Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.

ARTICLE IN PRESS

Case Studies on Transport Policy xxx (xxxx) xxx

Contents lists available at ScienceDirect

Case Studies on Transport Policy

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

Work from home in the post-COVID world

Xiaoqiang Kong [a], Amy Zhang [b], Xiao Xiao [a], Subasish Das [c,*], Yunlong Zhang [a]

[a] Texas A&M University, 3127 TAMU, College Station, TX 77843, United States
[b] The University of Texas at Austin, 305 E 23rd St, Austin, TX 78712, United States
[c] Texas A&M Transportation Institute, 1111 RELLIS Pkwy, Bryan, TX 77807, United States

ARTICLE INFO

Keywords:
Work from home
Pandemic
COVID-19

ABSTRACT

The working standard of shared office spaces has evolved in recent years. Due to the ongoing COVID-19 pandemic, many companies have instituted work from home (WFH) policies in accordance with public health guidelines in order to increase social distancing and decrease the spread of COVID-19. As the pandemic and WFH-related policies have continued for more than a year, there has been a rise in people becoming accustomed to the remote environments; however, others are more enthusiastic about returning to in-person work environments, reflecting the desire to restore pre-pandemic environments. As working from home is related to transportation issues such as changing commuting patterns and decreased congestion, motorized trips, and emission, there is a need to explore the extent of public attitudes on this important issue. This study used unique open-source survey data that provides substantial information on this topic. Using an advanced categorical data analysis method known as cluster correspondence analysis, this study identified several key findings. Not having prior WFH experiences, being eager to interact with colleagues, difficulties with adapting to virtual meeting technologies, and challenges with self-discipline while WFH were strongly associated with individuals who refused to continuously WFH at all after the pandemic. Individuals holding a strong view against the seriousness of the COVID-19 pandemic were also largely associated with never choosing WFH during and after the pandemic. For individuals with some prior WFH experiences, the transition to WFH every day in response to the outbreak was much easier, compared to those without prior experiences. Moreover, being forced to WFH during the COVID-19 pandemic positively influences the choice of WFH after the pandemic. The findings of this study will be beneficial to help policymakers and sustainable city planners understand public opinions about WFH.

1. Introduction

Working remotely has become a mantra for the younger generation in recent years due to the increased flexibility that it offers. When the COVID-19 pandemic started to spread throughout the world, many agencies shifted towards work from home (WFH) policies due to widespread lockdowns and the necessity of decreasing the spread of the virus. This new work culture has created a cultural paradigm shift for both workers and employers. Due to the continuation of WFH for over a year, this new work culture has impacted many issues, such as commuting patterns, congestion, safe travels, motorized trips, and emissions. Many employees started to get accustomed to WFH and will prefer to continue WFH even as pandemic-related restrictions relax. On the other hand, there are also employees who do not like WFH policies, and who will prefer a return to pre-pandemic office environments. As many corporations attempt to return to the normal office working environment, this tremendous shift of work culture is becoming a key issue. There is a need for performing a rigorous analysis in understanding the public opinions on the WFH choice.

Working from home is considered a modern management practice in which an increasing share of employees choose to be based in their homes. In the United States, the proportion of employees who primarily work from home has steadily increased over the past few decades (Bloom et al., 2015). Previous research regarding WFH policies has raised questions regarding productivity, profitability, and work-life balance (Berinato and Bloom, 2014; Bloom et al., 2015; Bloom and Roberts, 2015). In 2013, then new Yahoo CEO Marissa Mayer controversially banned working from home for Yahoo staff, citing a desire for increased worker productivity and a more communal company culture through co-presence (Goudreau, 2013). The global spread of COVID-19 prompted a forced broad shift towards WFH for many developed countries, representing a unique natural experiment and arguably the

* Corresponding author.
E-mail address: s-das@tti.tamu.edu (S. Das).

https://doi.org/10.1016/j.cstp.2022.04.002
Received 9 October 2021; Received in revised form 7 March 2022; Accepted 4 April 2022
Available online 6 April 2022
2213-624X/© 2022 World Conference on Transport Research Society. Published by Elsevier Ltd. All rights reserved.

most drastic shift to the global workforce since World War II (Baudot and Kelly, 2020) — for example, towards the beginning of the COVID-19 pandemic in April 2020, more than half of the American workforce was WFH (Ozimek, 2020). The lingering effects of this shift will have lasting implications for not only the future of remote work and hiring practices, but also on how societal infrastructures will respond to changing priorities with regard to commuting patterns and urban resiliency.

