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The role of pre-COVID-19 commuting distance and mode choices

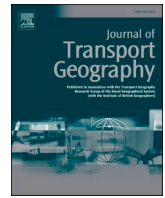Tao, Yinhua; Petrović, Ana; van Ham, Maarten

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Working from home and subjective wellbeing during the COVID-19 pandemic: The role of pre-COVID-19 commuting distance and mode choices

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ABSTRACT

Working from home (WFH) was prevalent among previous daily commuters during the COVID-19 pandemic and is expected to continue in post-COVID-19 society. By using WFH enforced by the UK government during the pandemic as a real-world experiment, our study investigates the relationship between switching from commuting to WFH, and subjective wellbeing (SWB). Particular interest lies in determining the extent to which this relationship depends on homeworkers' commuting behaviours prior to the COVID-19 outbreak. The data we used is from a COVID-19 panel survey on UK workers who were born in 1970. Results from the between-individual analysis and fixed-effect analysis show that the transition to WFH was not indicative of life satisfaction but it was conducive to affective wellbeing in the short term. This positive effect on affective wellbeing became insignificant after specific experiences of WFH were taken into account; that is, positive homeworking experiences were a result of strong social support, healthy lifestyles and stable financial circumstances during the pandemic. Crucially, the impact of switching to WFH on SWB was moderated by the pre-pandemic commuting behaviour. Previous long-distance commuters (one-way commuting distance >30 miles) reported better affective wellbeing when they could work from home, while commuters who had frequently walked or cycled to work had worse SWB outcomes after switching to WFH.

1. Introduction

Working from home (WFH) is not a new concept. It emerged in the 1970s when telecommuting technologies allowed workers to complete job tasks remotely and reduce regular travel between their homes and workplaces (Nilles, 1976). Since the outbreak of the COVID-19 crisis, WFH has become a common practice as governments around the world encourage or enforce homeworking as a way of suppressing the spread of coronavirus and ensuring the continuity of economic activities. In the UK, around half of the working population carried out some work at home during the COVID-19 pandemic, while prior to the pandemic, only 5.1% of the working population were routine homeworkers (Cameron, 2020). Leaving aside the heavy social, economic and health losses resulting from the COVID-19 crisis, WFH is regarded as a beneficial practice by transportation researchers given that it contributes to curtailing the operational costs of enterprises, decreasing the volume of traffic at rush hours and developing a more sustainable mobility system (Beck and Hensher, 2021).

From a person-centred perspective, research evidence is mixed regarding if the sudden transition to WFH is conducive to homeworkers' subjective wellbeing (SWB) during the pandemic. An increasing body of evidence has shown that people generally perceive WFH as a positive experience during COVID-19 lockdowns (Beck et al., 2020; Brodeur et al., 2021; Davillas and Jones, 2021). Besides reducing COVID-19 exposure risks as homeworkers, people attach great importance to the flexibility of their workplace and autonomy in their work-life schedule, which can be better fulfilled by working at home than at the official workplace (De Haas et al., 2020). In addition, evidence from lifestyle research indicates that teleworking is beneficial to health and SWB because homeworkers are left with more time and energy to prepare healthy foods, take frequent exercises and get enough sleep compared with regular commuters (Giovanis and Ozdamar, 2021; Fukumura et al., 2021). However, debates around this issue suggest that specific stay-at-home experiences account for homeworkers' SWB outcomes during the pandemic. Drawing upon the job demands-resources model, occupational health research shows that workplace wellbeing concerns the balance between the demands of remote work and the resources available to offset losses in SWB (Galanti et al., 2021; Meyer et al., 2021). On

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the demand side, work-family conflicts, such as the imbalance between pervasive workloads and demanding household chores, are salient after switching to WFH. This could cause distraction and undermine home-workers' productivity, thereby leading to dissatisfaction and psychological stress (Shamshiripour et al., 2020). On the resource side, social support from family and colleagues helps to combat loneliness and sustain social connection during the pandemic (Rubin et al., 2020). Also, appropriate home workspaces and financially secure jobs constitute resources for the maintenance of productivity and happiness.

Despite much discussion on homeworking experiences during the pandemic, less is known about the extent to which the effects of switching to WFH on SWB vary by homeworkers' pre-pandemic commuting patterns. In our study, governmental directives on WFH during the pandemic provide a real-world experiment, which can be used to examine how reduced or cancelled commuting journeys reshape people's SWB outcomes. The answer to this question will contribute to a better understanding of the causal relationship between commuting behaviours and SWB outcomes, in other words, the impact of long and motorised commutes on affective happiness and cognitive satisfaction. To date, the findings for commuting-SWB causality are inconsistent despite an increasing number of longitudinal studies on this topic (Chatterjee et al., 2020; Tao et al., 2022). Based on the exogenous workplace intervention experienced by a majority of the working population during the COVID-19 pandemic, we assume that if commutes do exert a significant effect on SWB, pre-pandemic commuters who travelled long distances to work would become better off in SWB outcomes after switching to WFH, while those who cycled or walked to work would miss the benefits of active commuting by experiencing reduced levels of SWB.

The aim of our study is to investigate the causal effects of commuting behaviours on SWB outcomes in the circumstance of transition from commuting to WFH due to the lockdowns during the COVID-19 pandemic. To achieve this aim, we used a longitudinal research design in the UK to analyse how the effects of switching to WFH on SWB outcomes during the COVID-19 pandemic depend on people's commuting distance and mode choices before the pandemic. The remainder of this paper is organised as follows. Section 2 presents a brief review of the longitudinal evidence on the commuting-SWB relationship. Section 3 introduces the data source, sample selection and modelling methods used in this study, followed by the model results of the between-individual analysis and the within-individual analysis in Section 4. In Section 5, we discuss the main findings of this study and the implications for transport geography research as well as for workplace arrangements in post-COVID-19 society.

2. Longitudinal evidence on the commuting-SWB relationship

The notion that travel is wasteful in itself is embedded in transportation research and planning: the only goal of, for example, travelling to work is to reach the workplace and perform job tasks. Based on this notion, job seekers strive to minimise commuting time by using motorised means of transport on the one hand, and to expand job choices by reaching more distant workplaces on the other hand (Banister, 2011). This has resulted in a greater spatial division between job and housing locations, along with the dominant car use for commuting journeys, over the last few decades. The long-distance motorised commuting pattern is environmentally unsustainable, given the challenges of massive carbon emissions, intensified energy consumption and heavy traffic congestion (Banister, 2008).

In recent years, a growing body of longitudinal studies has investigated whether longer commuting journeys are causally related to people's SWB outcomes by analysing within-individual changes in commuting and SWB over time. However, the results from these longitudinal studies are far from consistent (Chatterjee et al., 2020; Tao et al., 2022). Some studies find that individuals whose commuting journeys grow longer become worse off in SWB, because they underestimate the

emotional spill-overs (e.g., commuting stress leaking into work and family life) and resource constraints (e.g., little time available for exercises, sleeping and other daily activities) which can result from daily commutes (Stutzer and Frey, 2008; Wheatley, 2014; Ingenfeld et al., 2019; Tao et al., 2023b). Other longitudinal studies do not observe a systematic commuting-SWB relationship and ascribe this result to the utility equilibrium. Simply put, individuals will accept longer commutes only if they are compensated by a better job or housing, resulting in equivalent levels of SWB between individuals (Dickerson et al., 2014; Lorenz, 2018; Clark et al., 2020). Alongside the role of commuting time and distance, there is evidence suggesting that commuting mode choices exert an independent effect on SWB, and especially that a mode shift to cycling or walking leads to greater psychological health and life satisfaction (Martin et al., 2014; Jacob et al., 2021).

