Transportation Research Part A 174 (2023) 103748

Contents lists available at ScienceDirect

Transportation Research Part A

journal homepage: www.elsevier.com/locate/tra

Work flexibly, travel more healthily? How telework and flextime affect active travel in Switzerland

Fabienne Wöhner

Institute of Sociology, University of Bern, Fabrikstrasse 8, 3012 Bern, Switzerland

ARTICLE INFO

Keywords:
Active travel
Walking and cycling
Telecommuting
Flextime
Switzerland

ABSTRACT

The impact of flexible working arrangements, such as telework and flextime, on daily travel demand is widely discussed. Although there is no evidence that flexible working arrangements reduce traffic in Switzerland, they still might be beneficial for the environment and public health if they are associated with more active travel (i.e. walking and cycling). Hence, the aim of this study is to investigate the influence of telework and flextime on various active travel patterns as well as possible benefits for public health. Most studies agree on a positive association between telework and active travel. However, these studies mostly rely on spatial flexibility (i.e. working remotely), and do not consider temporal flexibility (i.e. flextime). This study is the first to include different extents of working schedule flexibility in order to analyze active travel behavior. Active mode choices and travel durations are analyzed using the 2015 Swiss Mobility and Transport Microcensus (MTMC) – a nationwide representative micro-data travel survey. The results of this study indicate that telework is not associated with the likelihood of using active modes of transport overall; however, teleworkers walk and cycle more for leisure purposes as compared to on-site workers. Furthermore, the analyses show that flextime (particularly core time) users are more likely to use active modes of transport as compared to people who have a predetermined working schedule, which is mainly attributed to the fact that flextime users walk more. In order to indicate some health benefits, flexible working arrangements are analyzed concerning traveling actively for 30 minutes or more per day. This threshold refers to the recommendation of the World Health Organization concerning health-enhancing amounts of physical activity. The analyses reveal that telework and flextime (core time) are significantly associated with a health-enhancing amount of active travel. Another important finding of this study is that the Body Mass Index (BMI) and the weather condition should be included as control variables in studies that aim to analyze the direct effect of flexible working arrangements on active travel behavior. Overall, this study shows the importance of both spatial and temporal flexibility for choosing active modes of transport. The latter finding in particular is important for future research and policy decisions, as until now the impact of telework on active travel has been the main consideration, without recognizing flextime.

1. Introduction

The ongoing digitalization of the labor market continuously promotes flexible working arrangements, such as telework and flextime. In Switzerland, employees and employers gained much experience with flexible working arrangements due to home office

E-mail address: fabienne.woehner@unibe.ch.

https://doi.org/10.1016/j.tra.2023.103748
Received 9 October 2022; Received in revised form 13 April 2023; Accepted 12 June 2023
Available online 30 June 2023

obligations wherever possible during the COVID-19 pandemic. Hence, they might become more and more important as they spread in the near future. Flexible working arrangements are broadly discussed as possible drivers of less and more evenly distributed traffic – hence, being beneficial for the environment. However, with a few exceptions (e.g. Elldér, 2020), there is no traffic-reducing effect of telework in various countries around the world (e.g. Chakrabarti, 2018; de Vos et al., 2018, Kim, 2017; Zhu and Mason, 2014). Even in Switzerland, data before COVID-19 showed no evidence that telework reduces motorized private transport overall (Ravalet and Rérat, 2019; Wöhner, 2022). This is interesting as Switzerland provides a well-developed public transport system and economically focuses on the tertiary sector, which generally offers good opportunities for flexible working arrangements. Despite these results, flexible working arrangements could still have an important impact on travel behavior as they might promote forms of active travel, such as walking or cycling.

Accordingly, the aim of this study is to analyze the relationship between flexible working arrangements and active mobility from a behavioral perspective in Switzerland. In the Swiss context, telework and flextime are well-established forms of flexible working arrangements; thus, both are taken into account. Telework is generally defined as working from somewhere other than the workplace. In the context of this study, telework refers to working remotely from home for part of the workday or the complete day. In 2015, already more than one-fourth of the workforce can use telework in Switzerland (see Section 5.1). Flextime means that the working hours are not completely predetermined, so the worker enjoys some degree of scheduling flexibility. In Switzerland, three-fifth of workers can decide to some extent on their working hours (see section 5.1). In the following, different kinds of working schedule flexibility are considered. Although both temporal and spatial flexibility is available to many workers at the same time, this is not the case for everyone. Therefore, this study aims to isolate these two aspects. Using empirical multivariate analyses based on actual travel behavior, this study evaluates the potential of promoting flexible working arrangements to increase active travel. Before elaborating on the association between working flexibly and traveling actively, it is useful to briefly outline the importance of active travel research.

In Switzerland, 41.2% of the population was overweight in 2012, which cost Switzerland more than 8 billion CHF (Schneider and Venetz, 2014). It also became apparent that overweight and obesity increased during the last two decades. Moreover, it was revealed that the costs associated with overweight and obesity had tripled within 10 years (Schneider and Venetz, 2014). In order to address overweight and the accompanying diseases, the World Health Organization (WHO) recommends at least 150 to 300 minutes (min) of moderate-intensity physical activity per week, preferably in 10+ minutes bouts, for adults (World Health Organization, 2010). Regular physical activity is beneficial for health and generally helps prevent many diseases because it strengthens muscles, immune system, and cardiovascular system (e.g. Furie and Desai, 2012; Pucher et al., 2010; Warburton et al. 2006; WHO, 2010). Using active modes of transport offers a useful opportunity to be physically active and helps to meet the health-enhancing WHO recommendations (e.g. Buehler et al., 2011; de Nazelle et al., 2011; Gibson-Moore, 2019; Stewart et al., 2016; Wanner et al., 2012; Panik et al., 2019). Therefore, traveling actively is not only beneficial for the individuals themselves but adds to public health as well (e.g. Merom et al., 2010; Laverty et al., 2013; Saunders et al., 2013; Tajalli and Hajbabaie, 2017, Winters et al., 2017). Moreover, it is the most environmentally friendly kind of travel as compared to motorized private transport and public transport. Hence, it is subject to research and policymaking to identify promoters and barriers to traveling actively.

There is a significant amount of research on different policies and interventions in order to increase active travel, such as financial incentives, providing personalized information, or specific programs in companies (e.g. Martin et al., 2012; de Nazelle et al., 2011; Petrunoff et al., 2016; Sulikova and Brand, 2022, Winters et al., 2017). However, such measures are often limited to small areas or single companies or are expensive and might be difficult to implement broadly. Because of that, this study follows a more general approach. If it is revealed that flexible working arrangements and active mobility are empirically associated, this insight could provide a starting point for large-scale policy measures to promote active travel behavior.

There are various arguments as to why the possibility of work time flexibility and working remotely might affect active travel, mainly relating to people's increased spatial and temporal flexibility during the day. Usually, the daily structure of a working person is largely determined by the job. People who work from home spend less time commuting. Assuming there is some certain basic need/desire to be mobile, the commuting time saved is likely to be reinvested in other purposes, such as running errands, leisure, or physical activities, including walking and cycling (Black, 2001; Chakrabarti, 2018; Lachapelle et al., 2018). Moreover, the saved time when not commuting on teleworking days can be used to travel via slower modes of transport for other trip purposes (Elldér, 2022). Furthermore, the commute is often combined with trips for other purposes; however, when working remotely, this is not possible anymore. Therefore, it seems obvious that people will execute daily needs closer to home (e.g. Pendyala et al. 1991; Lachapelle et al., 2018; Saxena and Mokhtarian, 1997). Such shorter distances, in turn, could often be managed well by walking or cycling (Mokhtarian, 1991). Flextime, which is deciding to at least some degree one's own working time schedule, lowers time constraints. This breaks up the largely given temporal structure of the day due to gainful employment. Hence, reduced time pressure makes it possible to use slower modes of transport, for instance to commute to work. Moreover, flextime might offer additional opportunities for active travel, for instance when breaks can be decided independently, during which workers can go for a walk to relax. This could contribute to reaching a sufficient amount of physical activity.

These considerations lead to the following questions in the context of this study. Do flexible workers use more modes of active travel as compared to on-site workers? Can job flexibility contribute to a more active lifestyle? Is there variation in terms of trip purpose? Are there different conclusions between walking and cycling? Do flexible working arrangements contribute to public health?