Current state-of-the-art studies have explored this critical issue. The literature review section provides a detailed overview of the studies on this topic. It is found that the data available for exploring this topic is limited. None of the previous studies examined the WFH characteristics in the post-COVID world. This study uses unique and open-source survey data to address this critical issue. The survey was composed of 2,018 residents in the Puget Sound Region in Washington State (Jabbari et al., 2020). The survey data contains many questions on WFH at different levels of the pandemic (before, during, and after). As the questionnaire design includes WFH characteristics in the post-COVID world, it is able to mitigate the current research gap. After exploring several categorical data analysis methods, this study finally applied cluster correspondence analysis to identify the latent trends of the key factors. The findings of this study will be beneficial for policymakers and sustainable city planners to understand the critical factors of WFH in the post-COVID world.

2. Literature review

The literature review section provides a broad overview of this topic based on three major perspectives: 1) travel behavior, 2) WFH characteristics, and 3) societal implications.

2.1. Travel behavior

The COVID-19 pandemic impacted the healthcare-related, economic, and social aspects of people's daily lives (Haleem et al., 2020; Lai et al., 2020). The Center for Disease Control and Prevention (CDC) and other scientific institutions suggested several non-pharmaceutical interventions to combat the spread of COVID (Flaxman et al., 2020). Measures such as travel restrictions (Chinazzi et al., 2020), self-isolation, and social distancing (Block et al., 2020) were proposed to reduce the spread of the virus by minimizing person-to-person physical contact (Lades et al., 2020). Orders and recommendations issued by the government across the U.S. included lockdowns, closure of schools and businesses, bans on gatherings, curfews, quarantines for travelers, etc.

These restrictions and precautions have shaped travel behaviors dramatically (Gostin and Wiley, 2020). The impacts of the COVID pandemic and related travel restrictions are extensive (Barbieri et al., 2020). For example, COVID has shaped the frequency (Meena, 2020) and mode (Hu et al., 2020) of many people's commutes. With an increasing number of students studying from a distance (Dorn et al., 2020) and people working from home (Angelucci et al., 2020), commuting volumes have changed significantly. People are gradually switching from traditional patterns to remote work (or WFH), and young people are more active in making this change (Brynjolfsson et al., 2020). During the transition phase, almost half of the commuters stopped traveling, and the rest remained unchanged. This is due to travel time, the key factor that influences the commuting decision (Pawar et al., 2020). Aside from private traffic, the impact on public transit is also significant. For example, bus ridership has decreased more than 60% in some areas in the U.S, with the largest declines being during morning and evening commute times on weekdays (Wilbur et al., 2020). The degree of decrease in the use of public transit is associated with individual-specific levels of income —lower-income groups are historically the most likely to be impacted by societal crises and are the least likely to own their own cars due to physical or economic barriers, causing them to be more reliant on public transportation to access public services and jobs, and COVID-era data indicates that there are significant differences in ridership decline between areas with higher incomes compared to those with lower incomes (Wilbur et al., 2020). Even though public transit usage has generally steeply declined, lower-income areas possibly maintain slightly higher public transit usage due to people working "essential worker" jobs in stores, sanitation, and more, who still need to use public transportation services in order to access their work, regardless of the threat of COVID-19. Prior research has also revealed that rural counties are more vulnerable to COVID-19, driven by there being less health and social services — however, urban counties with denser living conditions are more susceptible to community spread (Nguyen et al., 2020; Peters, 2020). Urban adults also more commonly had their work impacted by COVID-19, even though rural workers were less likely to WFH (Brooks et al., 2021).

