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Teleworking during COVID-19 in the Netherlands: Understanding behaviour, attitudes, and future intentions of train travellers

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ABSTRACT

With the arrival of COVID-19 in the Netherlands in Spring 2020 and the start of the "intelligent lockdown", daily life changed drastically. The working population was urged to telework as much as possible. However, not everyone had a suitable job for teleworking or liked teleworking. From a mobility perspective, teleworking was considered a suitable means to alleviate travel. Even after the pandemic it can (continue to) reduce pressure on the mobility system during peak hours, thereby improving efficiency and level of service of transport services. Additionally, this could reduce transport externalities, such as emissions and unsafety. The structural impact from teleworking offers opportunities, but also challenges for the planning and operations of public transport. The aim of this study is to better understand teleworking during and after COVID-19 among train travellers, to support operators and authorities in their policy making and design. We study the telework behaviour, attitude towards teleworking, and future intentions through a longitudinal data collection. By applying a latent class cluster analysis, we identified six types of teleworkers, varying in their frequency of teleworking, attitude towards teleworking, intentions to the future, socio-demographics and employer policy. In terms of willingness-to-telework in the future, we distinguish three groups: the high willingness-to-telework group (71%), the low willingness-to-telework group (16%), and the least-impacted self-employed (12%). Those with high willingness are expected to have lasting changes in their travel patterns, where especially public transport is impacted. For this group, policy is required to ensure when (which days) and where (geographical) telework takes place, such that public transport operators can better plan and operate their services. For those with low willingness, it is essential that the government provides tools to companies (especially in education and vital sector) such that they can be better prepared for teleworking (mostly during but also after the pandemic). Employers on the other hand need to better support their employees, such that they stay in contact with colleagues and their concentration and productivity can increase.

1. Introduction

COVID-19 first appeared in the Netherlands on the 27th of February 2020. On March 12th, the government drastically intervened

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and imposed an "intelligent lockdown" (Antonides and van Leeuwen, 2020). In this lockdown people were urged to stay at home as much as possible. This meant that among others schools were closed, people had to telework as much as possible (i.e. working from home), public transport operations were reduced (people were advised not to use public transport), and restaurants and bars were closed (de Haas et al., 2020). The large difference with lockdowns like imposed in e.g. France and Germany, is that people were still allowed to be outside and move around. All in all, these measures resulted in large changes in people's daily life.

For the working population, the intelligent lockdown resulted in a large adjustment: from working in office to teleworking as much as possible. Before the COVID-19 pandemic one in three employed people teleworked occasionally, with only 6% doing this almost full-time (Hamersma et al., 2020). With this, the Netherlands ranks second (after Sweden) in the European Union in terms of the share of employees that telework (Sostero et al., 2020). During the intelligent lockdown approximately 45–56% of the working population teleworked, where many did this full-time (Hamersma et al., 2020). Not every job is equally suitable for teleworking, as some professions require interaction with people (e.g. cashiers in supermarket, nurses in hospitals, and plumbers in customer's houses) (Sostero et al., 2020). In the Netherlands, the largest switch towards teleworking was found among the working population that is highly educated and/or commuted by public transport (Hamersma et al., 2020). Due to this switch towards teleworking and the advice of the government against using public transport, public transport use decreased significantly (Antonides and van Leeuwen, 2020). Train use, specifically, reduced to only 7% of the normal ridership at its lowest (Ton et al., 2020). Travel patterns in general changed drastically, with car use decreasing too and active mode use (walking and cycling) increasing (Currie et al., 2021; de Haas et al., 2020; De Vos, 2020; Riggs, 2020).

Many aspects of daily life, such as travel and work, are habitual (Schönfelder and Axhausen, 2010). As such, changes to these habits are difficult to realise. Large interventions, such as trials (Ton and Duives, 2021) or life events (Müggenburg et al., 2015) are known for their ability to change habits. The COVID-19 pandemic is a large, global intervention and it thus potentially provides the opportunity for changing habits. Nationwide, most kilometres are travelled (pre-COVID-19) using the car (50%), only 11% is travelled using public transport (CBS, 2020a). Commuting comprehended around 27% of total kilometres travelled, where this share is larger for public transport kilometres (33%). As road transport is responsible for more than 70% of all CO_2-emissions in the EU (Alonso Raposo et al., 2019), a reduction in car use due to more telework would positively affect environment, liveability and accessibility (Hamer et al., 1991). However, as the largest switch towards teleworking in this pandemic was observed among public transport (i.e., train) users, this potential change in habits is likely to affect public transport more than car use. Consequently, the potential for achieving sustainability benefits reduces. Furthermore, these potential changing habits have a large impact on the planning and operations of public transport. It is therefore essential to get a better understanding of the behaviour, attitudes and intentions of teleworkers during and after COVID-19, specifically those that use public transport.

The aim of this study is to better understand teleworking during and after COVID-19 among train travellers. We study the telework behaviour, attitude towards teleworking, and future intentions towards telework of the train traveller population via a longitudinal data collection effort. We apply a latent class cluster analysis to identify different types of teleworkers, each with different teleworking behaviour, attitude and intentions. This allows public transport operators and authorities to estimate the possible effect on ridership and adjustments that are required in their planning and operations. Furthermore, it increases our knowledge of teleworking and allows us to identify in which cases teleworking can be considered effective and useful and in which cases it is not. Next to a better understanding, the findings also offer input for policies (for operator, government, and employer) aimed at changing behaviour related to teleworking and commuting.

This paper is structured as follows. Section 2 discusses the methodology of this paper, where the conceptual framework is elaborated upon, the data is discussed, and the research framework is presented. Section 3 discusses the teleworker characteristics. Then, the teleworker types are identified and thoroughly discussed in Section 4. Section 5 discusses the findings in relation to the larger body of literature and Section 6 concludes this paper.

2. Methodology

The methodology for investigating teleworking during COVID-19 is discussed in this section. Section 2.1 presents the conceptual framework that details the relationships that are investigated. Section 2.2 discusses the data. Finally, Section 2.3 provides the analysis framework that details the specific methods and analyses that are applied to investigate teleworking during COVID-19.

2.1. *Conceptual framework*

Kowalski and Swanson (2005) argue that there are several critical factors for making teleworking a success, that are related to support, communication and trust. These critical factors are required at an organisational level, managerial level, and at an employee level. Given the sudden change that urged everyone to telework, regardless of organisation type, job type or individual preferences, we can assume that these critical factors will not have been met in all cases. In any case, these sudden changes did result in more frequent teleworking and new experiences for most people. Furthermore, new intentions regarding teleworking in the future (after COVID-19) are created. It is uncertain whether these intentions are related to the experiences in teleworking during COVID-19. We hypothesise that, given the sudden changes and large-scale implementation of teleworking, experiences differ per person and future intentions towards teleworking are independent from these experiences, as there are likely many more factors that impact these intentions. These elements form the core of our conceptual framework, depicted in Fig. 1.

Baruch and Nicholson (1997) identified four factors that need to be aligned before feasible and effective teleworking can be achieved; the organisation (support and culture), the job (nature of work), the home and family situation (physical space and family

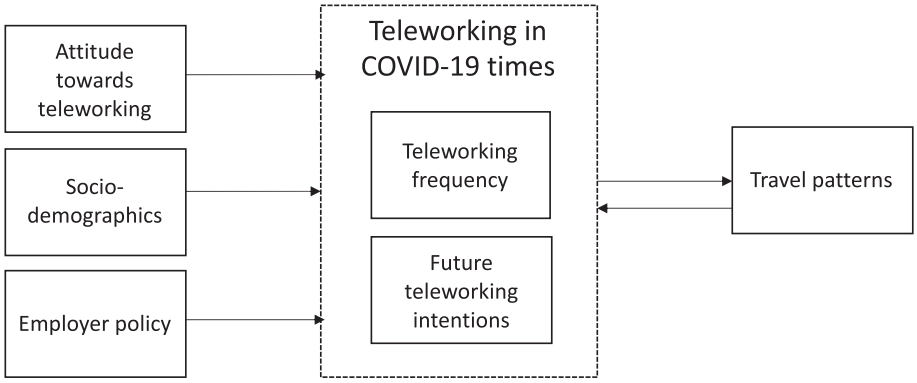

Fig. 1. Conceptual framework of teleworking during COVID-19.

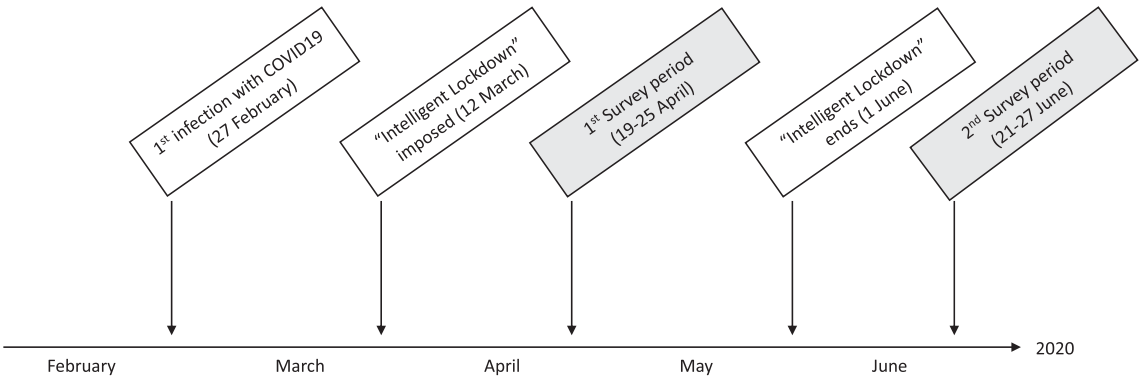

Fig. 2. COVID-19 timeline in the Netherlands.

relations), and the individual (preferences and beliefs). The sector in which the organisation operates, which is also directly linked to the nature of the job, is important for the possibility to telework. Sostero et al. (2020) found that, before the COVID-19 pandemic, higher-skilled, higher-paid, white-collar jobs at larger organisations (50+ employees) were overrepresented in teleworking. Next to that, self-employed people often telework (or work from home) (López-Igual and Rodriguez-Modroño, 2020; Sostero et al., 2020). Sostero et al. (2020) identify that within the European Union about 66% of the workers cannot telework or have a job that is not suitable for teleworking (also not during a pandemic). Hence, we include the employer policy towards teleworking in the framework. The individual and home or family situation are also found to affect teleworking both in experience and frequency. In pre-COVID-19 times, generally younger, higher educated people are teleworking (López-Igual and Rodriguez-Modroño, 2020). Furthermore, workers with children are more likely to telework (López-Igual and Rodriguez-Modroño, 2020; Sostero et al., 2020). The attitude towards teleworking might have an impact on people's teleworking behaviour (Ajzen, 1991). As a result, we also include socio-demographics that entail both individual and home situation characteristics and attitudes towards teleworking in the framework.