Previous research on this topic is scarce and leaves some insightful aspects out of consideration. There are only a few recent empirical studies, addressing the research questions using reliable micro-level data and multivariate statistical analyses. These studies will be described in further detail in the next section. They mainly conclude that telework is indeed associated with more active travel. This paper considers five specific aspects, which have rarely been addressed in the other studies to date. First, this study takes the impact of flextime into account, which is neglected in almost all other studies. Including flextime is useful as it addresses the temporal

aspect concerning active travel. This is also in line with the suggestion of Allen et al. (2015: 61) to isolate the effect of telework from flextime, as both might lead to different conclusions. Second, there is often no distinction made between different modes of transport used while traveling actively. The current study consists of separate analyses for walking and cycling, which has only been done once before and indeed led to different results (Elldér, 2022). Third, to obtain a general picture of the association between flexible working arrangements and active travel, various indicators concerning active travel behavior are considered. These include travel times, trip purposes, and health-enhancing amounts of active travel, where the latter two have only been addressed rarely. Fourth, another feature of this study is that it controls for the Body Mass Index (BMI) to estimate the direct effect of flexible working arrangements on active travel. Only one other study considered this variable before, but that study analyzed only a vague measure of active travel behavior. However, BMI is an important variable, because active travel can be differently exhausting depending on the level of BMI, and missing this aspect could lead to biased conclusions. Finally, the weather is included in all analyses as a control variable. It is surprising that this indicator is most of the time not integrated into active travel research. However, it is especially important for studies using one-day travel diaries as weather conditions might evidently influence both the decision to work from home and to walk or cycle.

The research questions are tested using the 2015 Swiss Mobility and Transport Microcensus (MTMC) – a rich nationwide representative micro-data trend survey on mobility behavior and attitudes. This database allows for the analysis of the impact of telework and flextime on different aspects of active travel behavior, such as walking and cycling and health-enhancing usage of active modes of travel, controlling for relevant background variables.

The remainder of this article is split into five sections. In the next section, previous studies that examine the relationship between flexible forms of work and active travel are reviewed. The research hypotheses are presented in section 3. Thereafter, section 4 describes the data, the operationalization, and the analytical strategy used to answer the research question. Following this, the results are given. The final section of the paper closes with a conclusion and discussion of the results.

2. Literature review

Active travel is executed when “the sustained physical exertion of the traveller directly contributes to their motion” (Cook et al., 2022: 154). This includes various forms of non-motorized travel such as walking and cycling, but also, inlineskating, swimming, skateboarding or the usage of manual wheelchairs (Cook et al., 2022). Although active travel is more than just walking and cycling, these two modes of transport are the most widespread for active commuting and active mobility in general. Accordingly, this study considers both types when analyzing the impact of flexible working arrangements on active travel.

Since the 1970s, there has been an extensive discussion about the impact of flexible working arrangements on travel patterns, mainly focusing on the question of whether working remotely reduces traffic (see Hook et al., 2020 for a recent review). However, only very few recent, empirical, micro-level studies analyze the association between flexible working arrangements and active travel behavior. Most of these few studies are based in North America (the U.S. and Canada), with the remainder based in Europe (the UK and Sweden).

Starting with research from North America, work by Chakrabarti (2018) analyzes multiple travel and activity indicators using the US National Household Travel Survey from 2009. A distinction is made between occasional and regular telework and flextime is controlled. Results show that regular teleworkers complete more walking trips during one week as compared to non-teleworkers, while no effect is found for occasional telework. In addition, another analysis shows that teleworkers are more likely to walk/cycle for at least one mile on their remote working days as compared to teleworkers on on-site days. Furthermore, the study investigates the association of telework with health-enhancing levels of physical activity (30+ minutes). Here, physical activity includes active traveling as well as exercising. Teleworkers as compared to on-site workers are more likely to be sufficiently active (i.e. 30+ minutes/day), and teleworkers are more likely to reach the recommended amount of physical activity on remote days than on days in the office. Unfortunately, one cannot assess the contribution of active travel to reaching sufficient physical activity here. Furthermore, Chakrabarti (2018) controls for temporal flexibility and finds that the possibility of deciding on the start of one’s workday is associated with more trips walked during one week, and a higher likelihood of being physically active for at least 30 min on the target day.

Work from Wang and Ozbilen (2020) analyzes data from the Central Puget Sound Region Travel Survey in the State of Washington (US) from 2017 applying machine learning. The dependent variable is the share of time spent traveling via active modes of transport during the survey period. They use a continuous measure of telework – that is, the daily duration of telework in minutes. Results show that the duration of telework is positively associated with the duration of active travel. Looking more deeply, there is a gradual increase in the share of travel time from 0.18 to 0.26 when the duration of telework increases from 0 to 420 min. A study by Ozbilen et al. (2021) researches on the reported duration of trips traveled with active modes of transport (walking and cycling) also using data from the Central Puget Sound Region from 2017. Again, a continuous measure of telework is used – while also including a dummy variable of whether the individual’s job allows telework. They do not find an effect of the duration of telework on the time traveled actively; however, individuals with a teleworkable job travel longer with active modes of transport as compared to individuals with a non-teleworkable job. The results are somewhat complicated to interpret, but it appears that the dichotomous telework indicator shows a positive relation with active travel, but there is no additional continuous effect of telework. Thus, it might be concluded that these results are still in line with other studies finding a positive association of telework and active travel behavior. Research by Sener and Reeder (2014) uses the Texas (US) add-on sample data from the 2009 National Household Travel Survey to estimate simultaneously physically active activities and active travel behavior. They find that individuals who work from home are more likely to travel by active modes of transport as compared to on-site workers. Moreover, they included flextime in their analyses, measured as the possibility to decide on the start of the working hours. Indeed, working schedule flexibility is positively associated with a higher likelihood

of traveling actively. Work from Canada conducted by Lachapelle et al. (2018) investigates the relationship between telework and health-enhancing amounts of active travel using a dichotomous indicator for 30+ minutes of walking and cycling on the target day as the dependent variable. They analyze the Canadian General Social Survey from 2005 and restrict the sample to residents of urban areas because they expect it unlikely that walking and cycling occur in rural areas. Their results show that working only from home as compared to working only on-site is associated with 77% higher odds of meeting the recommended amount of physical activity through active travel. Other research in Canada on active travel behavior was done as part of a master's thesis written by Garden (2012) using the TRANS origin–destination survey in the National Capital Region in the fall of 2005. The outcome variable is a binary measure of whether a trip during a one-day period was covered via walking/ cycling or another mode of transport. Results indicate that teleworkers are more likely to take trips via active modes of transport as compared to regular workers.

Turning to Europe, a study from the UK carried out by de Abreu e Silva and Melo (2018) analyzes the National Travel Survey from 2005 to 2012 with respect to different travel indicators, including the number of trips and the distance traveled with active modes of transport (walking and cycling). A strength of this study is that it uses weekly data and considers the frequency of telework (albeit only as an ordinal indicator). They show that frequent telework correlates with more frequent and further active travel. However, this is only the case for single-worker households and not for households in which two individuals are gainfully employed. Another study from the UK, carried out by Caldarola and Sorrell (2022), uses the English National Travel Survey from 2005 to 2019 to investigate the impact of medium- and high-frequency telework on various travel patterns, including active travel. They use weekly travel data, consider individual and household travel, and also conduct separate analyses for commuting, non-work travel and business trips. Results show that medium-frequency telework is associated with more frequent and longer active travel for private purposes (commuting and non-work travel). Furthermore, high-frequency teleworkers travel further for non-work purposes by active modes of transport as compared to non-teleworkers. In addition, they observe intra-household dependencies of household members' telework practice on total active travel usage of the whole household. A study from Sweden by Elldér (2022) uses the National Travel Survey from 2011 to 2016 to investigate the association of telework with various walking and cycling indicators. The strengths of the study are that it analyzes walking and cycling behavior separately and that it considers a direct measure of telework, so that it is clear whether teleworkers, actually worked remotely during the day or not. Hence, this allows telework and non-telework days to be distinguished. In general, the results show that teleworkers walk more but cycle less. This result is robust for different measures of active travel, including whether the mode of transport was used at all, the number of trips made, and the time spent traveling actively. That is interesting, as telework status is associated differently with walking and cycling. This means that combining both could hide important differences. Taking a deeper look, teleworkers walk more for service and leisure on days on which they work remotely only. This is in line with the previous argument that daily needs might be fulfilled closer to home and by slower modes of transport as time saved from the commute is reinvested. Using the same Swedish dataset, earlier work by Elldér (2020) finds that teleworkers are more likely to only walk and cycle, and not use other modes of transport, on teleworking days. Although this insight does not allow conclusions to be drawn about the amount of active travel behavior, it is still informative in terms of sustainability.