2.2. WFH characteristics

Researchers have studied the historical pattern of WFH (US Bureau of Labor Statistics, 2018). COVID amplified the trend of WFH (Béland et al., 2020; Gallacher and Hossain, 2020). Even though the shift to WFH was involuntary, many workers have revealed that they prefer WFH and will prefer remote work more after COVID than they did prior to the pandemic. This is due to their personally assessed increases in productivity (Baudot and Kelly, 2020). While many people have adapted to this new type of working style, some people considered commuting an essential part of work and missed it during shutdowns (Marks et al., 2020). Facilities and technologies are being increasingly developed to support remote work in the future. For instance, the popularity of virtual reality and remote workspace platforms is a trend (Fereydooni and Walker, 2020). Evidence additionally supports, contrary to expectation, that the labor supply of parents with children was not negatively impacted by the pandemic; instead, parents were more likely to be working remotely after the pandemic began (Barkowski et al., 2020; McLaughlin et al., 2020).

However, COVID-19 provides additional disruptions that need to be considered in the context of previous literature on WFH. While past research has extolled the benefits of WFH for decreasing commutes and increasing work-life balance for employees, factors like childcare, insufficient home space, lack of privacy, and decreased agency all challenge how productive a worker can be during the pandemic (Cuerdo-Vilches et al., 2021; Gorlick, 2021; Mazumder et al., 2021). Remote work increases experiences of social isolation, which increases stress and negatively impacts remote work satisfaction, particularly for workers who are more concerned about COVID-19 (Galanti et al., 2021; Toscano and Zappalà, 2020). One problem is that some people can choose to continue working from home, whereas some are either not able to or not willing to. Recently, researchers have paid attention to commuting and social inequalities in remote learning or working during COVID-19 (Gondim and Tanaka, 2020; Hernandez, 2020). This inequality problem persists in both remote work and distance learning (Murat and Bonacini, 2020). People in lower-income brackets are usually unable to be as flexible with their mobility, compared to those with higher incomes (Iio et al., 2020). The ability and willingness to WFH have been studied for people with different income levels, and these studies have shown that people with lower incomes are much less willing to WFH (Atchison et al., 2020). Aside from income, the factors that can affect commuting decisions during COVID-19 include race, ethnicity, gender, and level of education. Studies show that people with higher levels of education tend to WFH more during the pandemic, which may be related to the difference in types of work that are influenced by levels of educational attainment (Figueroa et al., 2020). Further, zip codes with low levels of educational attainment experienced higher prevalence rates of COVID-19, implying that social vulnerability from not being able to WFH can have large ramifications on how well communities recover from the pandemic (Kashem et al., 2021). The chance to maintain employment after WFH is also associated with factors like income and race. For example, high-income and white people

are more likely to choose WFH (Bick et al., 2020). The commute pattern could also vary for travelers of different genders. The research shows that the influence of COVID-19 on employment for men is more severe than that for women. Even though increased availability of WFH policies could be beneficial in terms of closing the labor gender gap, a simultaneous need for childcare coupled with a focus on traditional gender roles potentially negates any gains (Alon et al., 2020; Arntz et al., 2020).

2.3. Societal implications

COVID-19 has prompted a digital transformation of the workforce, and industry leaders must adapt to changing labor frameworks in order to reimagine the role of corporate culture and community, particularly with increased resistance to returning to a physical office from younger employees (Boland et al., 2020; Ito, 2021; Savić, 2020; Schwartz and Marcos, 2021; Weber, 2021). While in the United States only around 15% of working hours were conducted at home from 2011 to 2018 (Hensvik et al., 2020), data collected during the COVID-19 pandemic reveals that 32% of employees, many of whom have children, live in the suburbs, and have long commutes to work, never want to return to working in the office. 21% of employees (commonly young, single, and centrally located in metropolitan areas), however, strongly oppose future WFH policies (Bloom, 2021). Largescale reductions in commuting time will lead to benefits for workers post-pandemic, even though these benefits will largely be for those who are highly educated and well paid (Barrero et al., 2021). WFH policies have also forced shifts in local labor markets that create uneven geographic effects, as economic activity decreases in urban centers while increasing in residential suburbs, further contributing to supply chain issues (De Fraja et al., 2021; Ramani and Bloom, 2021). The impact of social distancing on transportation usage patterns may also impact the infrastructure of cities moving forward, highlighting the importance of multimodal transportation in order to increase the resiliency, affordability, accessibility, and sustainability of future transportation systems (Amekudzi-Kennedy et al., 2020; Bert et al., 2020; Keenan, 2020; Rupani et al., 2020; Vogel et al., 2021). It is important to understand how commuting patterns have changed for different groups before and during COVID-19. However, comparing commuting patterns before and during COVID-19 between income groups has seldomly been studied at an individual level. Additionally, it is important to understand how this pandemic will affect further post-pandemic WFH patterns. Urban design and infrastructure are particularly foundational to understanding how people interface with their built environments, and it is accordingly important to parse how changing priorities with regards to WFH will impact the United States in the future.