In addition to the instrumental role in accessing the workplace, commuting can be valued in its own right. Jain and Lyons (2008) consider travel as a gift because it provides a transition opportunity (the experience of distance when switching roles between family and work life) and an opportunity for 'time out' (the escape from family and job obligations). More specifically, Ory and Mokhtarian (2005) summarise the positive utility of daily commutes as an adventure- and variety-seeking, a sign of independence and freedom, a symbol of status and control, a form of escape and a transitional buffer, and a way of exercise and environmental exposure. Active commuting, such as cycling or walking to work, can easily integrate physical activity into daily routines and expose people to environmental and social amenities. This may explain why active commuters report better SWB outcomes in previous longitudinal studies. During the COVID-19 pandemic, people who follow the stay-at-home order are found to undertake more undirected travel by cycling and walking for recreation (De Vos, 2020), which lends support to the positive utility derived from the active travel experience.

The positive utility of commuting is also evidenced by telecommuting and teleportation studies. Before the COVID-19 pandemic, telecommuting or WFH was not common but only possible for a minority of working populations (e.g., information technology engineers and web-aid workers). To examine the commuting utility, transport researchers designed a "teleportation test", asking respondents to imagine if they are willing to teleport to the workplace with zero commuting time (Mokhtarian and Salomon, 2001; Humagain and Singleton, 2020). Their results show that although around two-thirds of the respondents prefer teleportation, the remaining respondents state a desire for spending some time for daily commutes, especially when they can walk or cycle to work in short distances. Notably, the ability of telecommuting may not spontaneously encourage short-distance commuting in the long term. The reason is that homeworkers may relocate to more desirable housing farther away from their workplaces, or choose a better job in a larger search area around the place of residence (Ory and Mokhtarian, 2006; Zhu, 2013; Tao et al., 2023a).

After the COVID-19 outbreak, governmental directives on WFH were imposed on a large number of working populations. This established a natural experiment in which homeworkers were given the opportunity to reflect on the experienced utility of their previous commuting journeys (Kroesen, 2022). This experimental design contributes to uncovering the commuting-SWB causality, compared with prior longitudinal designs that focus on within-individual analysis over time after controlling for any between-individual idiosyncratic confounders, for another two important reasons. First, the governmental stay-at-home order is an exogenous event. This exogenous intervention in reducing or cancelling regular commuting journeys precedes changes in SWB outcomes in time, which reduces the bias from reverse causality; that is, unhealthy and unhappy people are more likely to avoid commuting during the pandemic. Besides, commuters who switch to WFH are less likely to face losses in the job and housing markets compensating for the benefits of not commuting. Consequently, a net effect of (not) commuting on SWB can be better observed. Second, mandatory WFH during the pandemic creates an unstable context in which previous

commuters have to break their habitual commuting routines. This will trigger a reflective evaluation of SWB as homeworkers consciously compare the pros and cons of WFH and commuting to work. When WFH is experienced as satisfactory, people are likely to develop it into a habitual routine and decide not to go back to daily commuting, ultimately resulting in structural changes in commuting patterns and workplace arrangements in the post-COVID-19 era.

3. Data and methods

3.1. Data

Our study drew from a specially designed COVID-19 survey in the 1970 British Cohort Study (BCS70) that has been following the lives of people who were born in 1970 in the UK since their childhoods. The survey consists of three waves, with each wave corresponding to specific contexts of the COVID-19 prevalence and lockdown policies in the UK (Fig. 1). Wave 1 took place in May 2020, a month after the government announced the first national lockdown and introduced the stay-at-home order in reaction to the initial peak of COVID-19 cases. Wave 2 took place from September to October 2020 when the lockdown restrictions were eased and people were allowed to return to the workplace. Wave 3 took place between February and March 2021, just after the UK entered the third national lockdown and new confirmed COVID-19 cases escalated to over 50,000 per day. To retrieve the baseline measures before the COVID-19 outbreak, we linked the COVID-19 survey to the latest BCS70 survey wave that was conducted between 2017 and 2019 (denoted as 'the pre-COVID-19 wave' in our study).

Given our interest in the impact of switching from commuting to WFH, our study selected 2800 participants from the COVID-19 survey according to the following criteria: Participants always commuted to work before the pandemic, stay employed and did not change jobs during the pandemic, have no missing values in research variables, and have completed at least two waves of the COVID-19 survey. That is to say, our study sample was composed of an unbalanced panel of participants, with 1452 (51.9%) appearing in all three waves and 1348

(48.1%) in two waves, to reduce attribution bias from longitudinal sampling.

Here, we make two justifications for the sample selection process, and leave possible selection biases further discussed in the Research Limitations. First, participants who worked from home before the pandemic were dropped from the analysis because they only represented a small proportion of the working population (7.6% of the participants in the pre-COVID-19 wave of BCS70 as frequent homeworkers), and their work locations changed little following the COVID-19 outbreak (i. e., maintaining WFH). Second, we excluded participants who stopped work after the COVID-19 outbreak. Compared with participants who continued to work, unemployed workers tended to be self-employed and work in service, trades or elementary operations (Appendix Table A1). Their occupational characteristics, such as weak resistance to the crisis and the on-site operations required, mean that WFH is not a viable option for them, so we cannot examine their changes in SWB outcomes caused by switching to WFH. Moreover, we compared the pre-pandemic commuting behaviours of participants who continued to work versus those who stopped work after the COVID-19 outbreak (Table A1). There is little evidence that long-distance or public transport commuters were more likely to stop work during the pandemic. Therefore, the analysis of how WFH-SWB relationships depend on pre-pandemic commuting behaviours is less likely to be biased when unemployed workers are excluded from the analysis.

Table 1 shows the socioeconomic characteristics of all research participants and WFH participants. Generally, 60.2% of the research participants had experience with WFH in at least one wave of the COVID-19 survey. Research participants are socioeconomically representative of the 1970 cohort, except that women are mildly over-represented (55.4% female versus 44.6% male). Most of the participants are married, do not have school-aged children, own a house with more than one room per person, and reside in urban areas. Compared with all research participants, WFH participants are more likely to be well-educated, have a high income and work as managers or professionals, indicating that our findings for the effect of switching to WFH on SWB are specific to those people who are able to work from home during the
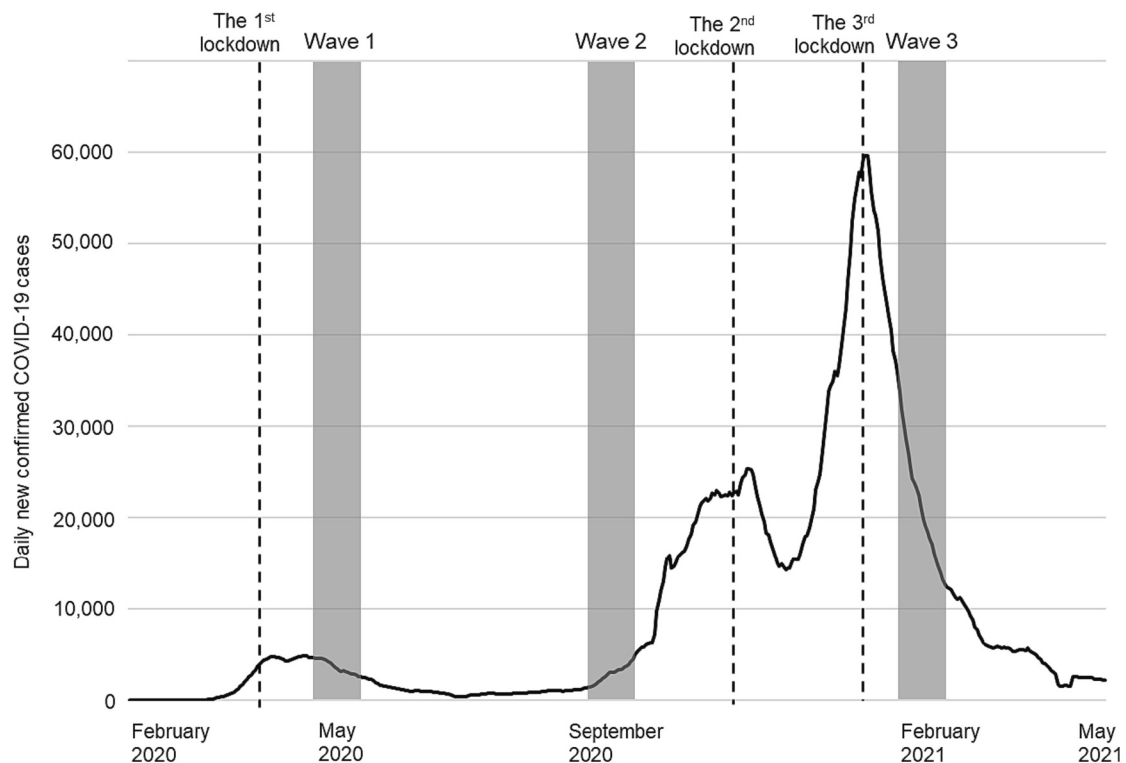

Fig. 1. Timeline of the COVID-19 survey and national lockdown restrictions with the number of daily new confirmed COVID-19 cases in the UK.