3. Hypotheses

The literature review clearly found that telework is indeed positively associated with more active travel. This result is interesting because the studies used various indicators to measure the two key concepts and were conducted in different contexts. Furthermore, it is noticeable that only two studies integrated flextime in their analyses. This is surprising as many studies argue for increased temporal flexibility due to telework, but do not look at the temporal component explicitly. Only two studies (Chakrabarti, 2018; Sener and Reeder, 2014) include the respondent's opportunity to decide on the start of the workday in their models. It turns out that schedule flexibility is positively associated with active travel behavior. However, neither study used a continuous measure of active travel such as the time walked/cycled, and also missed other extents of working schedule flexibility such as completely flexible working hours. Thus, there is still a need for further research on flextime and active travel behavior. As the daily structure is usually determined by the job, telework and flextime help to reduce the temporal constraints. This enables workers who have flexible working arrangements to use slower modes of transport, such as walking and cycling. Moreover, saved commutes from teleworkers might be reinvested in trips for other purposes closer to home. These shorter distances might then be executed more easily using active modes of transport. Thus, the following research hypothesis emerges:

H1: Telework and flextime promote active travel.

Most studies dealing with active travel consider only a few behavioral aspects, for instance whether people walk or cycle at all. In particular, the purpose of walking and cycling trips often remains unaddressed. Only three studies consider the purpose of active travel trips. One study from Canada includes the purpose as a control variable to explain active travel mode choice and observes differences in the likelihood of walking and cycling (Garden, 2012). Results show, for instance, that trips are more likely to be made via active modes of transport for recreational purposes as compared to medical purposes (reference category). A study from the UK made different analyses for commutes and non-work travel (Caldarola and Sorrell, 2022). They find no evidence that telework increases active commuting, but that telework is associated with more non-work active travel. The third study considering trip purposes is from Sweden and distinguished between trips to commute and for leisure and maintenance purposes (Elldér, 2022). The results revealed that telework is associated with more walking for maintenance purposes, but less cycling to work. This study is also the only one that has conducted separate analyses for walking and cycling so far (Elldér, 2022). However, this approach seems to be promising for future insights, as the results differed. Based on the empirical results, this study seeks to test whether there are also different findings

depending on the mode of transport and trip purpose in the Swiss context:

H2: The association between flexible working arrangements and active travel differs across trip purposes and the mode of transport.

It is often argued that active travel might be beneficial for the environment and for public health. Some studies investigate the impact of telework on the time traveled with active modes of transport, which is informative but is not yet sufficient to make statements about public health policies. Only two studies analyze this aspect directly using a binary indicator for 30+ minutes of active travel and physical activity respectively. One study (Lachapelle et al., 2018) shows that full-day telework helps people to meet a health-enhancing amount of active travel; however, the sample was restricted to urban areas only, which could have influenced the results. The other study (Chakrabarti, 2018) has limited explanatory power, as it investigates the impact of flexible working arrangements on physical activity (active travel and exercising) and, therefore, the relevance of active travel can only be guesstimated. However, the results at least suggest a positive impact of working flexibly on active travel. If telework and flextime create more temporal flexibility and thus lead to more active travel, this might help people to achieve the recommended level of physical activity. Moreover, there is evidence that active travel is likely to add to the amount of physical activity instead of replacing other kinds of exercise (Panik et al., 2019). Accordingly, the next research hypothesis addressing possible benefits for public health is as follows:

H3: Telework and flextime help to reach health-enhancing amounts of active travel per day.

Finally, two further important aspects will be addressed that have been neglected in the other studies. First, no study included the weight or BMI of respondents. This is remarkable as there is much research on the relationship between active travel and weight/BMI (e.g. Dons et al., 2018; Habinger et al., 2020; Kroesen and de Vos, 2020; Wanner et al., 2012). The decision to walk or cycle is often day dependent. Hence, active travel is likely to be influenced by weight, as it is more exhausting to travel actively for people with higher BMIs, and might thus be a less appealing mode of transport. In order to estimate the direct effect of flexible working arrangements on active travel behavior, the BMI needs to be controlled – especially in cross-sectional data or one-day travel diaries. Second, the weather was only considered in one study, which revealed an impact of weather conditions, such as a decreased likelihood of less walking and cycling when it rained (Garden, 2012). However, some other studies include the month (Sener and Reeder, 2014) or the season (Chakrabarti, 2018). The neglecting of weather is surprising since it seems obvious that the decision to walk or cycle also depends on the weather. Hence, the weather conditions seem particularly important for data based on one-day travel diaries. Accordingly, to estimate the direct effect of telework on active travel, one needs to control for the weather as this variable might be a confounder that influences both whether remote work is done as well as whether active modes of transport are used. As these two aspects might be important for future research on active travel behavior, a fourth hypothesis is formulated:

H4: BMI and weather are associated with active travel behavior.

4. Data and methods

4.1. Data

The data used in this paper is the most recent available Swiss Mobility and Transport Microcensus (MTMC) from 2015, which was conducted by the Swiss Federal Statistical Office and the Swiss Federal Office for Spatial Development ARE (2017a). The MTMC is a micro-level trend survey documenting the travel behavior and attitudes of a random sample of the Swiss resident population starting from age six. The data collection period covers a whole year (14 months) and the survey is repeated every five years. Respondents report a travel diary of one randomly selected target day via computer-assisted telephone interview. It contains detailed route recording of all ways traveled and further relevant information about these routes – such as distance, duration, mode of transportation, and purpose. Additionally, sociodemographic and economic information about the respondents is collected. Apart from this, the survey includes various characteristics of the target person's household; however, only one person out of each household is the target person whose travel behavior is recorded. The response rate of the MTMC in 2015 was 53%, leading to 57,900 travel diaries (Swiss Federal Statistical Office and Swiss Federal Office for Spatial Development ARE, 2017b).

A special feature of the MTMC is that, in addition to these main data, special topics are also collected in the form of additional randomly assigned modules. Module 2 is particularly relevant for this study. This module deals with active travel and the occupational situation. Here, both flexible working arrangements are recorded and in-depth questions about walking and cycling are asked. It should also be emphasized that BMI is part of the module, which is an important control variable in studying active travel. The module was randomly assigned to 30% of respondents (Swiss Federal Statistical Office and Swiss Federal Office for Spatial Development ARE, 2017b). Because of this, the sample size is reduced but no selection bias is expected due to the randomization.

In summary, the MTMC offers a random sample of the total Swiss population, uses accurate methods to record travel behavior, and collects additional relevant variables. Thus, the MTMC is the best available source for analyzing the impact of flexible working arrangements on active travel in Switzerland. Because of this topic, all analyses are carried out for people who are gainfully employed (not in training). The sample is also restricted to respondents aged between 18 and 65 years, because the latter is the regular retirement age for males in Switzerland. In the following, only trips traveled within the country are taken into account. Because only 30% of all respondents received module 2 and due to the substantiated sample restrictions, the number of cases drops considerably to about 8700

Table 1
Descriptive information of variables for the analysis subsample.