3. Methodology

3.1. Dataset overview

The dataset was published by a research team at the University of Washington. 2018 residents of the Puget Sound Region in Washington State participated in the survey (Jabbari et al., 2020). Out of the 2018 respondents, 1389 of them finished the survey. Since this study focuses on the WFH patterns among these participants, 874 participants with full-time or part-time positions were considered. The detailed data cleaning process is documented in the original report (Jabbari et al., 2020). Individuals with the same corresponding mails and phone numbers were considered as the same person. Thus, these duplicated rows were removed. For additional details on the survey design, interested readers can consult Jabbari et al. (2020). It is important to know that the Puget Sound Region is centered on Seattle and consists of nine counties, two urban center cities, and four satellite cities. As this survey provides critical information on the participant's attitudes towards WFH in the post-COVID world, the findings can be utilized for sustainable city design in the post-COVID world.

3.2. Variables available

Twenty-eight variables were considered in this study. Eight of them, shown in Table 1, are demographic factors of the survey participants, such as age, gender, race, and income. Five of them, shown in Table 2, are WFH-related features, such as WFH frequency before the COVID-19 pandemic (WHBC), WFH frequency during the COVID-19 pandemic (WHDR), and WFH frequency after the COVID-19 pandemic (WHAC). Table 3 contains three variables for the reasons for changes in WFH frequencies, travel mode, and work hours change. Twelve variables, shown in Table 4, are associated with participants' perception of certain social issues, such as if they think face coverings should be mandated.

3.3. Descriptive statistics

Tables 1–4 present the counts of the twenty-eight variables used in this study. Table 1 shows that the number of participants was nearly even, with 49% female and 51% male. The majority of.

Table 2 shows WFH-related features both before and during COVID, as well as the perceived WFH frequency in the future. The majority of participants (72%) never worked from home before COVID, and only 7% worked from home every day. During COVID, the total percentage of participants that worked from home at least one day a week increased to 81%, and a majority of the participants worked from home every day (66%). After COVID, 57% of the participants predicted that they will WFH at least one day a week, and 11% of participants predict that they will WFH every day. For trip modes before COVID, a large share of participants chose to drive alone (64%), while 17% of participants took public transit. The numbers decreased significantly for both driving alone (now 19%) and public transit (now 1%) during COVID. These new percentages likely reflect the number of employees who did not need to commute, along with increased unemployment as a result of COVID-19 impacting businesses.

Table 3 lists the reasons for WFH-related changes during COVID. Approximately half of the participants (45%) chose to WFH due to their employer's policies. Participants also switched to WFH for other reasons (25%). As for work hours, employer's policies had a share of 18%, while 'others' had a share of 62%. For the change of trip mode, employer's policies (17%) and voluntarily changing (20%) were both influential factors, and government rule (9%) was also a major reason. Similar to the other features, other reasons exist and made up about half of the total number of participants, meaning that governmental decrees and employer policies were not solely responsible for how much people worked from home.