Table 1

Participants' socio-economic characteristics at the pre-COVID-19 wave.

		All participants (N = 2800)	WFH participants (N = 1686)
Sex	Men	44.6	43.4
	Women	55.4	56.6
Qualification	General Certificate of Secondary Education (GCSE)	49.1	36.8
	Intermed	16.5	17.1
	Degree+	34.4	46.1
Occupation	Managers or professionals	53.2	68.3
	Service workers or operatives	46.8	31.1
Income (GBP/week)	≤ 500	25.0	20.7
	501–1000	43.0	39.7
	> 1000	32.0	39.6
Marital status	Married	67.5	69.3
	Other	32.5	30.7
Presence of school-aged children	≥ 1 child aged 6–12	18.3	21.0
	No child aged 6–12	81.7	79.0
Housing tenure	Self-owned	85.5	89.2
	Other	14.5	10.8
Housing condition	> 1 room/person	84.9	85.2
	≤ 1 room/person	15.1	14.8
Residential area	Urban	85.1	84.1
	Rural	14.9	15.9

Note. Results are shown in %.

COVID-19 pandemic.

3.2. Measures

The outcome variable is subjective wellbeing (SWB), including both affective and cognitive evaluations of SWB for each wave of the survey. The indicator of affective wellbeing was derived from the nine-item Malaise inventory. It incorporates nine dichotomous items (i.e., yes or no questions) to assess the prevalence of affective symptoms (i.e., feeling tired, depressed, worried, violent, scared, upset, jittery, nervous or angry) in participants' daily lives. A score of 4 or more affective symptoms is regarded as a sign that participants are experiencing a depressive symptom (Elliott and Shepherd, 2006). In our study, the 0 or 1 score of each item was aggregated and then reversed to 0 to 9 so that higher scores refer to greater affective wellbeing (or fewer affective symptoms). Cognitive wellbeing was measured by the single life satisfaction item. Participants were asked by the question: "Overall, how satisfied are you with your life nowadays?" The answer was rated from 0 to 10, with higher scores representing greater cognitive wellbeing (or higher levels of life satisfaction).

The key explanatory variables are the work locations during the pandemic on the one hand, and commuting behaviours before the pandemic (i.e., commuting distance and mode choices) on the other. The variable of work locations was taken from the three-wave COVID-19 survey and was dichotomised as switching to working from home (WFH; completely working from home or working some days at home and some days at employers' premises) and maintaining commuting to work (CTW; working at employers' premises). The variable of commuting behaviours was taken from the pre-COVID-19 wave of BCS70 and was collated by asking participants whether they had changed their commuting behaviours between the pre-COVID-19 wave and the COVID-19 survey. The one-way commuting distance was categorised as ≤5, 6–15, 16–30, or > 30 miles. According to Lorenz (2018) and Ingenfeld et al. (2019), this categorisation scheme performs well in removing the outliers in distance records and examining the non-linear

impact of commuting distance on SWB. Commuting mode choices were measured by the frequency of using the following means of transport to travel to work: car, public transport, bicycle and walking. The answer to each commuting mode was dichotomised as frequent mode use (e.g., always or usually commuting by car) or infrequent mode use (e.g., occasionally or never commuting by car).

There are five subsets of covariates. Baseline socio-economic characteristics were retrieved from the pre-COVID-19 wave, including sex, income, employment type, occupation, presence of a partner, and presence of school-aged children. The second subset is pre-COVID-19 SWB and the level of potential risks from COVID-19 (chronic diseases and risk awareness). The other three subsets of covariates varied between the three survey waves, including homeworking status and environment (financial status, working hours and the number of rooms per person), social support (satisfaction with partner relationships and support from other people), and daily lifestyles (frequency of exercises, healthy eating habits and sleeping hours). Area- and time-fixed effects were also taken into account by including the urban/rural dichotomy and three survey waves, respectively. The detailed variable settings are provided in Table A2.

4. Methods

The probabilistic theory of causality is often used in travel behaviour research to design modelling strategies. According to the probabilistic theory, "one event is the cause of another if the appearance of the first event is followed with a high probability by the appearance of the second, and there is no third event that we can use to factor out the probability relationship between the first and the second events" (Suppes, 1970). This points to two methodological conditions required for identifying a causal relationship, that is, the time precedence between exposures (e.g., commuting behaviours) and outcomes (e.g., SWB), and the exclusion of any other confounders. Our study is based on this probabilistic approach to investigate the causal relationship between commuting behaviours and SWB outcomes. This is done by examining how the wellbeing effect of switching between CTW and WFH depends on the pre-pandemic commuting behaviours in two modelling steps, i.e., the between-individual analysis pre-post the COVID-19 outbreak and the within-individual analysis between enforcing and easing lockdown restrictions during the COVID-19 pandemic (Fig. 2).

The between-individual analysis pooled the three-wave observations and used ordinal logistic regression models to examine between-individual variances in SWB (Formula 1). Robust standard errors were clustered at the individual level due to repeated sampling between survey waves. The models followed a step-by-step design. Model 1 investigated the association of switching from CTW (before the COVID-19 pandemic) to WFH with SWB outcomes after the onset of the pandemic. This association was established after controlling for pre-pandemic SWB and baseline socioeconomics, so the condition of time precedence between (not) commuting and SWB was met to infer causal relationships. Model 2 incorporated the variables of homeworking status and environment, social support, and daily lifestyles to recognise under which conditions switching to WFH was associated with SWB. Model 3 further built the interaction terms between WFH and the variables of commuting behaviours to study whether and how the wellbeing effect of switching to WFH was moderated by pre-pandemic commuting distance and mode choices.

$$logit(SWB_{i,t}) = \alpha X_{i,(t)} + \beta WFH_{i,t} + \gamma WFH_{i,t} \times CB_i + \epsilon_i \quad (1)$$