Hamer et al. (1991) performed the first experiment with teleworking in the Netherlands, where they investigated the effect of teleworking on changes in travel patterns. They found that the number of trips made by the teleworker and their household reduced drastically. In their sample, it affected both public transport and car use. They also found that travel for other trip purposes decreased in their sample. Furthermore, since Hamersma et al. (2020) indicated that mostly public transport users are affected, it is essential to understand the impact of teleworking on travel patterns both during and after the pandemic. Therefore, the (bi-directional) relationship between teleworking and travel patterns is also included in the framework.

2.2. Data

The COVID-19 pandemic has proven to be long lasting, furthermore the sudden change towards large-scale teleworking required adaptation for most workers. Therefore, longitudinal data is required to capture behaviour, attitude and intentions regarding teleworking. The present study uses data from a longitudinal data collection effort among the panel of Netherlands Railways (NS) (NS, 2020). This panel represents all train travellers in the Netherlands and participation in the panel is voluntary. The total panel encompasses more than 80,000 members. Panel members can receive invitations for a variety of research initiatives related to train travel.

The first survey was distributed among all panel members. 45,967 respondents (roughly 57% response rate) completed the survey,

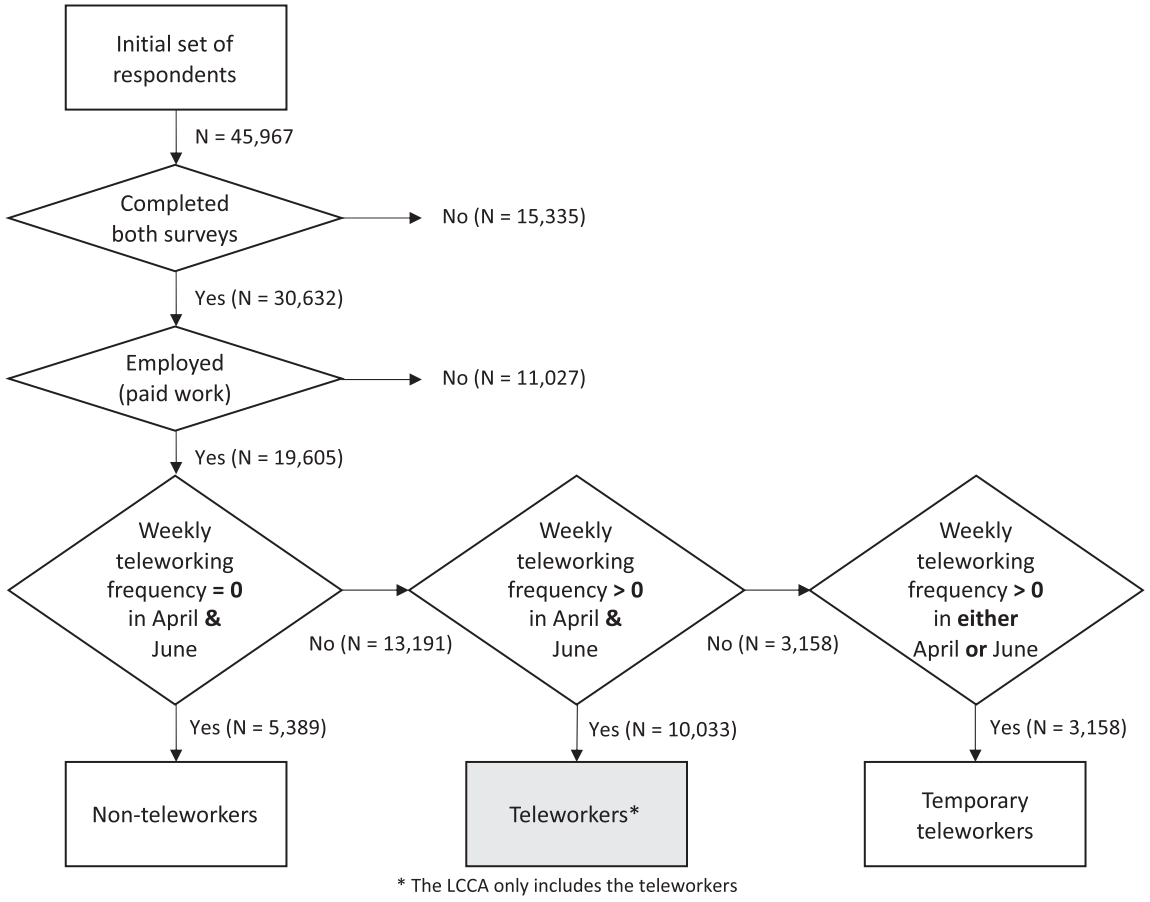

Fig. 3. Data filtering process.

which aimed at capturing respondents' behaviour in the week of 19–25 April 2020 during the "intelligent lockdown" (see Fig. 2). 96% of these respondents agreed to participate in a longitudinal study to monitor trends and changes. As the panel consists of voluntary subscribers, many 'train enthusiasts' and 'train haters' were expected to be included. Therefore, alongside this panel, an external panel was approached, where a sample representative for the train traveller population was invited (1,500 respondents) to verify the behaviour, attitudes and intentions of the internal panel members. These two panels showed largely the same patterns; hence, we conclude that the internal panel can be considered representative for train travellers in the Netherlands.

The "intelligent lockdown" ended on the 1st of June (see Fig. 2), implying for example, that public transport operated at full capacity again (but passengers had to wear face masks) and schools, shops and restaurants opened up again. However, still measures and limitations were in place. The government advised everyone to stay at home and telework as much as possible. As this ending of the lockdown was likely to change behaviour again, we distributed the second survey (which included mostly the same questions as in the first survey) aimed at capturing respondents' behaviour in the week of 21–27 June 2020. 30,632 respondents completed this survey (approximately 70% response rate).

The present study includes data from surveys one and two (as depicted in Fig. 2). However, for future reference and studies, three more surveys have already been organised: one in the last week of September 2020, because of the expected changes in behaviour after summer holidays ended and school started again, one in the week of 13–19 December 2020, because a second lockdown was imposed, and one in April 2021, because of lockdown measures being lifted. In essence, the data collection will be ongoing until the end of the pandemic.

The design of the surveys, tailored to the purpose of this study, is further detailed in Section 2.2.1. Furthermore, the data filtering applied for the current investigation is described in Section 2.2.2. Finally, a discussion on the differences between teleworkers and non-teleworkers in the sample is presented in Section 2.2.3.

2.2.1. Survey design

The survey consists roughly of four parts: socio-demographics and background information, objective behaviour, subjective experiences and attitudes, and future intentions. The latter three topics are briefly discussed below.

The objective behaviour targets the actual behaviour of respondents over the course of one week. Hence, the distribution of the survey was done right after the week ended and questioned the same week for all respondents. We asked them about their frequency of

Table 1
Characteristics of teleworkers, temporary teleworkers and non-teleworkers in the sample, compared to teleworkers in the Netherlands in the year 2019 (source: CBS (2020b)). Note that the scores per variable per group add up to 100%.

		Sample (train travellers)			Netherlands	
		Teleworkers	Temporary Teleworkers	Non-Teleworkers	Teleworkers	Working population
Share of working population		54%	17%	29%	39%	100%
Sector of Employment	Government	**26%**	11%	6%	–	–
	Education	23%	**28%**	4%	–	–
	Vital	30%	41%	**70%**	–	–
	Other	20%	20%	20%	–	–
Age	18–34 years	21%	21%	16%	26%	36%
	35–54 years	61%	60%	66%	52%	43%
	55–64 years	16%	17%	16%	19%	18%
	65 + years	2%	2%	2%	3%	3%
Household composition	Live alone	28%	31%	**41%**	17%	16%
	$\geq$ 1 adult(s)*	42%	42%	37%	29%	25%
	Child(ren) $\geq$ 12	17%	16%	16%	54%*	59**
	Child(ren) $<$ 12	13%	12%	6%		
Education level (completed)	Practical	9%	17%	**38%**	6%	20%
	High school	8%	9%	24%	29%	40%
	Uni. of App. Sc.	33%	**43%**	25%	65%**	40%***
	University	**49%**	31%	12%		

-not provided in source, *At least one more adult next to respondent, but no children, **No distinction between ages of children (original distinction based on difference between primary and secondary school age), ***No distinction between University of Applied Sciences and University (vocational education).

doing certain activities and using a large variety of modes. Regarding work, we asked about both teleworking and working outside home. In case the respondent both teleworked and worked outside home on the same day, we asked them for the activity that took most time on that day. For train travel specifically, more detailed questions were asked. The first survey targeted both the week during lockdown and an average week in February 2020, which represented the pre-COVID-19 situation. In doing so, we could compare the behaviour during COVID-19 with the behaviour before. The second survey only targeted one week.

Regarding the subjective experiences and attitudes, we were, among others, interested in their attitude towards teleworking. Measuring attitudes can be done in various ways. Most frequently, individuals are questioned about their opinion regarding specific aspects that are deemed important or relevant for the overall opinion towards a topic. The opinion is often measured on a Likert-scale (using three, five, or seven answer possibilities). This has been applied for example related to modes (De Vos, 2018; Ton et al., 2019b), COVID-19 (Ferdous et al., 2020), and teleworking (de Haas et al., 2020; Hamersma et al., 2020; Lim and Teo, 2000). In this survey, we designed statements with five answers on a Likert scale.

