds to 2.3–2.8 bicycle trips and 4.5–10.1 km on bicycle, and one bicycle trip corresponds to 1.9–3.9 km on bicycle.

Table 6 shows the estimates of total effects of campaign activities including the confidence interval derived from the parameter estimates’ standard errors.

The mean estimates of the number of cycling trips based on the two datasets and regression models are surprisingly close and can be taken as a validation of the ‘realness’ of the differences in cycling rates and changes reflected in the models. Based on the two sets of estimates, between 21 million and 64 million cycling trips could be attributed to the almost two and a half years of campaign activities in eleven municipalities with the original four partner municipalities as the core where most campaign activities took place. A general uncertainty imposed by the possibility of other efforts to promote cycling in the municipalities, which are not represented in the data, must be accepted.

As the additional model specifications that included control for the municipalities’ participation in the campaign (thus testing a hypothesis of special attributes of campaign municipalities, i.e. self-selection, being the explanation behind the apparent campaign effect) and time trends specific to each of the four partner municipalities (testing a hypothesis of whether longer term trends/itineraries for cycling frequencies in individual municipalities could be the explanation behind the apparent campaign effect) have reduced the effect estimate, we find it reasonable to refer to the low end of the interval of cycling trips as what can be attributed to the campaign.

5. Discussion and conclusions

With the main motivation to improve people’s health through increased physical activity, an extensive two and a half years

Table 6
Estimated effects for the whole campaign period (February 2015 – July 2017).

	Average	Interval
<i>Estimated based on KU data:</i>		
Cycling days	16.1 million	[8-24 million]
Cycling trips	42.5 million	[21-64 million]
Cycling km	153 million	[75-230 million]
<i>Estimated based on TU data:</i>		
Cycling trips	42.5 million	[24-62 million]
Cycling km	146 million	[81-213 million]

cycling campaign was conducted in Denmark. Local activities were concentrated within four partner municipalities across the country and after one year, they were supplemented by national campaigns, including the launch of the “cycling coach” – a customised app to support people in setting personal goals for cycling and achieving them. To motivate people to cycle, the campaign mainly focused on the positive health effects of cycling.

We have measured campaign effects based on repeated independent samples as they were available from the Danish national travel survey and a separate survey, which was setup as part of the project evaluation. While these are large and representative datasets, panels are often perceived as the more desirable solution. However, they have other problems in terms of costs, representatively and drop-out.

We identified significant positive effects of the campaign based on both datasets, and the independent estimations led to very similar results, which support the conclusion of significant differences between the campaigning municipalities and other municipalities.

While the ambitious campaign goal of 50 million additional cycling trips per year could not be reached, our results point to additional 21 million cycling trips during the campaign period as a cautious effect estimate, which means an increase by circa one percentage. The overall health effect of these additional cycling trips depends on which people have been reached by the campaign: is it mainly people who increased existing levels of cycling, or rather people who did not cycle before, which would have the more positive health outcome. It also makes a difference from which transport mode they switched to cycling; however, this was out of the scope of this study.

Examples of effect studies of large or national campaigns in Denmark include Troelsen et al. (2004) assessment of changes in cycling during the project ‘Odense Cykelby’. Conclusions drawn from TU-based analysis of changes in cycling among Odense residents (controlling for changes in other locations) pointed to a total increase of 35 million cycling trips in the municipality of Odense during the three project years (corresponding to 129 million kilometres on bicycle if an average cycling distance is assumed). Additionally, Willumsen and Duer’s (2012) assessment of the effects of the national ‘Bike-to-Work’ campaign in 2011 pointed to an increase of 29.5 million kilometres on bicycle based on 93,000 participants and their self-reported changes. Comparing these assessments to campaign costs results in direct campaign cost of between 0.08 EUR (Odense) and 0.2 EUR (Bike-to-work) per additional bike trip. Based on the conservative estimate of 21 million additional bike-trips, our estimate corresponds to a direct campaign budget cost of 0.07 EUR per bike trip. This is slightly less than in ‘Odense Cykelby’, which may be explained by the larger audience and reach of a campaign across several municipalities. However, real estimates of resource inputs to the campaign are difficult to assess due to the use of unpaid volunteers from the health organisations as a key resource to carry out local events.

As a limitation to the study, the operationalisation of the local campaign intensity can be pointed out. We measured the local campaign intensity by summing up the number of locations with campaign activities per municipality per month. One can expect that it makes a difference, how information was distributed to the households in a municipality and how well locations with campaign activities were connected to the local activity centres to maximise exposure. It will also depend on the number of volunteers at a location and their motivation and engagement, how many people will be reached and if they can be motivated to increase cycling or not.

Originally, a much more detailed measurement of campaign activities was planned. However, too high requirements in the documentation of (mostly) volunteers’ engagement appeared to be counterproductive in this study and the requirements were thus adapted in the process. Still, activities were not registered at the same level of detail in all municipalities, so that the lowest common denominator was the municipality name, activity description and the month of implementation. When wanting to achieve a more precise measurement, it would be relevant to have additional (paid) staff to observe and document the local activities in more detail. One could then distinguish between the number of people contacted personally, by mail, the number of information material distributed and the number of (different kinds of) incentives and could thereby also get information about which measure leads to the greatest effects.

While web-applications and social media activities are regarded as important campaign elements, they constitute a problem when it comes to the effect assessment. We have considered these elements to be national campaign activities as their geography is principally unlimited and based the measure on launches/quests, where each launch/quest counts as one activity. A more precise measurement would, for example, include the number of views but this information is restricted and unavailable to the campaign evaluation.

A more practical lesson to be learned from the implementation of this campaign is that it takes time to establish a strong partnership across sectors. With different partners, having their own agenda for promoting bicycling, it took some negotiations to find a common content for the campaign. Nevertheless, the campaign succeeded having a common tone of voice and message. Through the partnership’s diverse communication channels, the campaign reached a broad target group and enhanced bicycle trips across the country. The high reach and measurable effect might also be related to the fact that elements of the campaign were relevant for people at different stages in the process of behaviour change: Local activities and media reports focused on awareness raising, the cycling coach first helped to set personal goals, then providing feedback and social support and thereby motivated people to reach their goals and maintain the new behaviour.

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