Variable	Description / answering categories	Obs.	Min.	Max.	Mean / share	SD
Independent variables: telework and flextime						
Telework	• No telework = 0 (no possibility to work from home or choosing not to do so, that is 0% of workload working from home; reference category)	8737	0	1	0: 71.3%	
	• Telework / hybrid work = 1 (possibility to do home office and choose to work from home)				1: 28.7%	
Flextime	• Fixed working hours = 0 (predetermined start and end of the workday; reference category)	8724	0	3	0: 41.5%	
	• Core time = 1				1: 15.9%	
	• Fixed number of working hours = 2				2: 18.4%	
	• Flexible working hours = 3				3: 24.2%	
Dependent variables: travel behavior						
Traveled actively	• Did not walk/cycle = 0 (reference category)	8767	0	1	0: 40.2%	
	• Walked and/or cycled = 1				1: 59.8%	
Active travel duration	Natural log of total time traveled via active modes of transport	8767	0	6.6	2.10	1.88
Walked	• Did not walk = 0 (reference category)	8767	0	1	0: 45.4%	
	• Walked = 1				1: 54.6%	
Walking duration	Natural log of time walked	8767	0	6.6	1.86	1.84
Cycled	• Did not cycle = 0 (reference category)	8767	0	1	0: 89.6%	
	• Cycled = 1				1: 10.4%	
Cycling duration	Natural log of time cycled	8767	0	6.3	0.36	1.10
Walking to work	• Did not walk to or from work = 0 (reference category)	8767	0	1	0: 81.6%	
	• Walked to or from work = 1				1: 18.4%	
Cycling to work	• Did not cycle to or from work = 0 (reference category)	8767	0	1	0: 87.1%	
	• Cycled to or from work = 1				1: 12.9%	
Walking for leisure	• Did not walk for leisure = 0 (reference category)	8767	0	1	0: 68.7%	
	• Walked for leisure = 1				1: 31.3%	
Cycling for leisure	• Did not cycle for leisure = 0 (reference category)	8767	0	1	0: 87.9%	
	• Cycled for leisure = 1				1: 12.1%	
Walking for shopping	• Did not walk for doing shopping = 0 (reference category)	8767	0	1	0: 80.9%	
	• Walked for doing shopping = 1				1: 19.1%	
Cycling for shopping	• Did not cycle for doing shopping = 0 (reference category)	8767	0	1	0: 89.7%	
	Cycled for doing shopping = 1				1: 10.3%	
Active travel: 30 + minutes	• Did not walk/cycle for at least 30 min = 0 (reference category)	8767	0	1	0: 66.2%	
	• Walked/cycled for at least 30 min = 1				1: 33.8%	
Active travel: 30 + minutes in at least 10-minute bouts	• Did not walk/cycle for at least 30 min = 0 (reference category)	8767	0	1	0: 78.2%	
	• Walked/cycled for at least 30 min = 1				1: 27.8%	

(*continued on next page*)

Table 1 (*continued*)

Variable	Description / answering categories	Obs.	Min.	Max.	Mean / share	SD
Control variables						
Full-time work	• Part-time work = 0 (reference category) • Full-time work = 1 (90–100% of full-time equivalent)	8561	0	1	0: 34.9% 1: 58.5%	
Gender	• Male = 0 (reference category) • Female = 1	8767	0	1	0: 52.3% 1: 47.7%	
Age	In years	8767	18	65	43.65	12.03
Income	Household equivalent income in 1000 Swiss Francs (income is calculated using the mid value of class interval divided by the square root of the household size)	7592	0.44	17	5.90	2.57
Education	In years (calculated according to the educational attainment)	8732	0	17.5	12.45	2.94
Children	• Having no underage children = 0 (reference category) • Having underage children = 1	8767	0	1	0: 61.8% 1: 38.2%	
Area of home	• Rural community = 0 (reference category) • Agglomeration = 1 • City = 2	8767	0	2	0: 22.3% 1: 46.3% 2: 31.4%	
Public transport subscription	• No public transport subscription = 0 (reference category) • Owning a public transport subscription (which includes the Swiss “Generalabonnement” – a flat rate for the whole public transport in Switzerland - or a half-fare card, or a regional travel pass) = 1	8767	0	1	0: 47.8% 1: 52.2%	
Car availability	• No car available = 0 (reference category) • Car available and possession of a valid driver’s license = 1	8079	0	2	0: 4.5% 1: 95.5%	
BMI	Body Mass Index	8649	12.9	68.4	24.5	4.04
Weather	• Unpleasant weather conditions (fog, rain, snow, hot, frosty, very unstable) = 0 (reference category) • Pleasant weather conditions (sunny, nice, cloudy) = 1	8665	0	1	0: 43.3% 1: 56.7%	
Weekend	• Weekdays (Monday – Friday) = 0 • Weekend (Saturday, Sunday) = 1	8767	0	1	0: 70.5% 1: 29.5%	
Not leaving the house at all	• No, left the house on the target day = 0 • Yes, stayed at home all day = 1	8767	0	1	0: 92.7% 1: 7.3%	

Note: Obs. = number of observations, min = minimum, max = maximum, SD = standard deviation. Results of the independent and dependent variables are weighted.

observations (see Fig. S1 in the supplementary material). All descriptive results refer to the restricted sample of regular labor market participants and are weighted using the weighting coefficient provided in the MTMC data set.

4.2. Independent variables – Telework and flextime

This paper focuses on two flexible working arrangements, which could combine well with active travel behavior: telework and flextime. In the MTMC, workers were asked if they are able to do some of their work from home, so other kinds of telework such as working from a café are not considered. Respondents, who could work remotely were then asked to what extent (in percentage of full-time-equivalent). Since some of them choose not to work remotely, a variable was built that represents actual telework usage. It is important to say that the MTMC only records whether a person generally teleworks (e.g. working remotely 20% of the working time), but does not capture whether an individual actually teleworked on the target day. Hence, the analytical results are based on group comparisons evaluating differences between teleworkers with those who never telework. The second form of flexible working arrangement considered is working schedule flexibility, i.e. flextime. This study stands out because it considers four different kinds of working hours organization: predetermined start and end time of working hours (i.e. no flextime), predetermined core time, a fixed number of working hours per week or month, and completely flexible working hours. The last three categories lose the time constraints due to gainful employment to different extents, and thus they all are included separately. Please see Table 1 for an overview of how all variables used in this study were constructed, as well as descriptive information on them.

4.3. Dependent variables – Active travel behavior

In order to test the three research hypotheses, 14 dependent variables are used to capture a variety of active travel patterns. The MTMC records the exact route and the mode of transport that was used for the individual stages of all trips on the target day. H1, hypothesizing a positive impact of flexible working arrangements on active travel, is tested using two different kinds of variables. First, there are dummy variables that indicate the usage of active modes of transport. They are set to 1 if a respondent walked or cycled on the target day for more than 0.1 km. This threshold is used to make sure that actual active travel is captured, in contrast to situations in which individuals might walk to the parking lot or take a few steps to change trains, for instance. The binary indicators are 0 if a respondent did not travel actively (e.g. only used motorized private transport or public transport). Furthermore, they are also 0 when individuals did not leave the house on the target day at all, so that no cases get lost and that there is no selection bias due to working remotely. Second, the duration (in minutes) of all trips traveled actively is totaled up. Again, respondents who did not leave the house or only traveled by car and public transport are included with a value of 0, and distances shorter than 0.1 km are coded as 0 min of active travel. According to work from Sweden (Elldér, 2022), it is essential to analyze the modes of active travel separately, as they might lead to different outcomes and conclusions. Following this, the analyses are carried out for walking only, cycling only, and total active travel (i.e. walking and cycling). H2 seeks to explore the associations between flexible working arrangements and the purposes for which different active modes of transport are used. Accordingly, there will be six binary variables, addressing commuting, active travel for leisure reasons, and shopping trips, each built separately for walking and cycling respectively. Again, distances shorter than 0.1 km are coded with a value of 0. In order to test H3, which addresses the health benefits of active travel, two binary indicators are created. The first variable is 1 for individuals who travel actively (by bike and on foot) for at least 30 min on the target day. This threshold is chosen because of the WHO recommendation that recommends at least 150 min of physical activity per week (World Health Organization, 2010). Based on a typical work week with five working days for full-time employees, this results in an average of 30 min of active travel per day. Furthermore, the threshold of 30 min is harmonized with previous studies analyzing active travel and public health (e.g. Buehler et al., 2011; Lachapelle et al., 2018; Merom et al., 2010). The second indicator takes into account that longer periods of travel are even more health-enhancing as compared to multiple but very short stages of active travel. According to the WHO, physical activity should be practiced in bouts of at least 10 min duration (World Health Organization, 2010). As has been done in previous studies (e.g. Buehler et al., 2011), a binary indicator for sufficient active travel is generated that excludes active travel trips shorter than 10 min but still sums up to at least 30 min of walking and/or cycling.

4.4. Control variables

The aim of this study is to analyze the association of telework and flextime with different active travel patterns. It is therefore essential to control for possible confounders, which are variables that might affect both the presence of flexible working arrangements and active travel behaviors. Hypothesis H4 considers BMI and weather as important factors in active travel research. The BMI is calculated using self-reported height and weight. The weather condition on the target day is incorporated into the statistical models as a binary variable that distinguishes pleasant (i.e. sunny, nice, cloudy) from unpleasant (i.e. fog, rain, snow, hot, frosty, and very unstable) weather conditions for active travel. The weather data comes from the MTMC. The respondents stated what the weather was like for them on the target day. If at least one unpleasant condition, such as fog or snow, was mentioned, the binary indicator is set to unpleasant. Using weather data directly from the MTMC has the advantage that the respondents can indicate the weather at all the different locations that they encounter or are relevant, which is relevant to their travel decision-making.