Table 4 shows the participants' personal opinions and perceptions about social issues related to COVID. A majority of the participants agreed that face covers should be mandatory, everyone should stay at home if possible, physical distancing is an efficient approach, they are concerned about family, and they enjoy social interactions. The percentage of participants who hold these opinions reaches about 90%. For some opinions, such as thinking the media is not exaggerating about COVID-19, their family expects them to stay at home, they do not miss commuting, they can efficiently conduct work meetings at home, and they perform better when they interact with co-workers, a majority of people (around 70–80%) agreed rather than disagreed (20% to 30%). For some other opinions, such as increasing family conflict and making people less disciplined, the percentages of people who agreed were almost equal to those who disagreed.

3.4. Cluster correspondence analysis (Cluster CA)

Cluster correspondence analysis (cluster CA) combines dimension reduction with cluster analysis for categorical data. The method is to find a reasonable allocation of observations to the groups which are similar concerning observed variables (van de Velden et al., 2017). It conducts correspondence analysis for cross-tabulation of the cluster

Table 1
Counts of Demographic and personal features.

Variable	Detail	Attribute	Code	Count	Percentage	Bar Chart
PD2	commute distance	Not Applicable	0	80	9	
		less than 10 miles	1	395	45	
		10 to 20 miles	2	230	26	
		longer than 20 miles	3	169	19	
PD3	gender	female	1	430	49	
		male	2	444	51	
PD4	age	younger than 20	1	18	2	
		21-40	2	375	43	
		41-60	3	396	45	
		older than 60	4	85	10	
PD5	race	Asian	1	93	11	
		White	2	685	78	
		Others	3	96	11	
PD6	living situation	spouse	1	168	19	
		spouse and children	2	371	42	
		spouse and pet	3	93	11	
		others	4	242	28	
PD7	household income	Not answered	0	41	5	
		$50000 or less	1	77	9	
		$50,000 to $99,999	2	225	26	
		$100,000 or more	3	531	61	
PD8	education	Some college/technical training	1	79	9	
		Bachelor degree	2	339	39	
		Master or higher	3	333	38	
		Others	4	123	14	
PD9	living space	Apartment	1	134	15	
		House	2	589	67	
		Others	3	151	17	

participants are in the 21–40 and 41–60 age groups. The statistics in Table 1 also show that most participants have annual household incomes greater than $50,000. About 339 participants have a bachelor's degree, and 333 have a master's or higher degree.

membership and the variable categories (Markos et al., 2019). The method can maximize the cluster variance by optimizing the scaling values for rows and columns. Rows and columns represent clusters and categories in data, respectively. As a result, the clusters are optimally identified over the categorical variables. Categories with differing distributions over the clusters are optimized as well. An R package called 'clustrd' was adopted to perform the analysis (Markos et al., 2019). The method can be described as follows.

A dataset of n individuals on p categorical variables can be gathered in a super indicator matrix $\mathbf{Z}$ with dimensions of $n \times Q$, where $Q = \sum_{j=1}^{p} q_j$. Let $\mathbf{Z_k}$ be the $n \times K$ indicator matrix that indicates the cluster membership.$\mathbf{F}$ is a table that shows the cross-tabulated relationship between the cluster memberships and the categorical variables.

$$\mathbf{F} = \mathbf{Z_k}^{'}\mathbf{Z} \tag{1}$$

$\mathbf{P}$ denotes a data matrix with non-negative elements that sum to 1. Let.

$$\mathbf{P} = \frac{1}{np}\mathbf{F} \tag{2}$$

Then it writes that:

$$\mathbf{P} - \mathbf{P}1_Q 1_K^{'}\mathbf{P} = \frac{1}{np}\mathbf{Z}_K^{'}\mathbf{MZ} \tag{3}$$

where 1_Q, 1_K, and 1_n denote vectors of ones with the dimension of $Q, K,$ and n.