The future is still unknown. To acknowledge the fact that people will not know precisely what the future after the pandemic will look like, we used a reference case to measure the changes in their intentions. In this case, we used the pre-COVID-19 situation (measured via respondents' behaviour in February 2020) as the reference and asked the respondents if they thought they will perform specific behaviour less often, the same, or more often in the future. This is in line with the method applied by de Haas et al. (2020). The behaviours of interest pertain to activities, teleworking, and mode use.

2.2.2. Data filtering

The collected data in the surveys in April and June is filtered as depicted in Fig. 3. The collected data is weighted to represent train travellers in the Netherlands, based on travel frequency (pre-COVID-19), trip purpose, and age distribution. These variables were selected for three reasons; 1) they were expected to be relevant for this study, 2) they resulted in limited cells, and 3) they all had enough observations per cell. Other socio-demographic variables, such as gender and education level were verified on skewedness, but only showed a maximum deviation of 5% against the actual train traveller distribution. Respondents needed to complete both surveys (30,632 respondents) and need to be employed (64% of the respondents that completed both surveys). Being employed (paid), in our definition, means that a respondent has a job during both the first and the second survey. Note that most businesses that were affected by the pandemic in the Netherlands, were supported financially by the government. Hence, very few (train travelling) respondents lost their job between April and June 2020. Furthermore, note that being employed and being part of the internal panel of NS does not imply that a respondent commutes by public transport. However, as Hamer et al. (1991) point out that teleworking affects both commuting and non-commuting trips, all employed train travelling respondents are considered.

We define being a teleworker as a worker that has teleworked at least once a week in both surveys (10,033 respondents). Consequently, the frequency of teleworking varies largely within the teleworking population. A non-teleworker is someone that has

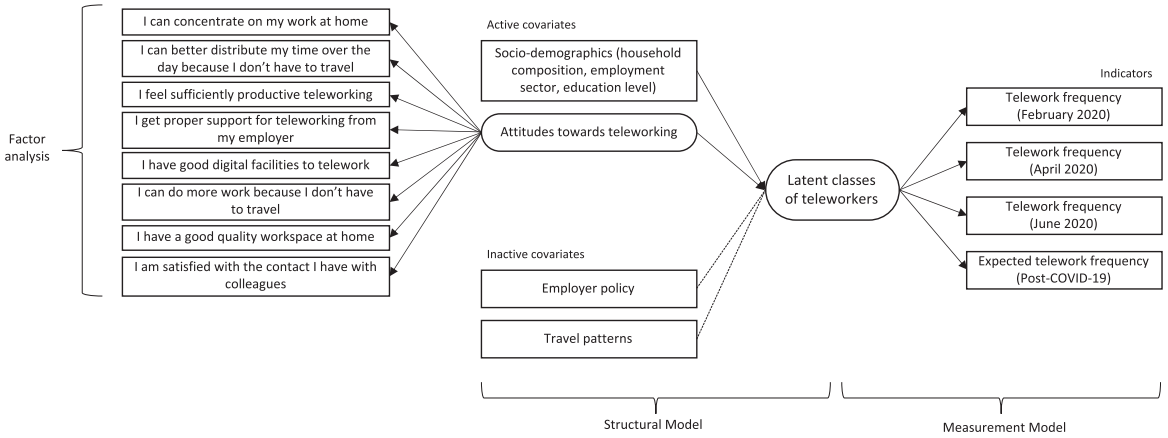

Fig. 4. Research framework.

not teleworked at all in both surveys (5,389 respondents). The final category represents workers that have temporarily teleworked (3,158 respondents), which means they have either teleworked at least once a week in April or in June (but not both). In total 13,191 respondents have teleworked in April and/or June, which is 71% of the working population. Sostero et al. (2020) concluded that within the European Union 66% of the employed population could not telework and only 34% has a job or works for an organisation that is suitable for teleworking. Our sample consists of a significantly higher share of workers that has teleworked during the pandemic. In line with the findings of Hamersma et al. (2020), we can thus conclude that train travellers (not necessarily being train commuters) are significantly more likely to have a job or work at an organisation where teleworking is possible.

2.2.3. Teleworker or not?

This study focusses on teleworkers, which we have defined as respondents who teleworked at least once a week in both April and June. As we saw in Fig. 3, only 54% of the working respondents teleworked both in April and June. Therefore, it is essential to understand the differences between these teleworkers, temporary teleworkers and non-teleworkers.

Table 1 shows the characteristics of the teleworkers (both April and June), temporary teleworkers (April or June), and non-teleworkers (neither April nor June) among the train traveller population. Next to that, teleworker characteristics of the entire Dutch working population, both frequent (14%) and occasional (25%) teleworkers (teleworkers who telework on average once a week or more), and the entire employed working population are shown (CBS, 2020b). This allows us to compare our sample with the Dutch (tele)working population. Note that the Dutch data stems from a pre-COVID-19 time, as no up-to-date data is yet available. The share of teleworkers is much larger in our sample than in the Dutch population, which is mostly due to comparing two different time periods. Hamersma et al. (2020) found in their comparative study among Dutch studies targeting teleworking that in April 45–56% of the working population teleworked, which is in line with our sample. We could not find information on the distribution of teleworkers over sectors of employment, however we did find some information on the share of workers per sector that teleworked in 2019 (CBS, 2020c). 33% of the people working in the vital sector (e.g., energy & water supply, wholesale/retail, transport & logistics, health care, rescue services, and cleaning) teleworks, whereas in education this share is 60%. In our sample people employed in the vital sector telework in 54% of the cases, for education this is 94%. This is significantly higher compared to the findings for 2019. Furthermore, regarding the age distribution, our sample has a larger share of 35–54-year-olds compared to the Dutch (tele) working sample (61% versus 52% and 43%), which could be attributed to our sample consisting of employed train travellers. Furthermore, our sample has an underrepresentation of families with children (30% versus 54% and 59%) and an overrepresentation of high educated workers (82% versus 65% and 40%). In sum, the teleworking train travelling population is rather different to the entire (tele)working population based on education, household composition and age distribution. This is taken into consideration when interpreting the results.

The non-teleworkers (Table 1) work mainly in the vital sector (70%), e.g., healthcare, and to a limited extent in government or education (10%). The temporary teleworkers are also mainly employed in the vital sector (41%), however a large share of them also works in education (28%). The Dutch primary and high schools have been closed during the "intelligent lockdown" and education took place mainly online. In June, these schools opened up again, which explains why a relatively large share of the temporary teleworkers work in education. A large share of the teleworkers also works in education (23%), we expect that these are mostly people employed at universities, as these did not open up yet. The teleworkers have a relatively high share of government employees (21%), this is plausible as this type of job might not require physical presence and also is often used as an example in (national) policies.

The highest completed education level also differs between the groups. The teleworkers are mainly university educated (49%), usually implying they do not have to be physically present at work. The temporary teleworkers have mostly completed university of applied sciences (43%) and therefore might be more often expected to be physically present. The non-teleworkers are mostly practical educated (38%).

Next to their actual teleworking behaviour, we asked the respondents if they were able to work at home and if this was not the case, why they were not. The majority of the non-teleworkers mentioned that they cannot telework, because they have to be physically

present (64%), furthermore 10% mentions they do not have the facilities to telework. Only 9% of them is able to telework. Of the temporary teleworkers, 66% mention they are able to telework in April, whereas this reduces to only 45% in June. This is most likely related to them being employed in education and having to be physically present. The vast majority of the teleworkers was able to telework in April (94%), this means that 6% has to telework while they state they are not able to.

2.3. Research framework

This section presents the research framework for investigating teleworker types. This research framework follows the conceptual framework, where behaviour, attitude, and future intentions form the core elements. Fig. 4 summarises the proposed research framework. Section 2.3.1 discusses the factor analyses applied to identify the attitudes towards teleworking. Section 2.3.2 describes the classification of teleworker types using latent class cluster analysis. Finally, Section 2.3.3 describes the approach towards analysing the relationship between teleworking types and the employer policy and travel patterns.

2.3.1. The attitude towards teleworking

The attitude towards teleworking is captured through eight specific aspects of teleworking and using a 5-point Likert-scale ranging from 'completely disagree' to 'completely agree'. The attitudinal statements included in the survey are mentioned in Fig. 4. These statements are in line with the statements included in other studies that investigate attitude towards teleworking (de Haas et al., 2020; Hamersma et al., 2020; Lim and Teo, 2000). The questions related to attitude towards teleworking are asked both in the April and June survey, hence a comparison over time is possible. The attitude towards teleworking from June is included in the latent class cluster analysis to identify different types of teleworkers.

Since some of these statements are correlated and measure similar aspects of the attitude towards teleworking, we therefore apply factor analysis to identify the latent variables underlying the attitudinal statements. A principal axis factoring analysis is applied, which ensures capturing the shared variance of attitudinal questions with latent variables (Field, 2009). Furthermore, varimax rotation is used, which maximises the possibility of capturing each attitudinal question using one factor (Field, 2009). The suitability of the data for applying factor analysis is tested using the Kaiser-Meyer-Olkin's (KMO) measure of sampling adequacy and Bartlett's test of Sphericity (Field, 2009). The resulting factors have a mean of zero, however when analysing the attitude toward teleworking we calculate pseudo-score averages by performing a factor-loading-weighted average of the Likert-scale responses for only the highly-loading variables, to identify whether the intrinsic (i.e. non-mean-centered) tendency of scores on the factor is positive or negative. In the LCCA, we do include the resulting factors as produced by the regression method.

2.3.2. Classification of teleworkers

Our hypothesis that experiences, attitudes and intentions vary per person is tested by clustering the teleworkers. This way we can identify which teleworking train travellers will continue teleworking in the future and who do not. Furthermore, we can provide input for government and/or employer policies towards teleworking. The teleworkers are analysed through a latent class cluster analysis (LCCA) using *Latent Gold* (Vermunt and Magidson, 2005). This method has been applied to the transportation field before, for example to cluster daily mobility patterns (Molin et al., 2016; Ton et al., 2019b), attitudes towards mobility as a service (Alonso-González et al., 2020), and travel behaviour changes in car use (Bamberg, 2013). Our study has several similarities with those studies, as we also investigate frequency of use and attitudes.