Where $logit(SWB_{i,t})$, the cumulative probability of each ordinal response to SWB measures for the participant i at the survey wave t, is a function of a vector of time-varying and time-invariant covariates $X_{i,(t)}$, the variable of switching to WFH after the COVID-19 outbreak $WFH_{i,t}$, the interaction terms between $WFH_{i,t}$ and pre-pandemic commuting
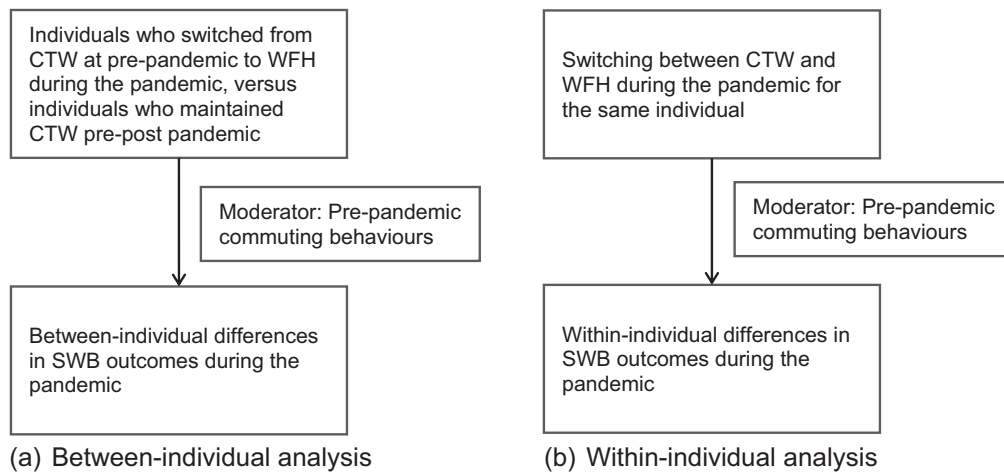
Fig. 2. The two-step model design.
Note. The between-individual analysis adjusted for baseline and time-varying covariates, while the within-individual analysis only controlled for time-varying covariates at the within-individual level.

behaviours CB_i, and a person-specific error term ϵ_i.

The within-individual analysis used the fixed-effect ordinal logistic models to examine within-individual variances in SWB between the three waves of the COVID-19 survey (Formula 2). The fixed-effect models, rather than the random-effect models, were chosen because the result from the Hausman test rejected that the time-invariant unobserved term is uncorrelated with the covariates (chi-squared(16) = 151.01, $p = 0.00$). For this reason, estimates from the fixed-effect models should be interpreted as the population-averaged (or marginal) effects irrespective of the random individual-specific effects (Gibbons et al., 2010). In other words, the model results indicate the wellbeing effect of switching between CTH and WFH during the pandemic averaged over the pre-COVID-19 commuting population. Compared with the between-individual analysis, the within-individual analysis performed better in inferring commuting-SWB causality because any unobserved time-invariant confounders between individuals were considered. Besides, by focusing on within-individual changes in SWB after the COVID-19 outbreak, the shock of coronavirus itself was isolated from abruptly undermining SWB. Changes in work locations (i.e., CTW or WFH) were thus attributed to exogenous lockdown restrictions rather than self-selective WFH for fear of coronavirus, indicating no serious problem of reverse causality. In the fixed-effect models, we incorporated all time-varying variables, including work locations, homework status and environment, social support and daily lifestyles, to explain within-individual changes in SWB during the pandemic.

$$logit\left(SWB_{i,t}\right) = \alpha X_{i,t} + \beta WFH_{i,t} + \gamma WFH_{i,t} \times CB_i + \delta_{i,t} + \varepsilon_i \qquad (2)$$

Where $logit\left(SWB_{i,t}\right)$ is a function of a vector of time-varying covariates $X_{i,t}$, the variable of work locations (WFH or CTW) during the COVID-19 pandemic $WFH_{i,t}$, the interaction terms between $WFH_{i,t}$ and pre-pandemic commuting behaviours CB_i, a within-individual time-varying error term $\delta_{i,t}$, and a between-individual time-invariant unobserved term ε_i.

Several sensitivity analyses were performed to test for the robustness of the relationships between switching to WFH and SWB outcomes, as well as the moderating effects of pre-pandemic commuting behaviours. First, we conducted the approximate likelihood-ratio test of proportionality of odds, given the ordinal measures of SWB outcomes. The Wald statistics did not support that the proportional odds assumption was violated at the significance $p < 0.05$, so the ordinal logistic models are methodologically appropriate. Additionally, we dichotomized the outcomes of affective wellbeing (≥ 6 or not) and life satisfaction (≥ 6 or not), and constructed the fixed-effect binary logistic models. The breaking points of SWB outcomes were determined by the results for the

marginal effects of switching to WFH and the interactions with pre-pandemic commuting behaviours on SWB outcomes. Second, we re-categorised the measure of work locations as WFH (completely working from home) and CTW (working at employers' premises, or working some days at employers' premises and some days at home), and then re-fitted the fixed-effect ordinal logistic models. This re-categorisation comes from the assumption that the wellbeing effects of completely and occasionally WFH could be different. Before fitting the above models, we calculated the variance inflation factor (VIF) values between independent variables to assess multi-collinearity. The results were all below 4.0 except between self-employment and poor financial status (VIF = 9.2), so we excluded the employment type variable in the models. All modelling analyses were conducted in STATA 17.

5. Results

5.1. Descriptive results

Table 2 shows the descriptive statistics of commuting behaviours, work locations and SWB before and after the COVID-19 outbreak. Among the 1970 cohort, around three-quarters of the participants travelled no >15 miles to work prior to the pandemic, while 10.1% of them had to commute over 30 miles to their workplaces. Despite the short commuting distance for most workers, 79.9% of the participants frequently commuted by car. By contrast, frequent public transport users, cyclists, and pedestrians accounted for 12.0%, 4.1%, and 12.8% of the participants, respectively. Considering the small number of cyclists, we grouped cyclists and pedestrians into active mode users in the following analysis. WFH became the new routine for roughly half of the 1970 cohort after the COVID-19 outbreak and subsequent lockdown measures. Although all participants regularly commuted to work before the pandemic, 59.3% of them occasionally or completely worked from home when the first national lockdown was enforced at Wave 1. After the lockdown was eased at Wave 2, the WFH proportion decreased to 46.7%, but quickly rebounded to 54.3% after the government reintroduced the stay-at-home order at Wave 3. In terms of temporal variances in SWB, participants' affective wellbeing and life satisfaction both declined throughout the pandemic. At Wave 1, particularly, participants reported mildly worse affective wellbeing when they worked at workplaces rather than at home.

After stratifying participants by their pre-pandemic commuting behaviours, we observed more clear patterns of the relationship between switching to WFH and the levels of SWB (Fig. 3). For long-distance commuters (one-way commuting distance >15 miles), the transition

Table 2
Descriptive statistics of commuting behaviours, work locations and subjective wellbeing.

Pre-pandemic commuting behaviours	Commuting distance	≤ 5 miles	6–15 miles	16–30 miles	> 30 miles
		41.9	32.7	15.4	10.1
	Commuting mode	Car	PT	Bicycle	Walking
		79.9	12.0	4.1	12.8
Survey waves		Pre-COVID-19 wave	Wave 1	Wave 2	Wave 3
Work locations	Working from home, WFH	0	59.3	46.7	54.3
	Commuting to work, CTW	100	40.7	53.3	45.7
Subjective wellbeing, SWB	Affective wellbeing	7.58 (1.82)	7.56 (1.79)	7.23 (1.97)	7.32 (1.95)
	WFH	–	7.64 (1.74)	7.27 (2.01)	7.35 (1.98)
	CTW	7.58 (1.82)	7.44 (1.85)	7.19 (1.93)	7.29 (1.90)
	Life satisfaction	7.66 (1.54)	7.40 (1.73)	7.31 (1.75)	6.96 (1.85)
	WFH	–	7.40 (1.68)	7.31 (1.77)	6.89 (1.80)
	CTW	7.58 (1.82)	7.40 (1.83)	7.32 (1.74)	7.03 (1.89)

Note. Results are shown in % or mean (standard deviation), and — represents the results not appliable.

to WFH was beneficial to their affective wellbeing, as indicated by the higher percentage of experiencing fewer than 4 affective symptoms among WFH participants compared to those who continued commuting to work. For short-distance commuters (one-way commuting distance ≤15 miles), however, there were negligible differences in affective wellbeing and life satisfaction whether they switched to WFH or maintained CTW. It is striking that pre-pandemic active commuters fare worse in both SWB outcomes after the transition to WFH. Conversely, the affective wellbeing of non-active commuters, especially public transport users, to some extent improved after WFH.