Furthermore, five other types of control variables are taken into account. First, there is an important job characteristic to consider. Full-time and part-time work need to be included, in order to disentangle the effect of temporal flexibility due to flextime from impacts due to fewer working hours. Second, the following sociodemographic characteristics of the respondents are included: gender, age (in years), household equivalent income (in thousand Swiss Francs), education (in years), and having underage children. Third, different

levels of the built environment are controlled by including the area of residence (the three categories are rural area, agglomeration, and city). Fourth, some travel-related indicators are considered, as they can offer alternatives or impose restrictions regarding active travel behaviors. These are holding a public transport subscription, and having a private car available. Finally, an important characteristic of the survey day is controlled. A binary indicator for weekends is included, in order to catch common differences to regular weekdays. Besides BMI and weather, whose inclusion in the analyses is a novelty of this study, all included control variables were found to be important in the previous studies reviewed.

4.5. Statistical models

The research hypotheses are tested by comparing the groups of teleworkers vs. on-site workers, and the different groups of working schedules (flextime) in multivariate regression models. The key variables of interest – telework, and flextime - are simultaneously included in all regression models in order to isolate their effects on the different active travel indicators (Allen et al., 2015). In the course of this, the previously described control variables are taken into account in order to estimate the direct effect of telework and flextime on active travel behavior.

H1 assumes that flexible working arrangements contribute to more use of active modes of travel. To test this hypothesis, three different aspects of active travel are considered: (a) active travel overall, (b) walking, and (c) cycling. Each of these groups includes two analyses: one logistic regression model, measuring whether the mode of transport was used at all, and one ordinary least squares (OLS) regression model, analyzing the time spent traveling actively. The latter is measured continuously. Since these durations are right-skewed, they are logged, as has been done in previous studies (e.g. Elldér, 2022). The value of duration is 0 for individuals who did not travel actively. To not lose these important cases, one minute is added to the durations before transforming it. As the natural logarithm of 1 equals 0, the new variable still represents workers who did not walk or cycle adequately with 0. Because of the transformation of the dependent variable, the OLS regression coefficients (β) are interpreted as percentage changes using this calculation: $(\exp(\beta) - 1) * 100\%$. Moreover, robust standard errors were applied to calculate the OLS regression models. The variance inflation factors (VIFs) of these models – testing for multicollinearity among the independent variables – are not noticeably large and the mean VIF is 1.30, which is reasonable. The second hypothesis seeks to explore associations between flexible working arrangements and different purposes for active travel. Six binary logit models are computed for walking and cycling respectively to (d) commute to work, (e) pursue leisure, and (f) do shopping. H3 addresses the possible benefits of flexible working arrangements for public health. In order to test this hypothesis, two logistic regression analyses are carried out for traveling actively for at least 30 min, and for traveling 30+ minutes in 10-minute bouts, respectively. The fourth hypothesis concerns the importance of weather conditions and BMI in active travel research. H4 is tested indirectly since these two indicators are included as control variables in all models.

5. Results

5.1. Descriptive results

Starting with some descriptive results, the data shows that 59.8% of Swiss labor market participants travel actively in one day. Moreover, the results demonstrate that walking (54.6%) is more common than cycling (10.4%) in Switzerland. Having a deeper look, the data shows that the average time spent traveling actively is about 31 min per day, of which 26 min are walked and only 5 min are cycled. Looking at the purposes for active travel, it becomes apparent that most people walk and cycle for leisure (34.8%). The second most important purpose for traveling actively is commuting (23%), followed by walking and cycling for shopping (21.5%). 33.8% of workers travel actively for at least 30 min on the target day. The travel of slightly fewer people – 27.8% – consists of trips that lasted at least 10 min and summed up to a minimum of 30 min. Thus, there are about 5% of labor market participants who travel actively for at least 30 min, but whose total duration of active travel is made up of several shorter stages. Finally, a few brief words are said about the spread of flexible forms of work in Switzerland. The majority of participants in the Swiss labor market cannot telework (68%). Interestingly, of all individuals who could work from home, 11.3% decide to not take up this option. Overall, this results in 28.7% of workers practicing telework, while 71.3% work on-site only. Looking at flextime, the most common type of working schedule organization is non-flexible working, i.e. the start and finish times of work are predetermined. The working times are fixed for 41.5%; however, this also indicates that almost three-fifths of workers can decide to some extent on their working times. 15.9% of labor market participants have a predetermined core time, which means that they can decide on the start of their working day within a given period. 18.4% benefit from even more temporal flexibility, as they have only a contractually agreed number of working hours per week or month. Finally, 24.2% of workers have completely flexible working hours. Overall, more labor market participants have temporal than spatial flexibility in their jobs in Switzerland. Furthermore, it becomes apparent that in Switzerland all combinations of temporal and spatial flexibility are present. For instance, there are teleworkers who cannot decide on their working hours, and there are also individuals who cannot work from home but can decide on their working day completely autonomously. However, it is most common that on-site workers do not have flexible working hours, and that teleworkers can fully decide on their working hours (see Table S1 in the supplementary material).

5.2. Flexible working arrangements and active travel usage

Table 2 presents the results of the regression models for active travel via (a) walking and cycling, (b) walking only, and (c) cycling only. In each case, the logistic regression is on the left, and the OLS regression is on the right. The coefficients presented for the logistic

regressions are odds ratios (OR). First, contrary to expectations, there is no statistically significant impact between telework and active travel; however, flextime is associated with active travel behavior. Workers, who can decide on the start of their working days (i.e. having core time) are more likely to use active modes of transport (model 1, OR = 1.23), and also travel 25.6% longer using active modes (model 2, β = 0.228) as compared to workers with fixed working hours. A further insight is that this is due to more (model 3, OR = 1.203) and 23% longer walking (model 4, β = 0.207), while no effect is found for cycling. Interestingly, individuals who can fully decide on their working hours cycle less (model 5, OR = 0.77; model 6, β = −0.086) as compared to workers with fixed working hours; however, there is no significant impact on active travel overall. Furthermore, results show that full-time work, the availability of a car, and an increasing BMI lead to less active travel, while education, denser infrastructure, a public transport subscription, and pleasant weather correlate positively with active travel behavior. Regarding the weather condition, the separate analysis of walking and cycling is informative. It shows that in pleasant weather people cycle more often and longer, and individuals also walk longer. However, there is no statistically significant effect of pleasant weather on the likelihood to walk at all. One reason for this could be that there are certain routes that must be walked in all weather conditions, such as the way to the public transportation stop. At the same time, the positive effect of good weather on the duration of walking suggests that the weather is indeed relevant for additional or "voluntary" distances covered on foot, such as going for a walk or walking to the supermarket. Additionally, people are less likely to use active modes of transport on weekends as compared to weekdays. The question might arise whether the group of individuals who did not leave the house at all is overrepresented in the group of teleworkers and if that could affect the results. A *t*-test shows that there is no statistically significant difference in the share of people who stayed at home all day between teleworkers and on-site workers (t = −1.46, p = 0.143, N = 8737). As a robustness check, all six models were also calculated without individuals who did not leave the house at all on the target day, which reduces the sample size by 439 cases (results not presented). No differences are found concerning the key variables telework and flextime. Furthermore, including telework and flextime in separate models did not change the main results.

5.3. Flexible working arrangements and active travel trip purposes

Next, Table 3 displays the results of the likelihood to walk and cycle respectively, separated for commutes, leisure purposes, and shopping trips. The coefficients presented in Table 3 are odds ratios. This separation into different purposes provides some different insights. Teleworkers are statistically significantly more likely to walk and cycle for recreational reasons (model 9, OR = 1.215; model

Table 2
Logistic and OLS regressions on active travel, walking and cycling behavior.