Fig. 4 shows the conceptual LCCA model applied in the analysis. The frequency of teleworking over time, being in February 2020 (pre-COVID-19), April 2020 (intelligent lockdown), and June 2020 (after lockdown, but still with the governmental advice to telework), together with the expected frequency of teleworking after COVID-19 has ended (relative to the pre-COVID-19 situation) are included as indicators in the model. The expected frequency was taken from the survey in June 2020; hence, it reflects the latest expectations of the respondents. The complete mathematical formulation of the model with covariates takes the following form (Vermunt and Magidson, 2013):

$$(yi|zi^{\mathrm{cov}}) = \sum_{x=1} k(x|zi^{\mathrm{cov}}) \prod m_{m=1} f(yim|x) \tag{1}$$

where x is the latent variable, which is a categorical variable and represents the different classes (K) that result from the analysis, that explains the associations between the indicator variables yim (M being the number of indicators). The first factor of the equation refers to the probability of belonging to a certain latent class given the individual's covariates, and the second factor is the probability density of yi given x. This mathematical formulation holds assuming that the indicator variables are independent of each other conditional on the latent variable x (Vermunt and Magidson, 2013). Each individual has a probability to belong to each class, based on its characteristics (active covariates (zi^{cov} is the set of covariates of individual i)). The active covariates are added to the model, after a model without active covariates with adequate model fit has been identified. The models with active covariates are evaluated on the R-squared statistics. *Latent Gold* provides the standard R-squared measure, which is a qualitative variance-based measure, indicating the portion of the variability in class membership that is explained by the included covariates (Magidson, 1981). The attitude towards teleworking (taken from the survey in June 2020) is included as active covariate, which largely improved the model fit of the base model and showed high R-squared values in the complete model. Furthermore, the socio-demographics are included as active covariates in the model, as these helped further improve the model fit. The employer policy and travel patterns did not contribute to a better model fit, hence they are included as inactive covariates. Consequently, they do not contribute to the model, but can still help

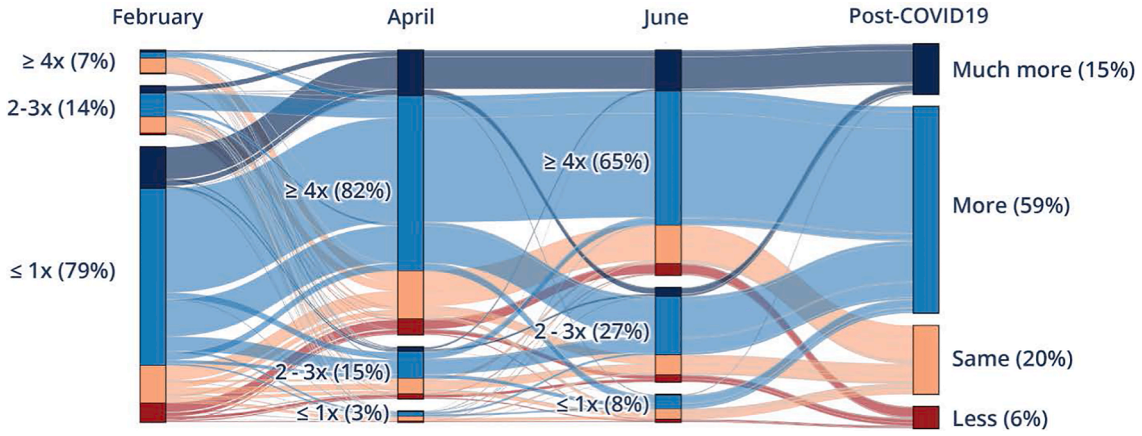

Fig. 5. Teleworking frequency over time and expectations for post-COVID-19.

understand the differences resulting classes.

The appropriate number of classes to model teleworker types can be decided in various ways. Often, statistical criteria like the Bayesian Information Criterion (BIC) or the Akaike Information Criterion (AIC) are assessed, which should be minimised (Nylund et al., 2007). To ensure that next to the global fit of the model, the local fit is also satisfactory, we also assess the bivariate residuals (BVR). The residuals are estimates of the improvement in the model fit (LL) in case a direct effect between the indicators was included (Vermunt and Magidson, 2005). The BVR are chi-square distributed, therefore values greater than 3.84 (df = 1) indicate that significant covariation remains, and the model does not have an optimal local fit. In this study, we use the LL, BIC and BVR as criteria to identify the optimum number of classes. We test models with 1 to 10 classes, where the number of classes is determined based only on the indicators. When the number of classes is decided upon, the model is estimated as a combined measurement and structural model, i.e., with both indicators and active covariates.

2.3.3. Teleworker types and employer policy and travel patterns

The employer policy is captured in two ways. First of all, the respondents were asked whether it was possible for them to telework before COVID-19 and second, we posed them the following statement in June: "my employer wants me to telework as much as possible". As each statement uses a categorical scale, we use the chi-square test to identify significant differences in answers between the teleworker classes (Field, 2009).

In case of the travel patterns, we are interested in changes over time in frequency of using a variety of modes: bicycle, car, train, and local transit (bus/tram/metro). This provides insights into the effect of different styles of teleworking on peoples travel patterns. Furthermore, we reflect on the expected frequencies of using modes in post-COVID-19 time (in relation to pre-COVID-19), to get an understanding of the impact of teleworking on travel patterns and identify the differences between classes.

3. Teleworker characteristics

In this section, we present the general characteristics of the teleworkers that are part of the core of our conceptual framework. We describe the teleworking frequency over time together with the intentions of teleworking in section 3.1. In section 3.2 the attitude towards teleworking is discussed.

3.1. Teleworking frequency and future intentions

Our requirement for being classified a teleworker is that one teleworked at least one day a week both in April and June. However, there is a large variety in frequency of teleworking among the teleworkers. Fig. 5 visualises the teleworking frequency over time, from February (pre-COVID-19), via April (the intelligent lockdown) and June (after the lockdown, but still advised to telework), to the post-COVID-19 expectations (in relation to pre-COVID-19 frequency). The latter dates from the survey in June. The figure shows that pre-COVID-19, 79% of the participants teleworked one day or less per week. In April, 82% worked 4 days or more per week from home and this number decreased after the relaxation of the limitations in June to 65%. About 74% of the people expect to telework (much) more often after COVID-19, compared to their pre-COVID-19 frequency.

Fig. 5 shows the teleworking frequency of various groups over time. We have combined two categories for all moments in time (not teleworking and teleworking once a week), which only hold for February 2020 because of data filtering, but for consistency we show this for all moments. The largest share of the teleworkers (in light blue) teleworked maximum once per week in February, teleworked four days or more during April and June and expects to telework more often post-COVID-19 compared to February (i.e., at least once a week). Smaller shares of the teleworkers have the exact same reported frequencies, however their intentions towards the future are very different; less than before (i.e., never, in red) or much more than before (i.e., two days to four days or more, in dark blue). This

Table 2
Results of the factor analyses on attitude towards teleworking.

Factor	Statements	Factor loading (April)	Factor loading (June)
Productivity and concentration	I can concentrate on my work at home	0.884	0.818
	I feel sufficiently productive teleworking	0.642	0.658
Facilities and support	I have a good quality workspace at home	0.494	0.559
	I have good digital facilities to telework	0.831	0.777
	I get proper support for teleworking from my employer	0.438	0.477
Productivity due to not commuting	I can do more work because I don't have to travel	0.840	0.878
	I can distribute my time better because I don't have to travel	0.701	0.685

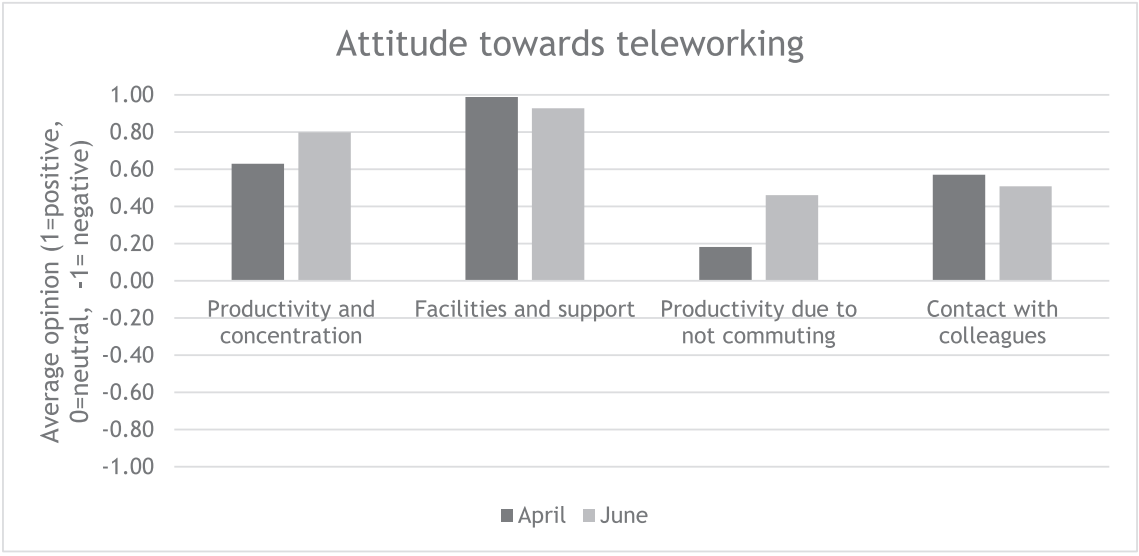

Fig. 6. Attitude towards teleworking.

suggests that the group in red did not like teleworking four days or more. Another group (in orange) teleworked four days or more even in pre-COVID-19 times. This shows that teleworkers have different behaviours, and their intentions show that they have different experiences regarding teleworking.