$$\mathbf{M} = \mathbf{I}_n - 1_n 1_n^{'} \tag{4}$$

Diagonal matrix $\mathbf{D}z$ is defined as:

$$\mathbf{D}_z 1_Q = \mathbf{Z}^{'} 1_n \tag{5}$$

$\mathbf{B}$ is the coordinate matrix and $\mathbf{B}^*$ can be defined as:

$$\mathbf{B}^* = \frac{1}{\sqrt{np}}\mathbf{D}_z^{1/2}\mathbf{B} \tag{6}$$

Given a $\mathbf{Z}_K$, the $\mathbf{B}^*$ can be calculated from the eigenvalue decomposition:

$$\frac{1}{p}\mathbf{D}_z^{-1/2}\mathbf{Z}^{'}\mathbf{MZ}_K\mathbf{D}_K^{-1}\mathbf{Z}_K^{'}\mathbf{MZD}_z^{-1/2} = \mathbf{B}^*\Lambda^2\mathbf{B}^{*'} \tag{7}$$

$\mathbf{Y}$ is an n by d matrix with reduced space coordinates for the observations, which is determined by:

$$\mathbf{Y} = \sqrt{\frac{n}{p}}\mathbf{MZD}_z^{-\frac{1}{2}}\mathbf{B}^* \tag{8}$$

The cluster means are calculated as:

$$\mathbf{G} = \mathbf{D}_K^{-1}\mathbf{Z}_K^{'}\mathbf{Y} \tag{9}$$

The algorithm for cluster CA can be described as the following: Firstly, random objects are assigned to clusters to generate an initial

Table 2
Counts of WFH-related Features.

Variable	Detail	Attribute	Code	Count	Percentage	Bar Chart
WHBC	WFH frequency before COVID-19	Never	1	629	72	
		1-2 days a week	2	152	17	
		3-4 days a week	3	30	3	
		Everyday	4	63	7	
WMBC	work trip mode before COVID-19	Not Applicable	0	62	7	
		Drive Alone	1	556	64	
		Public Transit	2	149	17	
		Carpool/Shared	3	53	6	
		Walk/Bike	4	54	6	
WHDR	WFH frequency during COVID-19	Never	1	162	19	
		1-2 days a week	2	49	6	
		3-4 days a week	3	86	10	
		Everyday	4	577	66	
WMDR	work trip mode during COVID-19	Not Applicable	0	521	60	
		Drive Alone	1	306	35	
		Public Transit	2	10	1	
		Carpool/Shared	3	7	1	
		Walk/Bike	4	30	3	
WHAC	perception of WFH frequency after COVID-19	Never	1	379	43	
		1-2 days a week	2	280	32	
		3-4 days a week	3	123	14	
		Everyday	4	92	11	

Table 3
Counts of WFH change reasons.

Variable	Detail	Attribute	Code	Count	Percentage	Bar Chart
WHCR1	WFHchange reason	Employer's policies	1	395	45	
		Government Rule	2	18	2	
		Voluntarily	3	81	9	
		Others	4	218	25	
WHCR2	work hours change reason	Employer's policies	1	154	18	
		Government Rule	2	58	7	
		Voluntarily	3	121	14	
		Others	4	541	62	
WHCR3	work trip travel mode change reason	Employer's policies	1	146	17	
		Government Rule	2	83	9	
		Voluntarily	3	174	20	
		Others	4	471	54	

cluster allocation $\mathbf{Z}_k$. Secondly, category quantifications $\mathbf{B}^*$ are calculated by applying CA to $\mathbf{F}$ using equation (7). Thirdly,$\mathbf{Y}$ is calculated using equation (8). Next, $\mathbf{Z}_k$ is updated by applying K-means clustering to $\mathbf{Y}$ using cluster means $\mathbf{G}$ calculated from equation (9). Finally, the steps before are repeated using $\mathbf{Z}_k$ for the cluster allocation matrix, until $\mathbf{Z}_k$, $\mathbf{Y}$, and $\mathbf{G}$ remain constant.