	(a) Active travel		(b) Walking		(c) Cycling	
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	Binary indicator (OR)	Duration (β)	Binary indicator (OR)	Duration (β)	Binary indicator (OR)	Duration (β)
Flexible working arrangements						
Telework (ref. = no telework)	1.039	0.054	1.043	0.0617	1.019	0.011
Flextime (ref. = fixed working hours)						
Core time	1.230**	0.228***	1.203*	0.207**	1.133	0.049
Fixed number of working hours	1.032	0.075	1.018	0.066	0.886	−0.017
Flexible working hours	0.952	0.003	1.002	0.054	0.770*	−0.086*
Full-time work (ref. = part-time work)	0.850*	−0.234***	0.904	−0.177**	0.757**	−0.100**
Women (ref. = men)	1.153*	0.086	1.263***	0.203***	0.653***	−0.156***
Age	0.998	0.002	0.998	0.001	1.005	0.002
Income (in thousand CHF)	0.995	−0.009	1.000	−0.007	0.973	−0.006
Years of education	1.037***	0.028**	1.027**	0.0177*	1.053***	0.019***
Children (ref. = no children)	0.968	−0.020	0.959	−0.040	1.083	0.031
Area of home (ref. = rural community)						
Agglomeration	1.236***	0.185**	1.224**	0.169**	1.222	0.050
City	1.782***	0.476***	1.604***	0.356***	1.877***	0.210***
Public transport subscription (ref. = no subscription)	1.847***	0.549***	1.662***	0.450***	2.136***	0.209***
Car availability (ref. = no car)	0.649**	−0.441***	0.725*	−0.361**	0.946	−0.076
BMI	0.977***	−0.027***	0.982**	−0.018**	0.935***	−0.019***
Weekend (ref. = weekdays)	0.795***	0.019	0.846**	0.076	0.644***	−0.111***
Pleasant weather (ref. = unpleasant weather)	1.154**	0.213***	1.065	0.125**	1.289**	0.106***
Constant		2.142***		1.785***		0.569***
Number of observations	6744	6744	6744	6744	6744	6744

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Coefficients of binary indicators = odds ratios (OR). Coefficients of duration = β; interpretation of β-coefficients in percentage-changes: (exp(β) – 1) * 100%.

10, OR = 1.403), and they are more likely to go shopping on foot (model 11, OR = 1.214). In contrast, no association is observed between core time work and active commuting and active leisure travel. However, workers with fully flexible working hours are more likely to commute to work on foot (model 7, OR = 1.232).

Some interesting conclusions emerge from the control variables. Car availability correlates with less commuting by active modes of transport. Additionally, the built environment seems to matter for executing regular needs, such as commuting and shopping: individuals living in cities are more likely to commute and shop on foot as compared to those living in rural areas. Also, older, higher educated, and full-time working people are more likely to cycle to work. Holding a public transport subscription promotes walking to work too. In general, a higher income decreases the likelihood of traveling by bike. On weekends, workers are less likely to commute on foot but are more likely to commute by bike. No correlation between BMI and purpose-dependent active travel behavior is found. However, this makes sense, since walking and cycling might be more exhausting for individuals with a high BMI in general, and not only when they are walking or cycling for recreational purposes for instance. No statistically significant association is observed between the weather condition and active travel for leisure purposes. However, these non-significant coefficients show at least a positive coefficient as expected. Surprisingly, good weather conditions are associated negatively with walking to work and with walking and cycling to do shopping. It might be that individuals avoid slower modes of transport for daily necessities on sunny days to save time for other recreational activities.

5.4. Flextime working arrangements and health-enhancing active travel

H3 hypothesizes that flexible working arrangements help people to reach a health-enhancing amount of active travel. Table 4 reports the results of two logistic regression models analyzing the impact of telework and flextime on 30 + minutes of active travel (model 13) and 30+ minutes of active travel in at least 10-minute bouts (model 14). The coefficients presented are odds ratios. Results show a statistically significant association between telework and the recommended amount of active travel (model 14, OR = 1.147). Interestingly, teleworkers are not more likely to travel for at least 30 min as compared to on-site workers (model 13), but it seems that they differ in terms of stage duration (i.e. they possibly travel for longer episodes). Furthermore, the results show a positive impact of working schedule flexibility on health-enhancing active travel. Individuals who can decide on the start and end of their working hours are more likely to walk and cycle sufficiently (OR = 1.2 and 1.225, respectively). Only having a fixed number of working hours as compared to a predetermined start and end of the work day also correlates with a higher likelihood of traveling actively for at least 30 min (model 13, OR = 1.178). Full-time workers are less likely to walk and cycle sufficiently, as are individuals for whom a car is available and who have higher BMIs. In contrast, health-enhancing active travel is more likely for workers who live in cities as compared to rural areas, and who hold a public transport subscription. Additionally, older and more educated people are more likely to

Table 3
Logistic regressions on walking and cycling separated by trip purposes.

	(d) Commute		(e) Leisure		(f) Shopping	
	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
	Walking	Cycling	Walking	Cycling	Walking	Cycling
Flexible working arrangements						
Telework (ref. = no telework)	1.082	1.124	1.215**	1.403***	1.214*	1.171
Flextime (ref. = fixed working hours)						
Core time	0.965	0.872	0.964	0.887	0.952	0.730*
Fixed number of working hours	1.031	0.903	1.045	0.990	0.931	0.859
Flexible working hours	1.232*	0.965	1.094	1.103	1.097	1.085
Full-time work (ref. = part-time work)	1.453***	0.936	0.891	0.858	0.920	0.802*
Women (ref. = men)	1.141	0.895	1.217**	0.930	1.365***	1.119
Age	1.002	1.008*	1.005	1.000	0.998	1.008*
Income (in thousand CHF)	0.998	0.943***	0.984	0.957*	0.975	0.938***
Years of education	1.018	1.045**	1.017	1.017	1.003	1.029
Children (ref. = no children)	0.897	0.888	0.929	0.883	0.893	0.838
Area of home (ref. = rural community)						
Agglomeration	1.037	1.027	1.013	0.966	1.170	1.092
City	1.217*	1.212	0.979	1.133	1.348**	1.051
Public transport subscription (ref. = no subscription)	1.151*	1.137	1.029	1.110	0.991	1.092
Car availability (ref. = no car)	0.727*	0.705*	0.939	0.788	0.726*	0.889
BMI	1.003	0.993	0.995	0.998	1.011	1.008
Weekend (ref. = weekdays)	0.785***	1.251**	1.937***	2.388***	1.274***	1.955***
Pleasant weather (ref. = unpleasant weather)	0.865*	0.969	1.051	1.040	0.863*	0.828*
Number of observations	6744	6744	6744	6744	6744	6744

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Coefficients = odds ratios (OR).

Table 4
Logistic regression on health-enhancing active travel behavior.

	Active travel: 30 + minutes	Active travel: 30 + minutes in at least 10-minute bouts
	Model 13	Model 14
Flexible working arrangements		
Telework (ref. = no telework)	1.101	1.147*
Flextime		
(ref. = fixed working hours)		
Core time	1.200*	1.225*
Fixed number of working hours	1.178*	1.086
Flexible working hours	1.046	1.008
Full-time work (ref. = part-time work)	0.725***	0.701***
Women (ref. = men)	1.045	0.986
Age	1.005*	1.006*
Income (in thousand CHF)	0.996	0.985
Years of education	1.025*	1.009
Children (ref. = no children)	1.018	0.987
Area of home (ref. = rural community)		
Agglomeration	1.148	1.081
City	1.451***	1.352***
Public transport subscription (ref. = no subscription)	1.546***	1.252***
Car availability (ref. = no car)	0.604***	0.783
BMI	0.970***	0.971***
Weekend (ref. = weekdays)	1.240***	1.546***
Pleasant weather (ref. = unpleasant weather)	1.319***	1.338***
Number of observations	6744	6744

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Coefficients = odds ratios (OR).

travel actively for at least 30 min per day. It is also more likely for labor market participants to walk and cycle sufficiently on weekends than on weekdays, and when the weather conditions are pleasant. The latter finding is in line with the results seen in Table 2. As a robustness check, both models are calculated without individuals who stayed at home all day (results not presented). No differences are found concerning the key variables telework and flextime. As a further robustness analysis, telework and flextime are included separately in the models. This does not change the main findings (results not presented).