3.2. Attitude towards teleworking

The statements pertaining to the attitude towards teleworking (see Fig. 4) are included in both surveys, therefore we can investigate the attitude both in April and June. The statements are all formulated positively, which could result with socially desired answers (agreeing) and could also introduce bias when respondents just agree because it is easiest. This is something that needs to be considered when analysing the results.

The statement relating to the contact with colleagues did not load on any factor when applying factor analysis on all statements, hence we excluded this statement from factor analysis and applied factor analysis on the remaining seven statements. We obtain a KMO of 0.748 in April and 0.786 in June, indicating decent sample adequacy. In both cases, Bartlett's test of sphericity is <0.001, which indicates sufficient relations between the statements to perform factor analysis. A total of three factors is identified, which are the same (but with different loadings) for April and June. In April, the total variance explained is 58.2%, while in June this is 59.5%. Table 2 shows the factors found and the factor loadings.

The attitude towards teleworking can thus be distributed into four elements: productivity and concentration, facilities and support, higher productivity due to not commuting, and contact with colleagues. Together these elements form the attitude towards teleworking in this study. Fig. 6 shows the average attitude towards teleworking for each element (note that the factor scores have a mean of zero, therefore the results in Fig. 6 represent the average score of each factor based on the 5-point Likert scale and factor loadings of only the highly loaded variables). In general, the teleworkers have positive attitudes regarding each of the elements. However, several interesting observations can be done. First, the opinion regarding increased productivity due to not commuting is more positive in June than in April. For some teleworkers it was the first-time teleworking and in April primary schools were closed, potentially resulting in children staying at home. Hence, it seems plausible that an adaptation-effect appears. In general, people are happy with their

Table 3
Profiles of each teleworker type (in bold the highest share per characteristic is indicated).

		LC1 **Enthusiastic and always** 31%	LC2 **Positive and partially** 21%	LC3 **Neutral, new, and frequently** 19%	LC4 **Content self-employed** 12%	LC5 **Forced and done with** 8%	LC6 **Indifferent and occasional** 8%	Total 100%
Indicators (teleworking frequency)								
February 2020	≥4x p/w	2%	0%	0%	**64%**	0%	0%	9%
	2-3x p/w	18%	7%	2%	**30%**	1%	5%	11%
	≤1x p/w	**68%**	63%	49%	6%	34%	61%	52%
	Never	13%	30%	49%	0%	**65%**	34%	27%
April 2020	≥4x p/w	**100%**	57%	**100%**	80%	74%	16%	79%
	2-3x p/w	0%	38%	0%	19%	25%	**50%**	17%
	1x p/w	0%	5%	0%	1%	2%	**34%**	4%
June 2020	≥ 4x p/w	**92%**	36%	63%	69%	41%	6%	60%
	2-3x p/w	8%	**48%**	33%	28%	46%	38%	30%
	1x p/w	0%	16%	4%	3%	13%	**56%**	10%
Post-COVID-19	Less	0%	0%	0%	7%	**86%**	7%	9%
	Same	8%	6%	25%	**67%**	13%	66%	24%
	More	92%	**94%**	75%	26%	0%	27%	68%
Active Covariates								
Type of employment	Government	**31%**	18%	18%	2%	14%	4%	19%
	Education	11%	11%	19%	6%	**24%**	**24%**	14%
	Vital	10%	22%	12%	2%	17%	**35%**	15%
	Other	45%	45%	**51%**	10%	43%	18%	39%
	Self-employed	3%	3%	0%	**80%**	2%	19%	14%
Household composition	Child(ren) < 12	4%	**11%**	4%	3%	3%	3%	5%
	Child(ren) ≥ 12	32%	26%	9%	30%	15%	**34%**	25%
	≥1 adult(s)	41%	34%	**50%**	46%	42%	38%	42%
	Live alone	23%	29%	36%	21%	**40%**	25%	28%
Education level (completed)	Practical	7%	6%	11%	7%	**18%**	14%	8%
	High school	4%	9%	7%	10%	**12%**	1%	7%
	Uni. of App. Sc.	32%	38%	25%	35%	39%	**44%**	32%
	University	57%	47%	**58%**	48%	30%	40%	48%
Attitude towards teleworking								
Productivity due to no commute	Mean (0 = neutral)	**0.86**	0.59	0.13	0.31	0.12	0.01	0.46
Facilities and support	Mean (0 = neutral)	**1.20**	0.89	0.67	0.94	0.58	0.50	0.93
Productivity and concentration	Mean (0 = neutral)	**0.85**	0.74	0.54	0.91	0.26	0.52	0.80
Good contact with colleagues	Disagree	9%	12%	25%	13%	**28%**	25%	16%
	Neutral	17%	30%	25%	**38%**	25%	31%	26%
	Agree	**74%**	58%	51%	50%	48%	44%	58%

productivity and concentration over time, but not having to commute was the biggest change for them. Second, even though the contact with colleagues is judged positively on average, the attitude decreases from April to June. It seems that a longer duration without actually seeing colleagues leads to a reduction in the satisfaction on this point. Finally, the facilities and support are judged most positively, even though for several teleworkers and companies it was the first-time teleworking.

4. Classification of teleworker types

This section discusses the results of the LCCA, which identifies teleworker types. In section 4.1, the teleworker types based on the LCCA are described. These teleworker types are more thoroughly investigated in relation to the employer policy (4.2), and their travel

behaviour (4.3).

4.1. Teleworker typologies

A total of 10 models was tested using LCCA to identify teleworking typologies, first by only including the indicators. Appendix A.1 shows the results for all models. The most suitable number of classes is determined by a minimization of the LL, BIC, and the total value of the bivariate residuals. The 6-cluster model proved to be most optimal (LL = -34,936.4, BIC = 70,187.9, and total BVR score = 4.13 with zero significant BVRs). This model was expanded with active covariates. We tested several combinations of covariates (as indicated in 2.3.2), taking care of correlations between covariates. The best result was obtained when including employment type, attitude towards teleworking, household composition and highest completed education (LL = -30,250.3, BIC = 61,504.9 and R^2 of covariates = 22.7%).

The model parameters for both the measurement and structural model can be found in Appendix A.2. When applying the models to all teleworkers in our sample, the profiles as provided in Table 3 are created. The resulting classes are coined: 'Enthusiastic and always, 'Positive and partially', 'Neutral, new, and frequently, 'Content self-employed', 'Forced and done with', and 'Indifferent and occasional'. Below we describe all classes in more detail.

4.1.1. Enthusiastic and always

This class consists of the largest share of the teleworking population (31%). These people are characterised by the fact that they had experience with teleworking before the pandemic commenced (87%), during the pandemic they telework four days a week or more (100% in April, 92% in June), and after the crisis ends, they intend to work at home more frequently than before (92%). They are very positive about teleworking and generally feel that they are productive at home (also due to not having a commute), have decent facilities and support, and stay in touch with colleagues. This class is most positive towards teleworking. These people are more than average employed by the government (31% vs 19%). Furthermore, this class contains more than average teleworkers with university degrees (57% vs 48%).

4.1.2. Positive and partially

This class consists of 21% of the teleworkers. The majority had experience with teleworking before the pandemic (70%), which is similar to the total teleworking population. During the pandemic they teleworked 2–5 days a week (95% in April and 84% in June). They want to telework more after the pandemic compared to before (94%), also shown in their attitude towards teleworking. They are positive, mostly comparable with the average population; however, they feel more productive due to the fact that they do not have to commute in comparison the average population. The share of people working in the vital sector is higher compared to the average population (22% versus 15%). Furthermore, this class contains more families with young children compared to the average population (11% vs 5%).

4.1.3. Neutral, new, and frequently

Half of this class (19%) has experience teleworking before the pandemic. During the lockdown they worked fully from home (100%). After the lockdown the majority kept doing this (63%), however a third reduced the number of teleworking days to 2–3 days a week (and was thus allowed to be at work on some days). The majority wishes to telework more after the pandemic ends (75%). These teleworkers are never self-employed, and the majority does not work in government, education or vital sectors (51%). They are neutral towards teleworking, which is less optimistic compared the average population. The majority has a completed university education (58%), which is more than in the average population (48%).

4.1.4. Content self-employed

This class (12%) consists mostly of self-employed teleworkers (80%). They generally work from home (or have an office at home), before the pandemic 64% teleworked four days a week or more, in April this was 80% and in June 69%. Hence, in June this group already returned to their original telework pattern. They are satisfied with the facilities and support and productivity and concentration; however, they do not feel more productive due to not commuting. The latter is related to the fact that they work at home frequently and therefore no new situation occurred. The contact with colleagues is often graded as neutral, which could be due to the fact that many have no employees or colleagues.

4.1.5. Forced and done with

This class contains 8% of the teleworker population. These teleworkers had generally no experience with teleworking before the pandemic commenced (65%). During the pandemic they teleworked 2–5 days a week (98% in April and 87% in June). However, 86% intends to do less telework post-COVID-19 than before (i.e. never again). They did not like teleworking, feel the least productive of all teleworkers and feel most negative about the contact with colleagues (which might be emphasised by the fact that many of them live alone). Hence, their dislike for teleworking shows in their intentions for the future. A large share of these teleworkers is working in education compared to the average population (24% vs 14%). Furthermore, this class contains more practical educated and high school educated people compared to the average population (respectively 18% vs 8% and 12% vs 7%).

4.1.6. Indifferent and occasional

The 'indifferent and occasional' teleworker class is the same size as the 'forced and done with' teleworkers (8%). The teleworkers in

Table 4
Teleworker types and the possibility to telework before COVID-19.