5.2. Model results

Table 3 presents the pooled ordinal logistic model results for examining between-individual variances in SWB. Model 1 shows that switching from commuting before the pandemic to WFH was associated with better affective wellbeing during the pandemic, but not related to higher levels of life satisfaction. To observe the long-term effect of WFH, we re-fitted Model 1 based on the subsample of those participants who completely worked from home in all three survey waves. The results, however, show that WFH was not significantly associated with the two SWB outcomes. After taking specific stay-at-home experiences into account, Model 2 indicates that the effect of switching to WFH on affective wellbeing became insignificant, suggesting the mediating effect of homeworking conditions. Specifically, a satisfied relationship with the partner, strong social support from others and adequate time to sleep were associated with greater affective wellbeing and life satisfaction, while worse financial situations were related to worse SWB outcomes. Besides this, participants who exercised more frequently reported higher
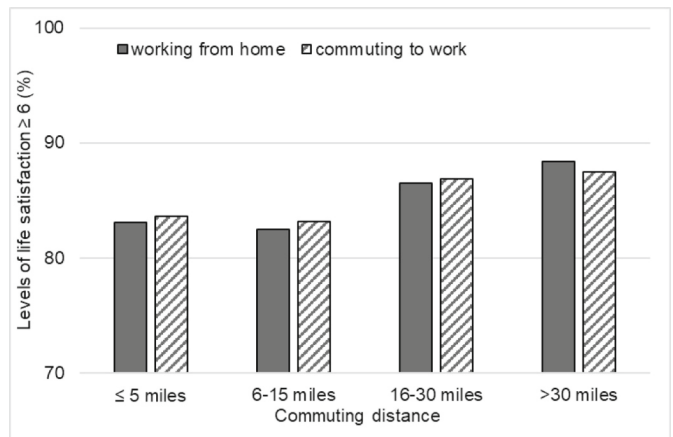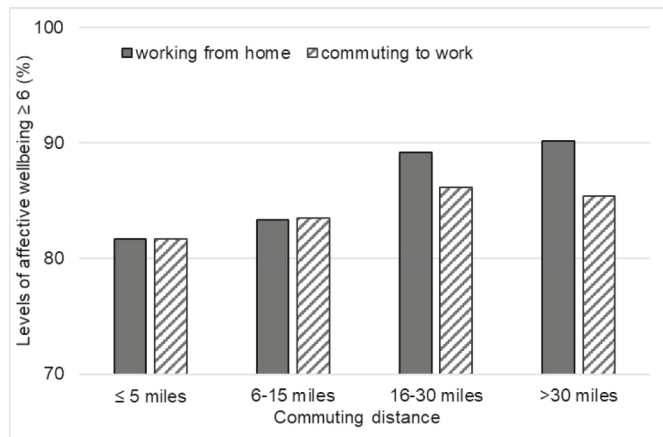
(a) WFH – affective wellbeing, by commuting distance

(b) WFH – life satisfaction, by commuting distance
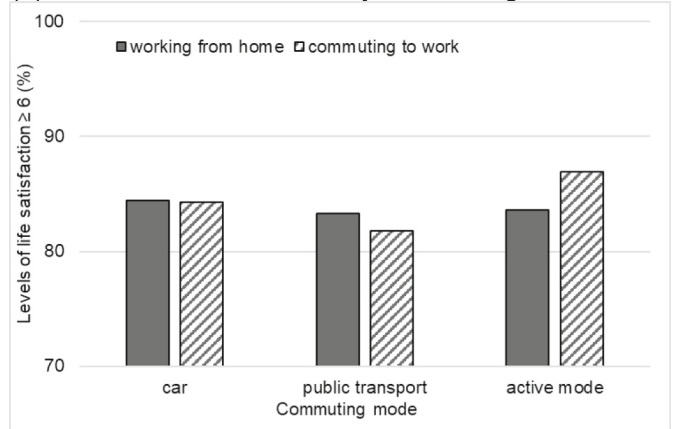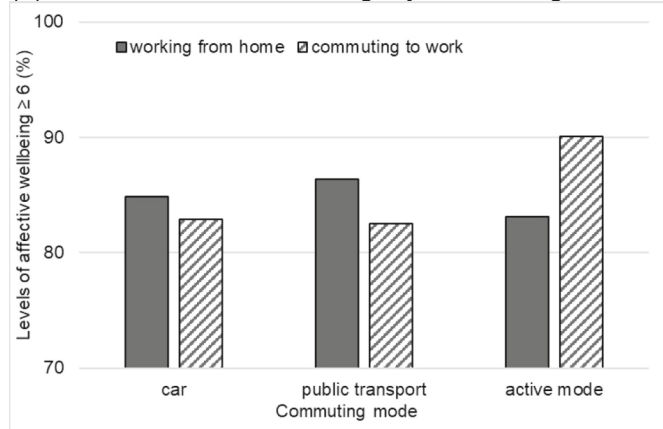
(c) WFH – affective wellbeing, by commuting mode

(d) WFH – life satisfaction, by commuting mode

Fig. 3. The two-way relationship between work locations and subjective wellbeing, stratified by pre-pandemic commuting distance and travel mode.

Table 3
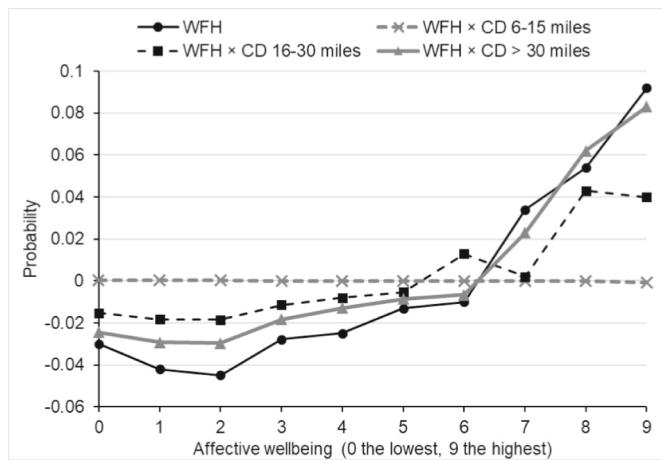Ordinal logistic models for between-individual variances in SWB.