6. Conclusion and discussion

The aim of this study is to analyze the association between telework/flextime and active travel behavior in order to gain insights into possible impacts on public health and the environment. The results show that both flexible working arrangements and active travel are quite common in Switzerland. H1 assumed that telework and flextime increase active travel and the results show that telework correlates with more walking for leisure and shopping purposes. In addition, teleworkers are more likely to cycle for recreational purposes as compared to on-site workers. Furthermore, flextime, more precisely core time, is associated with more and further active travel, which is mainly covered by foot. In summary, the empirical evidence for Switzerland only supports H1 partly. Despite the positive impacts of flexible working arrangements, it needs to be mentioned that the results do not show up in all respects of active travel patterns. For instance, telework is only found to affect leisure and shopping trips, but no association was found when looking at active travel behavior overall. H1 is also contradicted to some extent by the fact that only certain flextime arrangements correlate with active travel, and that workers with completely flexible working hours cycle less. The analyses in this study stressed the importance of traveling actively for leisure and shopping purposes, while no association was found for the ways to and from work. Accordingly, it is advised to approach active travel broadly, in contrast to focusing on impacts on the commute only. Furthermore, the analyses revealed that core time affects walking but not cycling in Switzerland. Therefore, the association between flexible working arrangements and active travel patterns differs across trip purposes and mode of transport, meaning H2 is supported. From this, it can be derived that different active modes of transport and various conceptualizations of active travel patterns (e.g. considering travel reasons) contribute to a more detailed understanding of active travel behavior and the underlying mechanisms. This finding is important for modeling approaches in future studies, as well as for targeted measures from policymakers. Next, analyses reveal that telework and flextime (especially core time) help people to reach a health-enhancing amount of active travel per day, which supports H3, and this might be an important insight for public health authorities. Finally, H4 addressed the significance of including BMI and weather conditions in active travel research. The analyses suggest that higher BMIs correlate with less active travel overall, less walking and cycling, and a lower likelihood of reaching 30+ minutes of active travel per day. The effect of BMI did not vary between trip purposes, but this was not necessarily expected. Because of the first finding, which is in this case the more important one, it is

concluded that there is support for H4. Furthermore, the weather conditions have mainly a significant positive influence on active travel behavior, and thus, represent a potential confounder when analyzing the relationship of active travel with flexible working arrangements. However, it is important to note that there is a need for more detailed research concerning the trip purposes, as these results here are somewhat contradictory and inconclusive. Anyways, it is advisable to take the weather into account. Even if no weather data is collected in travel diaries, it could be a good idea to feed weather data externally. In summary, H4 is supported: BMI and weather conditions are associated with active travel. What is more, the results show that public transportation subscriptions correlate positively with active travel behaviors. This could indicate that the development of public transport infrastructure is not only beneficial for the environment but also for public health. In summary, the conclusions of this study are largely consistent with the other studies, while at the same time setting new priorities such as the consideration of flextime, or the inclusion of BMI and weather conditions as important control variables.

Next, the limitations of this study and some open questions for further research are discussed. This study uses cross-sectional data; accordingly, the impacts of telework and flextime on active travel cannot be interpreted causally. There could be some selection effects; for instance, generally more active people could have sorted themselves into jobs with flexible working arrangements. Another possible explanation could be dog-ownership, as telework allows taking care of pets and is empirically associated with more walking for leisure purposes. Hence, this study cannot be used to draw conclusions about the effectiveness of promoting flexible working arrangements for more active travel. However, in combination with the theoretical considerations, the observed associations may at least indicate what policies could be considered. Then, the efficiency of such policies needs to be tested in future research using panel or experimental data. Furthermore, the results of this study are based on one-day travel diaries of only one member per household. This fact could hide some interesting findings, as work from studies using household data demonstrated some intra-household effects (e.g. Caldarola and Sorrell, 2022). Moreover, as only one-day travel diaries were used, no conclusions could be drawn about effects over a work week, consisting of both remote and on-site working days for the same individuals. In addition, this study only used a general indicator of telework and flextime, thus only allowing group comparisons of teleworkers and flextime workers as compared to regular workers on aggregate. More detailed analyses of the underlying mechanisms are possible if, first, longer periods of time are observed and, second, if it is clear whether someone teleworked or used their working schedule flexibility on the target day(s). This study aims to address possible benefits for public health. However, this study only considers active travel behavior and leaves some questions open with regard to total levels of physical activity. It could not be analyzed to what extent active travel contributes to the daily amount of physical activity. It might be the case that flexible working arrangements promote more exercise, as work from Texas showed (Sener and Reeder, 2014), but they could also replace other kinds of physical activity. Although active travel is only part of all physical activities, the analyses provide at least the insight that core time and telework correlate with more active travel.

This study stands out because it uses the most recent nationwide available data for Switzerland to analyze different active travel patterns and consequences while controlling for relevant and new aspects. First, previously mostly neglected flextime was included as another flexible working arrangement that could positively impact active travel, as it loosens the time constraints imposed by gainful employment. The results are in favor of this argument. This study is the first to include different extents of schedule flexibility. Interestingly, it was core time as compared to fixed working hours that showed the most important impact on the usage of active modes of transport and for reaching sufficient amounts of physical activity. This is surprising, as core time only adds small temporal flexibility as compared to fully flexible working hours for instance. This insight is especially important for policy decisions because it reveals that even small opportunities to decide on the structure of one's day could have relevant impacts for public health. Second, BMI was included in this study and was found to be negatively associated with active travel behavior. This result cannot be interpreted causally but it might indicate that the physical condition on the target day might influence the decision to travel actively and, if so, for how long. It could indeed be that this is due to more efforts in walking and cycling but could also point to different habits. There is a need for future research with regard to the causality, as there are studies that argue that more active travel reduces the BMI in the long term (e.g. Dons et al., 2018) but also those that suggest that it is rather the BMI that determines decisions to travel actively (e.g. Kroesen and de Vos, 2020). Furthermore, the BMI itself is a somewhat simplified concept, as it does not differentiate between fat and muscles, and because it might be biased across different socio-demographics. However, it is quite feasible and can be easily captured in travel surveys, as many people know their height and weight. In this study, the usage of the BMI should not be problematic, because the models include many relevant variables as controls. Still, there is potential for future travel research that considers alternative concepts or additional control variables. In summary, the results suggest that the BMI (or some comparable concept) is an important control variable that should be considered in studies that aim to analyze the direct effect of flexible working arrangements on active travel patterns. Third, analyzing walking and cycling behavior separately leads to different insights. This is in line with research from Sweden that found contradictory impacts of telework on walking and cycling behavior respectively (Elldér, 2022). Furthermore, it becomes apparent that all studies, including this one, only considered walking and/or cycling. However, there is a variety of other active modes of transport, such as skateboards, kick scooters, or skates, whose association with flexible working arrangements has not been analyzed yet. Finally, the literature review also revealed that these large-scale studies based on representative micro-level data are only conducted in North America and Europe, so studies in other parts of the world will be important in the future. Additionally, flexible working arrangements are already quite well-established in Switzerland. But this is not yet the case for several countries around the world. It is supposable that the association between telework/ flextime and active travel behavior is similar in many countries – independently of the spread of flexible working arrangements. However, this is an empirical question that needs to be clarified in future studies. Moreover, this study used data from before the COVID-19 pandemic. Further research is needed in order to investigate if a lasting change in the spread of flexible working arrangements and the use of active modes of transport occurred as a result of the pandemic, and whether the conclusions drawn from this study still hold.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgement

This work was supported by the Swiss National Science Foundation (SNSF). Grant number: 188866. The funding source had no involvement in the preparation of this paper.

Appendix A. Supplementary material

Supplementary material to this article can be found online at https://doi.org/10.1016/j.tra.2023.103748.