Teleworker type	Did you have the possibility to telework before COVID-19?	
	Yes	*No*
Enthusiastic and always	93%	7%
Positive and partially	76%	24%
Neutral, new, and frequently	69%	31%
Content self-employed	96%	4%
Forced and done with	49%	51%
Indifferent and occasional	52%	48%

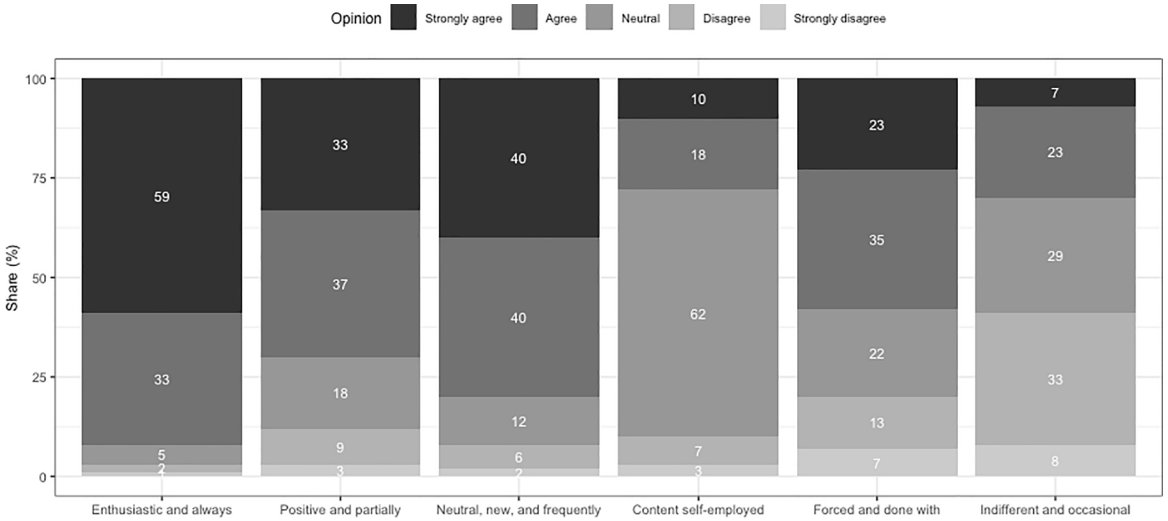

Fig. 7. Opinion on "My employer wants me to telework as much as possible" per teleworker type (June).

this class generally teleworked once a week or more before the pandemic (66%). During the pandemic this level increased a little bit to 1-3x per week in April (84%) and June (94%). This is the class with the lowest teleworking frequency during the pandemic. 66% of them also intend to continue this way after the pandemic ends, whereas 27% wants to increase the telework frequency. Employment in the education and vital sector is more common in this class compared to average (respectively 24% vs 14% and 35% vs 15%). Even though they mostly had experience in teleworking, they are most negative towards it. Especially related to the productivity related to not commuting and the facilities and support they receive. This is also the class that has the highest share of child(ren) over the age of 12 (34%).

4.2. Employer policy

The employer policy is measured in two ways, first through the possibility to telework before COVID-19 and second through the share of teleworkers which is urged to telework as much as possible (in June).

In total, 80% of the teleworkers had the possibility to telework before COVID-19. Having the possibility to telework means that a teleworker had the means needed to telework and was allowed by the employer to do so. The 80% is not equally distributed over the teleworker classes. The difference between classes is significant ($\chi^2(5) = 1374.99$, $p < 0.001$). Most of the 'enthusiastic and always' teleworkers and the 'content self-employed' could telework pre-COVID-19 (see Table 4). Of the 'forced and done with' and 'indifferent and occasional' teleworkers, only half of them indicate they could telework before COVID-19. This suggests that having had the possibility to telework before the pandemic relates to the attitude towards teleworking, such that experience in "easy" times leads to a more positive attitude during "difficult" times. Of all teleworkers, 70.5% indicate that their employer urges them to telework as much as possible. Fig. 7 shows the distribution of answers per teleworker class. The differences between teleworker classes are significant ($\chi^2(20) = 3701.46$, $p < 0.001$). Several differences are noticeable. First, the 'content self-employed' have highest share of neutral answers (62%), which can be explained by the fact that they are self-employed and often work at home, because that is where their office is located. Second, the 'enthusiastic and always' teleworkers agree almost fully with this statement and more than half (59%) strongly agrees. Third, the 'positive and partially' teleworkers and 'neutral, new, and frequently' teleworkers both have a relatively high share that agrees or strongly agrees with the statement, whereas they telework less frequently (especially the former). This suggests that the interpretation of the term 'as much as possible' differs per group. The 'enthusiastic and always' telework (almost) all days, whereas the others are also present at work. Fourth, a small majority of the 'forced and done with' (58%) agree with the

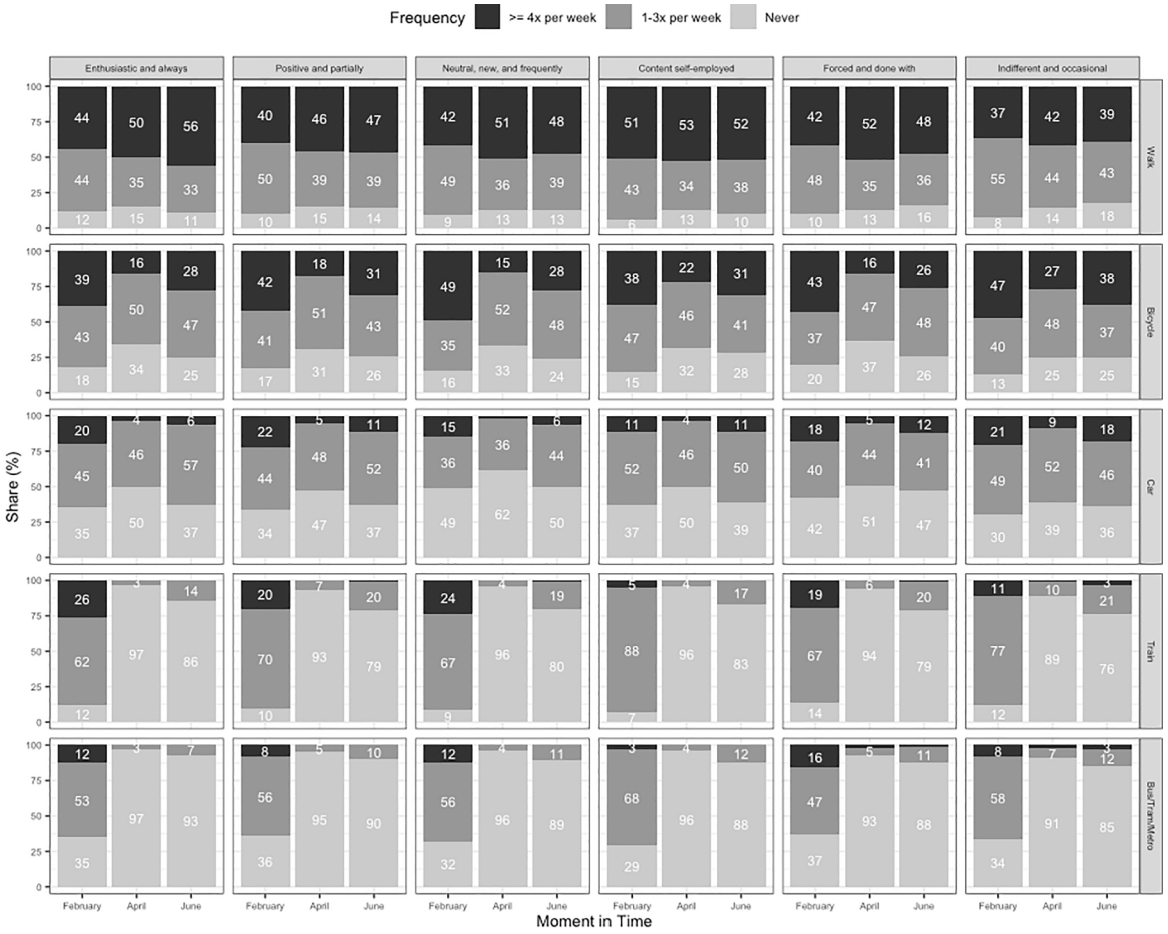

Fig. 8. Frequency of using various modes over time per teleworker type.

statement, probably (partially) explaining their attitude towards teleworking. The difference between this class and the first three classes could potentially be explained by the alignment of the organisation and job characteristics mentioned by Baruch and Nicholson (1997), where for the first three classes have a higher alignment, resulting in lower need to be physically present at work and better opportunities to telework. Finally, the 'indifferent and occasional', who telework least, also disagree most with this statement. In conclusion, the different teleworker classes showcase that the employers' demands regarding telework are granted most of the time, even though the employee might be disagreeing as a result.

4.3. Travel patterns

During the intelligent lockdown, people were recommended to stay at home as much as possible. After the lockdown, the government recommended people to telework as much as possible (as did 70% of the employers in this sample). Teleworking and not travelling on government advise (nothing was obligatory) has drastically impacted the travel patterns. In this section we explore how the different teleworker classes differ in their travel patterns over time. The travel patterns are explored by looking at the frequency of travel (in number of days per week) by different travel modes, being bicycle, car, train, and bus/tram/metro (see Fig. 8).

Since the respondents in the sample are all train travellers (both frequent and infrequent), it is not surprising to see that the share of respondents not using the train in an average week before the COVID-19 crisis started is very low (ranging 7–14%). During the pandemic, this increased manifold.