4. Results

Fig. 1 shows the biplot of the first two dimensions (Dim 1 and Dim 2). Five clusters (Cluster 1 to Cluster 5) are identified in the biplot with different colors. The points on the plot indicate the location of the attributes in a two-dimensional space. The number of clusters selected was conducted by trial and error. Finally, five clusters are selected for explaining the hidden trends of the unsupervised data. The dimension reduction process of the cluster CA minimizes the distances within each cluster and maximizes the distance between clusters. As a result, the features within clusters are closely associated with each other, and each cluster has a distinct representation of the patterns from the rest of the clusters. Except for cluster 5, clusters 1 to 4 are close to the center of the plot. The closeness of each cluster to the center point (red dot) indicates that the clusters align with the majority of the features in the dataset. Cluster 1 to 5 explains 34.3%, 31.9%, 17.6%, 10.1%, and 6.1% variations of the data, respectively. With a large number of categorical features, it is impractical to interpret the clusters directly from crowded Fig. 1. The cluster CA algorithm provides the standard residual bar plots for each cluster. The righthand side of the bar plot is the top features associated with each cluster. The length of the bar in the bar plots represents the value of the standard residual, which is calculated from the eigenvalues. Categories with a longer bar have more dominance in the cluster compared to other categories associated with the cluster. The following figures (Figs. 2–6) show the bar plots of each cluster.

Within Fig. 2, each bar plot displays one of the first thirty attributes with the highest standard residuals in each cluster, containing attributes associated with the perception of WFH decisions after the pandemic (WHAC). Markos et al. (2019) stated the standard residual calculation method in their original publication, demonstrating how the residual, whether positive or negative, reflects how far an attribute deviates from

Table 4
Counts of personal opinion or perception of social issues.

Variable	Detail	Attribute	Code	Count	Percentage	Bar Chart
PO1	media is exaggerating about COVID	Agree	1	152	17	
		Disagree	2	722	83	
PO2	face cover should be mandatory	Agree	1	819	94	
		Disagree	2	55	6	
PO3	shutting down businesse is not worth the economic damage it caused	Agree	1	187	21	
		Disagree	2	687	79	
PO4	everyone should stay as home if possible	Agree	1	807	92	
		Disagree	2	67	8	
PO5	physical distancing is an efficient approach	Agree	1	824	94	
		Disagree	2	50	6	
PO6	conern about family will experience serious healthissue if being infected	Agree	1	822	94	
		Disagree	2	52	6	
PO7	my family expected me to stay home	Agree	1	667	76	
		Disagree	2	207	24	
PO8	wfh increases family conflicts	Agree	1	385	44	
		Disagree	2	516	59	
PO9	I miss commute	Agree	1	188	22	
		Disagree	2	686	78	
PO10	I can efficiently replace work meetings to online meetings	Agree	1	635	73	
		Disagree	2	239	27	
PO11	I perform better when interact with co-works in person	Agree	1	627	72	
		Disagree	2	247	28	
PO12	I enjoy social interactions with my colleagues	Agree	1	765	88	
		Disagree	2	109	12	
PO13	wft makes me less decipline	Agree	1	387	44	
		Disagree	2	487	56	
PO14	I don't mind travel on crowed bus	Agree	1	53	6	
		Disagree	2	821	94	
PO15	traveling by bus or light rail poses a risk to my health	Agree	1	761	87	
		Disagree	2	113	13	
PO16	I am confortable sharing a ride with a stranger	Agree	1	72	8	
		Disagree	2	802	92	
PO17	perfer transportation option that involve less contact	Agree	1	797	91	
		Disagree	2	77	9	
PO18	I would like to share ride if it saves money	Agree	1	143	16	
		Disagree	2	731	84	
PO19	I would travel on a bus or light rail if the physical distancing measures are	Agree	1	425	49	
		Disagree	2	449	51	
PO20	personal space is important to me when I travel	Agree	1	831	95	
		Disagree	2	43	5	

the attribute distribution conditional independence on the cluster. A positive residual indicates an attribute with an above-average frequency in the cluster. The longer the bar is, the more dominance that attribute has in that cluster. The purpose of this study is to explore the association among the dominant attributes in each cluster. Thus, only the bars with positive values on the right-hand side will be discussed. To simplify the clustering visualization, the attributes of each category are numerically coded. The details about the numerical coding process can be found in the data description section. For example, the bar with the highest residual in cluster 1 (Fig. 2) is 'WHCR1.2.' This means that the reason for WFH behavior change is due to government rule. To facilitate the interpretation of each cluster, the meaning of all positive attributes in each cluster are stated in the table following each residual plot. The cells of the attributes of WFH frequency before, during, and after the COVID-19 pandemic are colored in light blue, light grey, and light orange colors, respectively (see Table 5-Table 9).