References

Allen, T.D., Golden, T.D., Shockley, K.M., 2015. How effective is telecommuting? Assessing the status of our scientific findings. Psychol. Sci. Public Interest 16 (2), 40–68.
Black, W.R., 2001. An unpopular essay on transportation. J. Transp. Geogr. 9, 1–11.
Buehler, R., Pucher, J., Merom, D., Bauman, A., 2011. Active Travel in Germany and the U.S. Contributions of Daily Walking and Cycling to Physical Activity. Am. J. Prev. Med. 41 (3), 241–250.
Caldarola, B., Sorrell, S., 2022. Do teleworkers travel less? Evidence from the English National Travel Survey. Transport. Res. A: Pol. Pract. 159, 282–303.
Chakrabarti, S., 2018. Does telecommuting promote sustainable travel and physical activity? J. Transp. Health 9, 19–33.
Cook, S., Stevenson, L., Aldred, R., Kendall, M., Cohen, T., 2022. More than walking and cycling: What is "active travel"? Transp. Policy 126, 151–161.
de Abreu e Silva, J., Melo, P.C.,, 2018. Does home-based telework reduce household total travel? A path analysis using single and two worker British households. J. Transp. Geogr. 73, 148–162.
de Nazelle, A., Nieuwenhuijsen, M.J., Antó, J.M., Brauer, M., Briggs, D., Braun-Fahrlander, C., Cavill, N., Cooper, A.R., Desqueyroux, H., Fruin, S., Hoek, G., Int Panis, L., Janssen, N., Jerrett, M., Joffe, M., Andersen, Z.J., van Kempen, E., Kingham, S., Kubesch, N., Leyden, K.M., Marshall, J.D., Matamala, J., Mellios, G., Mendez, M., Nassif, H., Ogilvie, D., Peiró, R., Pérez, K., Rabl, A., Ragettli, M., Rodríguez, D., Rojas, D., Ruiz, P., Sallis, J.F., Terwoert, J., Toussaint, J.-F., Tuomisto, J., Zuurbier, M., Lebret, E., 2011. Improving health through policies that promote active travel: A review of evidence to support integrated health impact assessment. Environ. Int. 37 (4), 766–777.
de Vos, D., Meijers, E., van Ham, M., 2018. Working from home and the willingness to accept a longer commute. Ann. Reg. Sci. 61, 375–398.
Dons, E., Rojas-Rueda, D., Anaya-Boig, E., Avila-Palencia, I., Brand, C., Cole-Hunter, T., de Nazelle, A., Eriksson, U., Gaupp-Berghausen, M., Gerike, R., Kahlmeier, S., Laeremans, M., Mueller, N., Nawrot, T., Nieuwenhuijsen, M.J., Orjuela, J.P., Racioppi, F., Raser, E., Standaert, A., Int Panis, L., Götschi, T., 2018. Transport mode choice and body mass index: cross-sectional and longitudinal evidence from a European-wide study. Environ. Int. 119, 109–116.
Elldér, E., 2020. Telework and daily travel: new evidence from Sweden. J. Transp. Geogr. 86, 102777.
Elldér, E., 2022. Active travel and telework in Sweden: teleworkers walk more, but cycle less. Transp. Res. D: Transp. Environ. 109, 103362.
Furie, G.L., Desai, M.M., 2012. Active transportation and cardiovascular disease risk factors in U.S. adults. Am. J. Prev. Med. 43 (6), 621–628.
Garden, B., 2012. Telecommuting travel behavior: Examining the influence of work status on distance and mode choice in the National Capital Region. Open Access Dissertations and Theses. McMaster University Paper.
Gibson-Moore, H., 2019. UK chief medical officers' physical activity guidelines 2019: What's new and how can we get people more active? Nutr. Bull. 44 (4), 320–328.
Habinger, J.G., Chávez, J.L., Matsudo, S.M., Kovalskys, I., Gómez, G., Rigotti, A., Sanabria, L.Y.C., García, M.C.Y., Pareja, R.G., Herrera-Cuenca, M., Zimberg, I.Z., Guajardo, V., Pratt, M., Bolados, C.C., Valenzuela, C.F., Marques, A., Peralta, M., Leme, A.C.B., Fisberg, M., Werneck, A.O., Silva, D.R.d., Ferrari, G., on behalf of the ELANS Study Group, 2020. Active transportation and obesity indicators in adults from Latin America: ELANS Multi-Country Study. Int. J. Environ. Res. Public. Health 17(19), 6974.
Hook, A., Court, V., Sovacool, B.K., Sorrell, S., 2020. A systematic review of the energy and climate impacts of teleworking. Environ. Res. Lett. 15, 093003.
Kim, S.-N., 2017. Is telecommuting sustainable? An alternative approach to estimating the impact of home-based telecommuting on household travel. Int. J. Sustain. Transp. 11 (2), 72–85.
Kroesen, M., De Vos, J., 2020. Does active travel make people healthier, or are healthy people more inclined to travel actively? J. Transp. Health 16, 100844.
Lachapelle, U., Tanguay, G.A., Neumark-Gaudet, L., 2018. Telecommuting and sustainable travel: reduction of overall travel time, increases in non-motorised travel and congestion relief? Urban Stud. 55, 2226–2244.
Laverty, A.A., Mindell, J.S., Webb, E.A., Millett, C., 2013. Active travel to work and cardiovascular risk factors in the United Kingdom. Am. J. Prev. Med. 45 (3), 282–288.
Martin, A., Suhrcke, M., Ogilvie, D., 2012. Financial incentives to promote active travel. An evidence review and economic framework. Am. J. Prev. Med. 43(6), e45–e57.
Merom, D., van der Ploeg, H.P., Corpuz, G., Bauman, A.E., 2010. Public health perspectives on household travel surveys. Active travel between 1997 and 2007. Am. J. Prev. Med. 39 (2), 113–121.
Mokhtarian, P., 1991. Telecommuting and travel: State of the practice, state of the art. Transportation 18 (4), 319–342.
Ozbilen, B., Wang, K., Akar, G., 2021. Revisiting the impacts of virtual mobility on travel behavior: an exploration of daily travel time expenditures. Transp. Res. A: Pol. Pract. 145, 49–62.
Panik, R.T., Morris, E.A., Voulgaris, C.T., 2019. Does walking and bicycling more mean exercising less? Evidence from the U.S. and the Netherlands. J. Transp. Health 15, 100590.
Pendyala, R.M., Goulias, K.G., Kitamura, R., 1991. Impact of telecommuting on spatial and temporal patterns of household travel. Transportation 18, 383–409.
Petrunoff, N., Rissel, C., Wen, L.M., 2016. The effect of active travel interventions conducted in work settings on driving to work: a systematic review. J. Transp. Health 3 (1), 61–76.
Pucher, J., Buehler, R., Bassett, D.R., Dannenberg, A.L., 2010. Walking and cycling to health: a comparative analysis of city, state, and international data. Am. J. Publ. Health 100 (10), 1986–1992.
Ravalet, E., Rérat, P., 2019. Teleworking: Decreasing mobility or increasing tolerance of commuting distances? Built Environ. 45, 582–602.
Saunders, L.E., Green, J.M., Petticrew, M.P., Steichbach, R., Roberts, H., 2013. What are the health benefits of active travel? A systematic review of trials and cohort studies. PLoS ONE 8 (8), e69912.
Saxena, S., Mokhtarian, P.L., 1997. The impact of telecommuting on the activity spaces of participants. Geogr. Anal. 29 (2), 124–144.

Schneider, H., Venetz, W., 2014. Cost of obesity in Switzerland 2012. Studie im Auftrag des BAG. Federal Office for Public Health, Bern.
Sener, I.N., Reeder, P.R., 2014. An integrated analysis of workers' physically active activity and active travel choice behavior. Transp. Res. A: Policy Pract. 67, 381–393.
Stewart, G., Anokye, N.K., Pokhrel, S., 2016. Quantifying the contribution of utility cycling to population levels of physical activity: an analysis of the Active People Survey. J Public Health (Oxf) 38 (4), 644–652.
Sulikova, S., Brand, C., 2022. Do information-based measures affect active travel, and if so, for whom, when and under what circumstances? Evidence from a longitudinal case-control study. Transp. Res. A: Policy Pract. 160, 219–234.
Swiss Federal Statistical Office and Swiss Federal Office for Spatial Development ARE, 2017a. Dataset: Mobility and Transport Microcensus 2015. Bundesamt für Statistik und Amt für Raumentwicklung, Bern.
Swiss Federal Statistical Office and Swiss Federal Office for Spatial Development ARE, 2017b. Verkehrsverhalten der Bevölkerung. Ergebnisse des Mikrozensus Mobilität und Verkehr 2015. Neuchâtel and Bern: BFS-Nummer: 840–1500.
Tajalli, M., Hajbabaie, A., 2017. On the relationships between commuting mode choice and public health. J. Transp. Health 4, 267–277.
Wang, K., Ozbilen, B., 2020. Synergistic and threshold effects of telework and residential location choice on travel time allocation. Sustain. Cities Soc. 63, 102468.
Wanner, M., Götschi, T., Martin-Diener, E., Kahlmeier, S., Martin, B.W., 2012. Active transport, physical activity, and body weight in adults: a systematic review. Am. J. Prev. Med. 42 (5), 493–502.
Warburton, D.E., Nicol, C.W., Bredin, S.S., 2006. Health benefits of physical activity: the evidence. Can. Med. Assoc. J. 174 (6), 801–809.
Winters, M., Buehler, R., Götschi, T., 2017. Policies to promote active travel: evidence from reviews of the literature. Curr. Envion. Health Rep. 4, 278–285.
Wöhner, F., 2022. Work flexibly, travel less? The impact of telework and flextime on mobility behavior in Switzerland. J Transp. Geogr. 102, 103390.
World Health Organization, 2010. Global Recommendations on Physical Activity for Health. World Health Organization, Geneva.
Zhu, P., Mason, S.G., 2014. The impact of telecommuting on personal vehicle usage and environmental sustainability. Int. J. Environ. Sci. Technol. 11, 2185–2200.