The identified teleworker types show several differences in their travel patterns. However, the differences in mode use over time are larger than the differences between teleworker types. Hence, the impact of COVID-19 and the measures taken by the government, have impact on all teleworkers. The 'enthusiastic and always' teleworkers show the highest share of people not using the public transport, which indicates that they used public transport for their commute, given that they telework (almost) full-time. The 'positive and partially' teleworkers roughly follow the pattern of the former group; however, they have higher shares of using all modes during and after the lockdown. This is most likely due to the fact that they telework less frequently. The 'neutral, new, and frequently' teleworkers were the most frequent cyclists before the lockdown but did not cycle as much during the COVID-19 pandemic. As they also fully resort

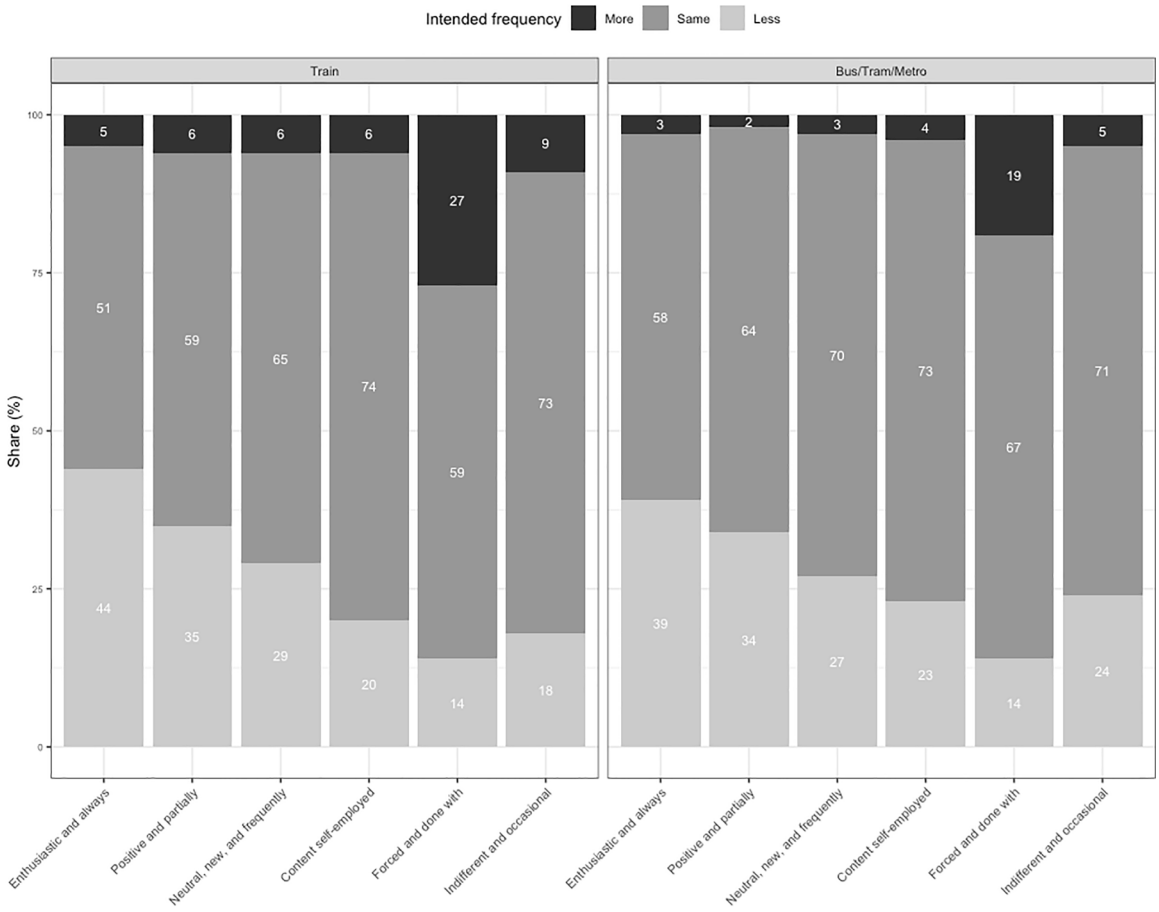

Fig. 9. Intention of using public transport post-COVID-19 compared to pre-COVID-19.

to teleworking during the lockdown, their use of modes in that period drops drastically. Finally, this group has the lowest use of the car over time of all teleworker types. The 'content self-employed' decreased their car use during the lockdown, but afterwards it is back to its original level. The 'forced and done with' teleworkers used the bicycle the least during the lockdown. The 'indifferent and occasional' teleworkers, who also sometimes commute to work, show the smallest decrease in use of all modes during and after lockdown of all groups.

The impact of the COVID-19 pandemic on travel patterns is largest for public transport (train and bus/tram/metro), consequently we investigate the intentions of using these modes in a post-COVID-19 world in relation to the use pre-COVID-19 (see Fig. 9). Those teleworker types that are most positive about teleworking during the COVID-19 pandemic and intend to do this more often ('enthusiastic and always' and 'positive and partially'), are also more negative in relation to using public transport after the pandemic. Again, a suggestion that these individuals use public transport for commuting (the 'enthusiastic and always' also feel most restricted to travel by public transport of all classes). The two types that indicated mostly to continue teleworking on the same frequency as before the pandemic ('content self-employed' and 'indifferent and occasional') also indicate mostly that their frequency of using public transport remains the same (the individuals in these two classes also feel least restricted to travel by public transport of all classes, albeit that they still feel restricted). The 'forced and done with' teleworkers, who were forced to work at home during the lockdown and did not enjoy teleworking, actually indicated mostly to telework less frequently after the pandemic. This again is reflected in the intention of using public transport, as a high share of these teleworkers indicate that they intend to increase their frequency of use compared to before the pandemic.

5. Discussion

In general, our findings on frequency of, attitudes towards and future intentions to telework are in line with previous Dutch and Australian studies (Beck et al., 2020; de Haas et al., 2020; Hamersma et al., 2020). In this study, instead of investigating the general trends, we focused on understanding differences between teleworkers in different situations (type of work, organisation, person, and home/family). In this section we discuss the model approach and the differences and similarities in-depth.

The proposed model to classify teleworkers into different classes poses some limitations. In the proposed structure, we assume that

current behaviour and future intentions are independent from each other. The results of the model also suggest that this is the case, as the bivariate residuals between these indicators are not significant. However, previous studies have shown that there is a relationship between current and future behaviour (e.g. Ton et al., 2019a). Potentially, a crisis situation such as the COVID-19 pandemic results with such an uncertainty that future intentions and current behaviour are unrelated. However, more research is required to verify this statement. Furthermore, the proposed model structure assumes that the attitude towards teleworking and the future intentions of teleworking are independent. Ajzen (1991) suggests that attitude does impact the future intentions. Ideally, the relationship between attitude and intentions should be modelled as such. As this represents a crisis situation, we believe the proposed structure will also hold. Next to that, we have asked about future intentions regarding teleworking in June 2020 and asked respondents to compare to the situation before COVID-19. For some respondents, this question might be straightforward because of the obvious changes in their teleworking behaviour, but for others who have changed their behaviour less drastically, this might be difficult to answer. This might lead to inaccuracies (bias) in the answering of this question. On the other hand, the future intentions reflect the situation in June 2020, which might change over time when other measures or situations arise. Hence, the future intentions need to be interpreted with care.

COVID-19 brought a sudden change for the working population: the advice was to telework as much as possible. As mentioned by Baruch and Nicholson (1997), efficient teleworking requires the alignment of the organisation characteristics, job characteristics, individual characteristics and family and home environment. Our analysis shows that this alignment is definitely not present for everyone. One class however, the 'enthusiastic and always' teleworkers, which represent 31% of the teleworking train passenger population, show that this alignment is very well possible. 93% of this group had the possibility of teleworking before the pandemic, which indicates that the organisation is prepared for teleworking and their job is suitable. On the other end of the spectrum, we find the 'forced and done with' teleworkers (8% of our population), who had limited experience with teleworking and only half of them had the possibility to telework before the pandemic. They were forced to telework during the pandemic, both by the government and their employer. However, these findings suggest that the organisation was not prepared for teleworking. Finally, one class seems largely unaffected by the sudden changes of this pandemic: the 'content self-employed' (representing 12% of our population). They have teleworked frequently before the pandemic and are content with it. This shows in the fact that after the lockdown they have quickly returned to the same rhythm they had before. Their travel patterns are still affected, probably due to the government regulations, but their intentions towards future mode use and teleworking suggest that they will return to their former behaviour.

The six identified classes can roughly be divided into two groups regarding their willingness to telework, after having experienced teleworking during the pandemic: high willingness-to-telework and low willingness-to-telework. One class does not match with either group, as they seem to be unaffected by the pandemic: the 'content self-employed'. Therefore, in the discussion regarding willingness-to-telework and its consequences for travel patterns, we focus on the other classes.

High willingness-to-telework fits the 'enthusiastic and always', 'positive and partially', and 'neutral, new, and frequently' teleworkers. They are neutral to positive about teleworking and intend to telework more frequently in the future. 72% of this group teleworked before the pandemic, and most had the possibility to telework before. Combining this with the fact that this group contains most high educated people, which usually work more independently, suggests that their profiles are very suitable for teleworking (Sostero et al., 2020). However, in addition to what people themselves want, other factors play a role that determine whether employees are also allowed to work from home, such as social pressure from the employer, colleagues or the environment in the private sphere. This group encompasses 71% of the train travelling teleworking population, hence large changes in travel can be expected (Hamer et al., 1991). This group contains the most frequent train travellers (24% of them travelled four times a week or more by train) and 37% of this group intend to travel by train less frequently compared to pre-COVID-19. Consequently, the findings of Hamersma et al. (2020) that public transport is most affected by teleworking, is confirmed here, as this group will most likely decrease their frequency of train travel. Since, we do not yet know when the pandemic will end, it is difficult to picture the exact impact of increased teleworking on travel patterns. Additional survey(s) in later stages of the pandemic will provide more clarity when asking the intended frequency of teleworking and the days on which they intend to telework. This will support public transport operators and authorities in planning and managing their services, according to their policy goals in a new post-COVID-19 context.

Low willingness-to-telework fits the 'forced and done with' and 'indifferent and occasional' teleworkers. Especially the former was forced to telework, whereas our findings suggest that their organisations were not ready, individuals did not like teleworking and most likely their jobs were not suitable, given that many worked in education and vital sectors. This group encompasses 16% of the train travelling teleworker population. They telework less frequently compared to the other group and intends to either telework less than before or on a similar frequency, which translates to either maximum once per week or never again. In terms of travel patterns, we expect them to largely return to their original patterns. However, the 'forced and done with' teleworkers might even increase their travel frequencies.