	Model 1				Model 2				Model 3			
	Affective wellbeing		Life satisfaction		Affective wellbeing		Life satisfaction		Affective wellbeing		Life satisfaction	
	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
Work locations												
WFH (ref. CTW)	0.12*	0.06	−0.04	0.05	0.05	0.06	−0.07	0.06	0.44	0.26	0.03	0.11
Homework status and environment												
Worse financial status (ref. about the same)					−0.23**	0.07	−0.33**	0.06	−0.20**	0.07	−0.33**	0.06
Better financial status (ref. about the same)					0.11	0.06	0.14**	0.05	0.12*	0.06	0.15**	0.06
Working hours					−0.01	0.01	−0.01	0.01	−0.01	0.01	−0.01	0.01
> 1 room per person					0.15	0.08	−0.11	0.08	0.24	0.13	−0.11	0.08
Social support												
Satisfaction with partner relationships					0.07**	0.02	0.31**	0.02	0.07**	0.02	0.31**	0.02
Support from other people					0.12**	0.02	0.18**	0.02	0.11**	0.02	0.18**	0.02
Lifestyles												
Frequency of exercises					0.01	0.01	0.03*	0.01	0.02	0.01	0.03*	0.01
Healthy eating habit					0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01
Sleeping hours					0.30**	0.03	0.18**	0.03	0.30**	0.03	0.17**	0.03
WFH × Commuting distance (CD) (ref. WFH × CD ≤ 5 miles)												
WFH × CD 6–15 miles									−0.05	0.10	−0.07	0.09
WFH × CD 16–30 miles									0.03	0.12	−0.10	0.12
WFH × CD > 30 miles									0.28*	0.13	0.06	0.10
WFH × Commuting mode												
WFH × Car									0.05	0.10	0.02	0.10
WFH × Public transport									0.07	0.13	0.02	0.11
WFH × Active mode									−0.14*	0.06	−0.12	0.11
Socio-demographics												
Men (ref. women)	0.54**	0.11	0.11	0.06	0.63**	0.07	0.16*	0.06	0.54	0.30	0.17*	0.07
Income 501–1000 (ref. ≤ 500)	0.07	0.07	−0.16*	0.07	0.04	0.08	−0.22**	0.07	0.07	0.08	−0.19**	0.08
Income >1000 (ref. ≤ 500)	0.23**	0.09	−0.09	0.08	0.19*	0.09	−0.12	0.08	0.20*	0.09	−0.11	0.08
Manager or professionals	−0.08	0.06	−0.26**	0.08	−0.11	0.07	−0.31**	0.06	−0.07	0.06	−0.32**	0.06
Living with the partner	−0.19*	0.07	0.17	0.10	−0.59**	0.11	−0.96**	0.11	−0.54**	0.11	−0.97**	0.11
Living with the school-aged children	−0.03	0.08	−0.06	0.07	0.04	0.08	−0.02	0.07	0.08	0.08	−0.02	0.07
COVID-19 risks and pre-COVID-19 SWB												
Chronic physical diseases	−0.36**	0.06	−0.17**	0.06	−0.36**	0.06	−0.14*	0.06	−0.33**	0.06	−0.14*	0.06
Risk awareness towards COVID-19	0.09**	0.01	0.11**	0.02	0.09**	0.01	0.11**	0.02	0.10**	0.02	0.11**	0.01
Pre-COVID-19 affective wellbeing	0.68**	0.06	0.11**	0.02	0.66**	0.02	0.08**	0.02	0.67**	0.03	0.09**	0.02
Pre-COVID-19 life satisfaction	0.13**	0.03	0.50**	0.03	0.09**	0.02	0.42**	0.03	0.07**	0.02	0.42**	0.04
Area- and time-fixed effect												
Urban areas (ref. rural areas)	−0.15*	0.06	−0.03	0.08	−0.15*	0.07	−0.03	0.08	−0.12	0.08	−0.03	0.07
Wave 2 (ref. Wave 1)	−0.39**	0.03	−0.17**	0.04	−0.32**	0.05	−0.08	0.05	−0.35**	0.05	−0.07	0.05
Wave 3 (ref. Wave 1)	−0.23**	0.04	−0.58**	0.05	−0.19**	0.05	−0.52**	0.05	−0.21**	0.05	−0.52**	0.05
Pseudo R-squared	0.14		0.07		0.16		0.12		0.17		0.12	

Note. Results are shown in the regression coefficient (Coef.) and robust standard error (S.E.). Significance * $p < 0.05$, ** $p < 0.01$.

levels of life satisfaction during the pandemic.

In Model 3, we incorporated the interaction terms of switching to WFH with the pre-pandemic commuting distance on the one hand, and with the pre-pandemic commuting mode on the other, to analyse the moderating role of commuting behaviours. Conforming to the descriptive results, the model results support that pre-pandemic long-distance commuters benefited from WFH with better affective wellbeing, whereas previous active mode users valued their commuting journeys and reported worse affective wellbeing as homeworkers during the pandemic. This pattern became more clear by illustrating the marginal effects of the interactions between switching to WFH and pre-pandemic commuting behaviours in Fig. 4. Specifically, compared with the participants who continued CTW after the COVID-19 outbreak, WFH participants had an increased probability of reporting higher levels of

affective wellbeing, and especially, the probability of rating affective wellbeing levels >6 increased by 3.4%–9.2%. For previous long-distance commuters (> 15 miles), the probability of rating high levels of affective wellbeing (> 6) increased even more, while active mode users marginally decreased the likelihood of reporting the levels of affective wellbeing ≥6. Compared with the results for affective wellbeing, the marginal effects on life satisfaction were insignificant and milder in magnitude, except that those homeworkers who commuted >30 miles before the pandemic had a positive probability of reporting the levels of life satisfaction >7. A final note is that the fully adjusted model (Model 3) had a moderate model fit with pseudo R-square 0.17 and 0.12 for affective wellbeing and life satisfaction, respectively, indicating that SWB is a broad term involving the assessment on a myriad of life domains and the commuting domain does act as one of the daily hassles.
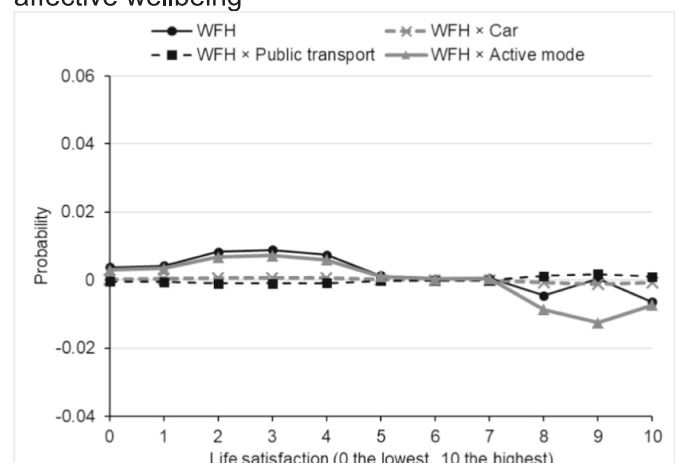
(a) Effects of WFH and WFH × commuting distance (CD) on affective wellbeing
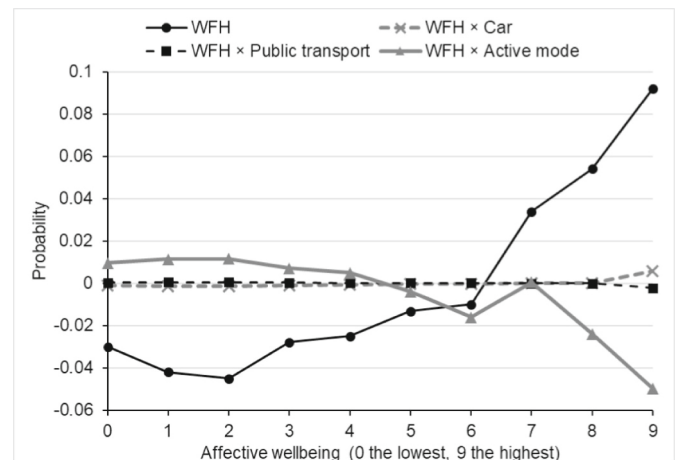
(b) Effects of WFH and WFH × commuting mode on affective wellbeing
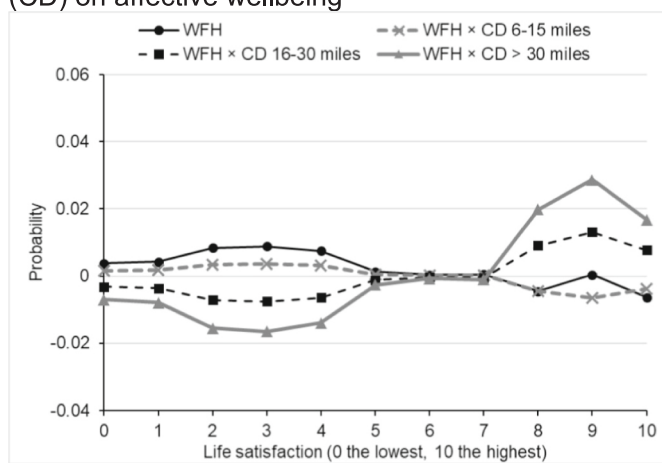
(c) Effects of WFH and WFH × commuting distance (CD) on life satisfaction

(d) Effects of WFH and WFH × commuting mode on life satisfaction

Fig. 4. Marginal effects of switching to WFH and the interaction with pre-pandemic commuting behaviours on SWB outcomes.