We only include teleworkers that teleworked during both survey-periods and excluded the temporary teleworkers that only teleworked during one of the survey-periods. As we did not investigate the reasons for these respondents to not telework during one of the survey-periods, we cannot tell how they would fit and impact the classes that were identified in the LCCA. However, it is more likely that these temporary teleworkers are more in line with the 'forced and done with' and 'indifferent and occasional' teleworkers that show low willingness-to-telework. Hence, when including all teleworkers, it is likely that we underestimate the size of the low willingness-to-telework group and overestimate the group with high willingness-to-telework. Similarly, if we would have included data from the next survey too, this might show that the respondents in the current low willing-ness-to-telework group would be excluded because they would not telework anymore. Hence, we overestimate the size of the group that shows high willingness-to-telework in relation to the group that shows low willingness-to-telework.

6. Conclusions and recommendations

This paper presents the findings of an investigation into teleworking during COVID-19. The sudden changes and adaptations that were required of the working population to telework as much as possible, resulted in a suboptimal situation for several people. In this study, longitudinal data of train travelling teleworkers in times of COVID-19 is used to investigate differences and similarities among the population in terms of attitude towards teleworking, frequency of teleworking and intentions related to teleworking after the pandemic has ended. We apply a latent class cluster analysis to identify six different types of teleworkers: 'enthusiastic and always', 'positive and partially', 'neutral, new, and frequently', 'forced and done with', and 'indifferent and occasional'. These six classes differ largely from one another. We can classify these based on their willingness-to-telework: the high willingness-to-telework group (71% of the teleworking train passenger population), the low willingness-to-telework group (16%) and the self-employed (12%). The first group largely work for organisations that are prepared for teleworking and have a job, personality, and home situation that fits teleworking. This group also experienced the biggest impact on their travel patterns, and due to their intentions to telework more often after the pandemic, it will also affect their future travel patterns most. This groups consists of many frequent train travellers; hence we can expect a decrease in their train use in the future. The future will show if social pressure will have an impact on the travel frequency at the end of the day. The second group largely work for organisations where teleworking was not possible/allowed/done before de pandemic, have unsuitable jobs or have a less positive attitude towards teleworking. They are mostly employed in the education and vital sectors. Their travel patterns are affected in the pandemic; however, they intend to return to their previous patterns. The third group already teleworked frequently before the pandemic and are least affected by the pandemic (both during and after the pandemic).

The classes with high willingness-to-telework are expecting to decrease their public transport use (for commuting) in the future. For public transport planning and operations, it is essential to also understand when (which days of the week) and where (geographical) the decrease in ridership will occur. Currently, the peak hours shape the required capacity of the public transport systems (both regarding infrastructure and vehicle capacity). Peak hours are most crowded on Monday, Tuesday and Thursday. Lowering these peaks would result in a potential better use of the entire system (as the capacity can be used more efficiently), which would be a positive outcome of this reduction in demand. Also, flexible working hours (or office hours) could be beneficial, implying avoiding the peak hour(s). This new (tele)working behaviour requires that employers and government urge their employees to telework on certain days of the week and/or moments on the day, to ensure spreading the demand. Hence, policies and communications are required that regulate teleworking better (from both government and employer). On the other hand, a reduction in demand leads to a decrease in revenues, which might (on the long-term) negatively impact the service and operations of the public transport operators (Tirachini and Cats, 2020; van Hagen et al., 2021).

The classes with low willingness-to-telework are expecting to return largely to their former behaviour both in terms of teleworking and travel patterns. Hence, the impact of this group for public transport operations and planning remains limited. However, as the government has urged people to use public transport only if necessary, these people need to be welcomed back again by the operators (via for example campaigns) before they will return. Furthermore, during the pandemic, several improvements are required if these people have to increase their telework frequency again (as is the case in the lockdown of December 2020). These employees' organisations seem to not to be ready to host teleworking, hence big steps in preparation are required to ensure a robust system and more efficient teleworking. It is essential that the government provides tools to companies (especially in the education and vital sectors). Employers on the other hand need to better support their employees, such that they stay in contact with colleagues and their concentration and productivity can increase. If they fail to do so, the pandemic might have severe impact on the employees' satisfaction with work and productivity and concentration.

The four types of teleworking (the alignment of the organisation characteristics, job characteristics, individual characteristics and family and home environment) by Baruch and Nicholson (1997) seem promising to give more grip on the factors that contribute to the degree of teleworking and can be combined with the six groups on teleworking we found in this research. With regards to future research, it would be useful to track how these six groups further experience teleworking during the pandemic and how that affects their intentions. This project has ongoing data collection and every time drastic changes in measures are introduced, behaviour, experiences and intentions are measured again. The longevity of this crisis and economic impact might result in drastic changes or transitions among these classes. Furthermore, this study focusses on train travellers, which is expected to be the mode of transport that is affected most by the transition to teleworking after the pandemic. It would be interesting to perform a similar analysis among either car users/commuters or the entire population, to investigate the differences between these and get more grip on the impact of potential policies. Additionally, in this study the attitude or fear towards COVID-19 and using shared/public modes, was not included implicitly. It would be interesting to see to what extent this attitude impacts the behaviour and intentions of teleworking and commuting.

CRediT authorship contribution statement

Danique Ton: Conceptualization, Data curation, Methodology, Investigation, Formal analysis, Visualization, Writing – original draft, Writing – review & editing. **Koen Arendsen:** Conceptualization, Investigation, Methodology, Formal analysis, Visualization, Writing – review & editing. **Menno de Bruyn:** Data curation, Writing – review & editing. **Valerie Severens:** Data curation. **Mark van Hagen:** Data curation, Writing – review & editing. **Niels van Oort:** Funding acquisition, Writing – review & editing. **Dorine Duives:** Data curation.

Table A1
Evaluation criteria to determine the optimal number of clusters based on indicators.

# Clusters	LL	BIC(LL)	Npar	L^2	Class.Err.	# significant BVRs	Total BVR score
1	−37212.7	74508.8	9	5177.0	0	6	3108.78
2	−35997	72123.7	14	2745.6	0.111	5	156.12
3	−35777	71730.2	19	2305.6	0.188	4	36.16
4	−35290.6	70803.6	24	1332.7	0.110	4	76.28
5	−35039.5	70347.8	29	830.6	0.155	2	30.70
6	*−34936.4*	*70187.9*	*34*	*624.3*	*0.173*	*0*	*4.13*
7	−34941.3	70244.2	39	634.2	0.200	2	14.73
8	−34907	70221.8	44	565.5	0.238	1	12.75
9	−34788	70030.3	49	327.7	0.216	0	1.47
10	−34778.3	70057.2	54	308.2	0.231	0	0.84

Table A2
Parameters of the 6-cluster LCCA model for teleworking typology (with indicators and active covariates).

Prediction of the indicators in the measurement model (teleworking frequency)									
		C.1	**C.2**	**C.3**	**C.4**	**C.5**	**C.6**	**Wald**	**p-value**
	February 2020	−0.50	0.41	1.17	−3.45	1.80	0.58	1054.3	0.000
	April 2020	−3.47	2.08	−4.71	1.06	1.40	3.63	344.3	0.000
	June 2020	−2.16	0.59	−0.35	−0.60	0.43	2.09	604.4	0.000
	Post-COVID-19	2.53	2.85	1.19	−0.85	−4.92	−0.81	1013.5	0.000
	Intercepts	**Feb. 2020**		**April 2020**		**June 2020**		**Post-**	
	Wald	1708.6		184.0		491.9		498.8	
	p-value	0.000		0.000		0.000		0.000	
	frequency		*frequency*		*frequency*		*frequency*		
	>= 4x p/w	−2.64	>= 4x p/w	3.00	>= 4x p/w	0.76	Less	−2.01	
	2-3x p/w	0.04*	2-3x p/w	0.52	2-3x p/w	0.46	Same	1.05	
	<= 1x pw	1.89	<= 1x p/w	−3.52	<= 1x p/w	−1.23	More	0.95	
	Never	0.72							
Prediction of latent class membership in the structural model									
	Value	**C.1**	**C.2**	**C.3**	**C.4**	**C.5**	**C.6**	**Wald**	**p-value**
Intercept		0.57	0.96	−0.76	−0.15	−0.17	−0.45	7.2	0.000
Type of employment	Government	1.12	0.44	1.50	−1.51	−0.08*	−1.47	1200.9	0.000
	Education sector	−0.49	−0.54	1.23	−0.51	0.33	−0.01*		
	Vital sector	−0.52	0.24	0.97	−1.30	−0.02*	0.63		
	Other sector	−0.01*	0.07*	1.54	−0.77	0.04*	−0.87		
	Self-employed	−0.10	−0.22	−5.25	4.10	−0.27	1.72		
Attitude towards teleworking									
Productivity due to no commute		0.78	0.34	−0.23	−0.04	−0.32	−0.52	285.1	0.000
Facilities and support		0.77	0.17	−0.21	0.06	−0.31	−0.48	199.1	0.000
Productivity and concentration		0.10	0.10	−0.12	0.52	−0.50	−0.10	172.1	0.000
Contact with colleagues	Disagree	−0.21	−0.23	0.15	−0.01*	0.20	0.10	45.6	0.000
	Neutral	0.03*	0.29	−0.06*	0.00*	−0.19	−0.07*		
	Agree	0.18	−0.06	−0.09	0.01*	0.00*	−0.03*		
Household composition	Child(ren) < 12 years	−0.34	0.59	−0.02*	0.26	−0.23	−0.26	220.2	0.000
	Child(ren) greater than 12 years	0.53	−0.01*	−0.76	0.25	−0.40	0.39		
	1 or more adults	−0.20	−0.51	0.32	0.16	0.19	0.03*		
	Live alone	0.01*	−0.07*	0.46	−0.67	0.44	−0.15		
Education level (completed)	Practical education	−0.51	−0.76	−0.14	0.30	0.29	0.82	369.1	0.000
	High school	−0.44	0.35	0.18	0.50	0.60	−1.19		
	University of App. Sc.	0.18	0.17	−0.29	−0.34	−0.11	0.39		
	University	0.77	0.24	0.24	−0.45	−0.79	−0.02*		

*not significant at 0.05 significance level.

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.

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Appendix A. Latent class cluster analysis model

Tables A1 and A2.

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