Table 4 presents the results of fixed-effect ordinal logistic models for examining within-individual variances in SWB during the pandemic. Compared with the pooled analysis in Table 3, the within-individual analysis improved the model fit after controlling for the time-invariant unobserved factors for different individuals. Results from the fixed-effects models corroborated the results from the pooled analysis — the mediation of specific stay-at-home experiences in the WFH-SWB relationship, better affective wellbeing for the pre-pandemic long-distance commuters who worked from home during the pandemic, and worse affective wellbeing for pre-pandemic active commuters after homeworking. Notably, two differences in the fixed-effect models further indicate the significant role of pre-pandemic commuting behaviours in moderating the WFH-SWB relationship. First, compared with short-distance commuters (≤ 5 miles), long-distance commuters (> 30 miles) had a much larger effect size (than that in the pooled analysis) in reporting better affective wellbeing when they switched from CTW to WFH between easing and enforcing lockdown restrictions during the pandemic. Second, the pre-pandemic active commuters performed worse in not only affective wellbeing but also life satisfaction when turning to homeworking. After fitting the fixed-effect models for the subsamples of male and female participants, we found that only long-distance female commuters (> 30 miles) reported greater affective wellbeing when they worked from home during the pandemic, while the effect of WFH on SWB was insignificant for previous long-distance male commuters.

The results of sensitivity analyses are shown in Appendix Table A3. In Model A1, we dichotomized SWB outcomes as the levels of affective wellbeing and life satisfaction ≥6 or not, respectively, based on the marginal effects illustrated in Fig. 3. Results from the fixed-effect binary logistic models were largely consistent with the fixed-effect analysis of the ordinal SWB measures. This adds further support to the result that the effect of switching to WFH on SWB outcomes depended on the commuting distance and mode choices at the pre-COVID-19 time. Also, the main results remained after we differentiated WFH on some days of the week and always WFH during the pandemic in Model A2.

6. Discussion and conclusions

6.1. Discussion of main findings

Transportation research suggests that WFH will be one of the most important structural changes in people's daily activities and travel behaviours that will last in post-pandemic society (Beck et al., 2020; Beck and Hensher, 2021). Drawing upon the real-world experiment of WFH enforced by the UK government after the COVID-19 outbreak, this longitudinal study investigated the relationship between switching to WFH and SWB outcomes during the pandemic and the moderating role of pre-pandemic commuting behaviours in this relationship. Our main findings are that WFH contributed little to improving life satisfaction during the pandemic but alleviated affective symptoms in the short term. The

Table 4
Fixed-effect ordinal logistic models for within-individual variances in SWB.

	Model 4				Model 5: Men				Model 6: Women			
	Affective wellbeing		Life satisfaction		Affective wellbeing		Life satisfaction		Affective wellbeing		Life satisfaction	
	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
Work locations												
WFH (ref. CTW)	0.65	0.38	0.04	0.14	0.86	0.53	0.03	0.20	0.54	0.49	0.07	0.16
Homework status and environment												
Worse financial status (ref. about the same)	−0.20*	0.10	−0.40**	0.08	−0.02	0.15	−0.35**	0.12	−0.31*	0.12	−0.36**	0.11
Better financial status (ref. about the same)	0.18*	0.08	0.04	0.07	0.38**	0.13	0.14	0.10	0.10	0.11	0.04	0.09
Working hours	−0.01	0.00	0.00	0.01	−0.02*	0.01	0.00	0.01	−0.01	0.01	−0.01	0.01
> 1 room per person	0.69**	0.18	0.04	0.13	0.47*	0.25	−0.33	0.19	0.77**	0.21	0.20	0.16
Social support												
Satisfaction with partner relationships	0.17**	0.02	0.38**	0.02	0.19**	0.04	0.44**	0.03	0.14**	0.03	0.34**	0.02
Support from other people	0.23**	0.03	0.27**	0.02	0.17**	0.04	0.26**	0.04	0.29**	0.03	0.28**	0.03
Lifestyles												
Frequency of exercises	0.08**	0.02	0.09**	0.02	0.06*	0.03	0.09**	0.02	0.08**	0.02	0.08**	0.02
Healthy eating habit	0.01	0.02	0.02	0.01	0.04	0.02	0.03*	0.02	0.01	0.02	0.01	0.02
Sleeping hours	0.47**	0.04	0.25**	0.03	0.37**	0.06	0.20**	0.05	0.47**	0.05	0.18**	0.04
WFH × Commuting distance (CD) (ref. WFH × CD ≤ 5 miles)												
WFH × CD 6–15 miles	0.02	0.19	−0.24	0.14	−0.10	0.30	0.04	0.23	0.12	0.22	−0.25	0.16
WFH × CD 16–30 miles	0.39	0.23	−0.18	0.17	0.42	0.36	−0.07	0.26	0.11	0.28	−0.14	0.21
WFH × CD > 30 miles	0.84**	0.27	0.03	0.20	0.51	0.35	0.11	0.26	0.74*	0.35	0.05	0.30
WFH × Commuting mode												
WFH × Car	0.03	0.26	−0.09	0.14	0.18	0.29	−0.01	0.19	0.07	0.27	−0.08	0.17
WFH × Public transport	−0.01	0.09	0.10	0.20	−0.04	0.13	0.14	0.29	0.02	0.11	0.04	0.26
WFH × Active mode	−0.20*	0.09	−0.36*	0.15	−0.20	0.13	−0.30*	0.16	−0.21*	0.09	−0.33	0.29
LR test (chi-squared(1), p)	978.6	0.00	802.7	0.00	897.2	0.00	653.3	0.00	934.4	0.00	719.9	0.00
R-squared, within	0.20		0.16		0.22		0.18		0.24		0.17	
R-squared, between	0.38		0.35		0.40		0.36		0.42		0.39	

Note. Results are shown in the regression coefficient (Coef.) and standard error (S.E.). Significance * $p < 0.05$, ** $p < 0.01$.

positive effect of WFH on affective wellbeing was ascribed to specific stay-at-home experiences, including strong social support, healthy lifestyles and stable financial circumstances. Moreover, daily commuting behaviours are causally related to long-term SWB outcomes considering that pre-pandemic commuting behaviours moderated the WFH-SWB relationship during the pandemic. Homeworkers would report greater affective wellbeing if their pre-pandemic commuting journeys covered >30 miles, while pre-pandemic commuters who frequently walked or cycled to work were worse off in SWB outcomes after switching to WFH.

Compared with recent research evidence regarding WFH as a generally positive experience (Beck et al., 2020; Brodeur et al., 2021; Davillas and Jones, 2021), our results indicate that the wellbeing benefits of WFH are determined by its interference with work and family lives, and only appear in the short term during the COVID-19 pandemic. First, the association of WFH with affective wellbeing became insignificant after stay-at-home experiences were accounted for. As evidenced by occupational health and lifestyle research, the sudden transition to WFH during the pandemic requires homeworkers to reconcile their home and work domains (Rubin et al., 2020; Fukumura et al., 2021; Meyer et al., 2021). Lack of financial resources and social support from family or colleagues constitute a threat to SWB, while reduced commutes and flexible work schedules leave more time and energy for homeworkers to develop a healthier lifestyle with adequate sleep and frequent exercises. Second, there were insignificant associations of WFH with life satisfaction, as well as with affective wellbeing for people who always worked at home throughout the three-wave survey, indicating the uncertainty of homeworking experiences in the long term. To justify the long-term benefit of WFH, further research is warranted to continue monitoring people's workplace choices and resultant SWB outcomes

after the pandemic subsides.

Despite the uncertainty about the long-term benefit of WFH, pre-pandemic long-distance commuters were better off in SWB after switching to WFH. Specifically, homeworkers showed greater affective wellbeing when their regular commuting journeys that stretched over 30 miles were entirely or partly cancelled by the lockdown restrictions during the pandemic. Our finding for the moderation of commuting distance in the WFH-SWB relationship is complementary to a recent study that focuses on commuting time in the Netherlands (Kroesen, 2022). In this study, commuters, especially female commuters, whose journey to work took over one hour reported better life satisfaction after switching to WFH. Notably, distance or proximity to workplaces was underrepresented in previous travel-related SWB research due to the following two take-for-granted notions: travel time is more of a proxy for evaluating the experienced utility of travelling than travel distance (Stutzer and Frey, 2008); and job seekers desire to move at higher speed and access more job options (Banister, 2011). This results in more long-distance commuting journeys by motorised travel modes, leading to increasing job-housing mismatch. The COVID-19 outbreak and the subsequent lockdown policies provide a window of opportunity to experiment with an alternative workplace arrangement, WFH, which has the potential to reduce long-distance commuting journeys and enhance people's affective wellbeing.

Regarding the role of commuting mode, commuters who frequently walked or cycled to work before the pandemic had worse SWB outcomes when they worked from home during the pandemic. This result was established after we adjusted for the short-distance characteristic of most active commuting journeys, which corroborates the positive utility derived from the experience of walking or cycling to work (Ory and

Mokhtarian, 2005; Jain and Lyons, 2008). It is inspiring to observe that people miss the benefit of active commuting during the lockdown periods. This means that these previous active commuters value the active mode itself and may reconsider it as the mode choice after they return to the workplace. Counterintuitively, our model results show little evidence that motorised mode users, especially public transport commuters, had better SWB after homeworking, even though commuting by public transport was found to be more dissatisfying than any other travel modes prior to the pandemic (De Vos et al., 2016). This can be explained by the fact that, in order to keep social distancing during the pandemic, pre-pandemic public transport commuters might switch to other travel modes, thereby mixing the reference group and misestimating the effect of public transport use on SWB.

Another interesting finding is that female long-distance commuters benefited more from WFH in terms of affective wellbeing than their male counterparts. This is not to say that the gender gap in SWB has decreased because women still reported worse SWB outcomes during the pandemic. Our tentative evidence suggests that when women are free from long-distance commuting journeys on a daily basis, they are psychologically more relieved by being able to better manage work and family responsibilities (Giovanis and Ozdamar, 2021). Another household-level longitudinal evidence in China also suggests that when wives' commuting time increases over time, husbands report worse life satisfaction because they have less support from wives for family chores (Tao et al., 2023b). Even so, the gendered commuting-SWB relationship may still exist because women are more likely to stop work or serve as front-line key workers in the midst of COVID-19 and less likely to be long-distance commuters before the COVID-19 outbreak, which determines their little possibility of WFH and benefiting from WFH in the first place (Wielgoszewska et al., 2020).

6.2. Research implications

The outbreak of the COVID-19 pandemic and subsequent lockdown restrictions make WFH a common choice of work locations for a large number of previously commuting populations. This also prompts transport researchers to rethink a more socially acceptable way to organise people's home space and workspace in post-COVID-19 society. An important contribution that transport geographers can make is to bring the distance element back to travel behaviour research. Conventional transport paradigms regard travel as a derived demand to access diverse activity destinations. This results in dramatic increases in travel distance, along with dominant car use to keep travel time within an acceptable budget (Mokhtarian and Salomon, 2001; Banister, 2011). The real-world experiment of WFH during the COVID-19 pandemic tells us a lesson that regular commuters welcome the possibility of working more from home, and particularly, they value the experience of active travel to work in short distances. Therefore, job-housing distances, rather than travel time or speed, should be at the centre of the debate. Great proximity to workplaces and the resultant mode switch to active commuting will deliver the benefits of not only reducing unsustainable commuting patterns but also improving commuters' SWB outcomes.

Our study suggests an ideal way for workplace arrangements as the combination of WFH on some days of the week and active commuting to nearby workplaces on the other days. Admittedly, remote work at home is not always possible in some occupations that require face-to-face communications or on-site operations. However, it is viable to apportion parts of the workload to be completed at home if workers desire to do so. Besides, supportive family and social relationships, stable financial circumstances and healthy lifestyle behaviours are also important preconditions for a positive homeworking experience. Given that people missed the benefit of active commuting under the influence of COVID-19, a window of opportunity has opened to increase the take-up of active modes that have drastically declined in the UK over the last decade. Possible planning strategies include developing safe and attractive active transport networks, and encouraging high-density and mixed-use neighbourhoods to mitigate job-housing mismatch and diversify localised activity destinations. According to Beck and Hensher (2021), another viable strategy is the introduction of satellite offices or neighbourhood business hubs to support working close to home, which can avoid stressful long commutes and the potential burdens of WFH (e. g., social isolation and work-family conflicts) at the same time.

6.3. Research limitations

First, our study selected the participants who always commuted to work before the pandemic and remained employed during the pandemic to examine how previous commuting populations evaluated their WFH experiences after the COVID-19 outbreak. We believe that excluding pre-COVID-19 homeworkers did not introduce a serious bias in the results given their small numbers. However, a fair proportion of workers stopped work during the pandemic (30% of the BCS70 participants by May 2020; Wielgoszewska et al., 2020), and these unemployed workers might suffer from the greatest decline in SWB. In our study, we estimated the SWB effect of switching to WFH with the reference term of maintaining CTW, leaving the participants who stopped work out of consideration. For this reason, our results should be regarded as a conservative estimation of positive WFH experiences. In addition, the results from the 1970 cohort may not be generalisable to other birth cohorts, and especially to young couples who lived with their children when kindergartens and schools were closed during the lockdowns.

Second, the impact of WFH on people's SWB and sustainable commuting patterns is uncertain in the long term after the COVID-19 crisis ends. Our results are based on the three-wave COVID-19 survey ranging from May 2020 to March 2021, which is, to our knowledge, one of the richest longitudinal data sources including the information of work locations and SWB during the pandemic. However, our results may not be directly extrapolated to the post-COVID-19 era when WFH is more of a personal choice rather than a result of lockdown restrictions directed by the government. Over time, people may change their attitudes towards WFH (e.g., WFH being more acceptable among long-distance commuters) once they regain the freedom to choose their work locations. They may also adapt to WFH experiences and show little difference in SWB outcomes whether working at home or in an office. In the longer term, routine homeworkers may even adjust their housing and job locations farther away from each other, because the proximity to workplaces is not that important (Tao, 2023; Tao et al., 2023a). Taking all these into account, we acknowledge that research on this topic is still at a nascent stage. It is too early to draw definite conclusions about the complex interactions between commuting behaviours, the choices of residence and workplaces, and SWB outcomes in post-COVID-19 society.

6.4. Concluding remarks

Our study regards governmental directives on WFH during the COVID-19 crisis as a natural experiment to investigate the causal relationship between (not) commuting and SWB outcomes. The results indicate that switching from commuting to WFH led to better affective wellbeing for pre-pandemic long-distance commuters, but resulted in worse affective wellbeing and life satisfaction for people who had frequently walked or cycled to work before the pandemic. These findings lead us to recommend a mix of WFH and active commuting over short distances in post-COVID-19 society. Despite the barriers for homeworking in some occupations and the uncertainty of homeworking experiences in the long term, this hybrid workplace arrangement deserves due consideration for its co-benefits of easing traffic congestion, promoting environmental sustainability, and enhancing public health and wellbeing.

Credit author statement

Yinhua Tao developed the research idea.

Yinhua Tao wrote the manuscript and conducted the data analysis with some input from Ana Petrović and Maarten van Ham.

Ana Petrović and Maarten van Ham revised the manuscript.

All authors approved the final manuscript.

Declaration of Competing Interest

None.

Data availability

The authors do not have permission to share data.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jtrangeo.2023.103690.

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