Five clusters (C1, C2, C3, C4, and C5) were identified and presented in this study. C1 and C3 show two patterns of the individuals who are unwilling to WFH at all after the COVID-19 pandemic (WHAC = never). C2 is the pattern of the individuals who are willing to WFH several days a week after the COVID-19 pandemic (WHAC = 1–2 days a week or WHAC = 3–4 days a week). C4 and C5 are the two patterns for the individuals choosing to WFH every day after the COVID-19 pandemic.

4.1. C1- strongly oppose WFH due to less productivity

The attributes on the right-hand (positive) side of the C1 bar plot in Fig. 2 are the dominant attributes in cluster 1. This cluster shows the pattern of the group that does not want to WFH after COVID-19 at all.

Due to local government rules and employer policies, this group

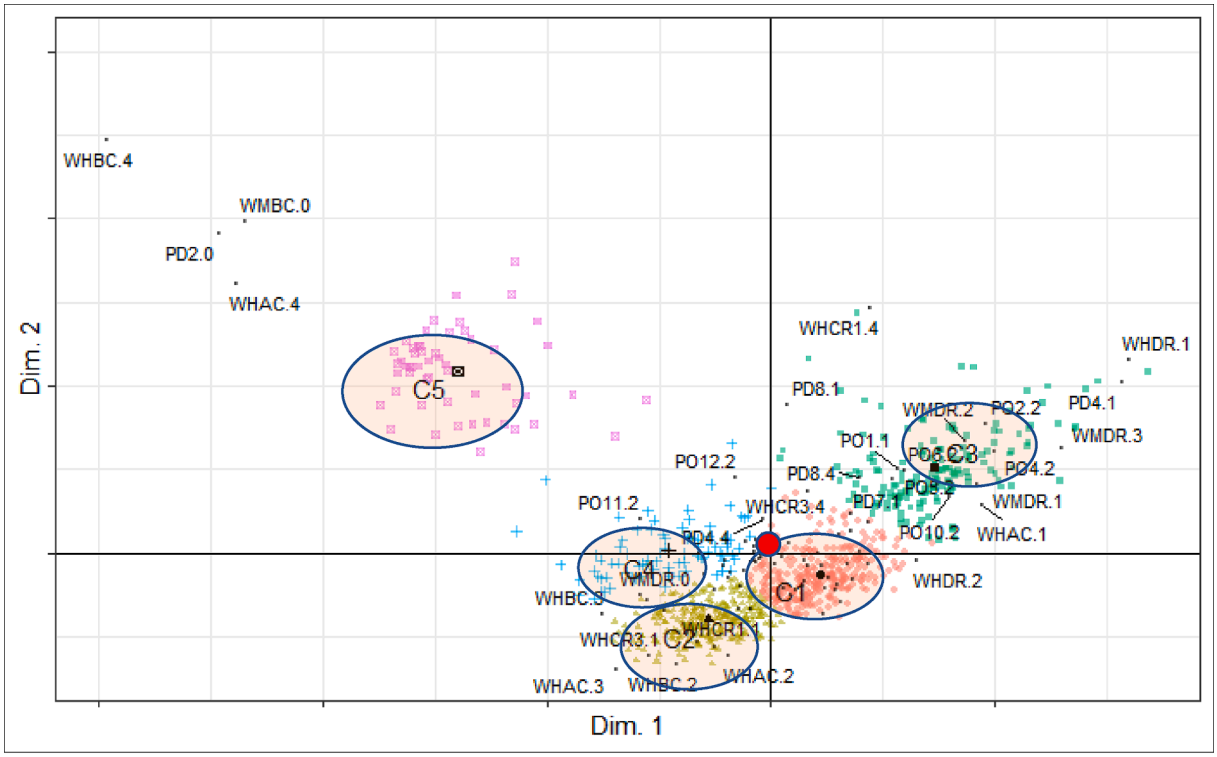

Fig. 1. Cluster CA biplot of first two dimensions.

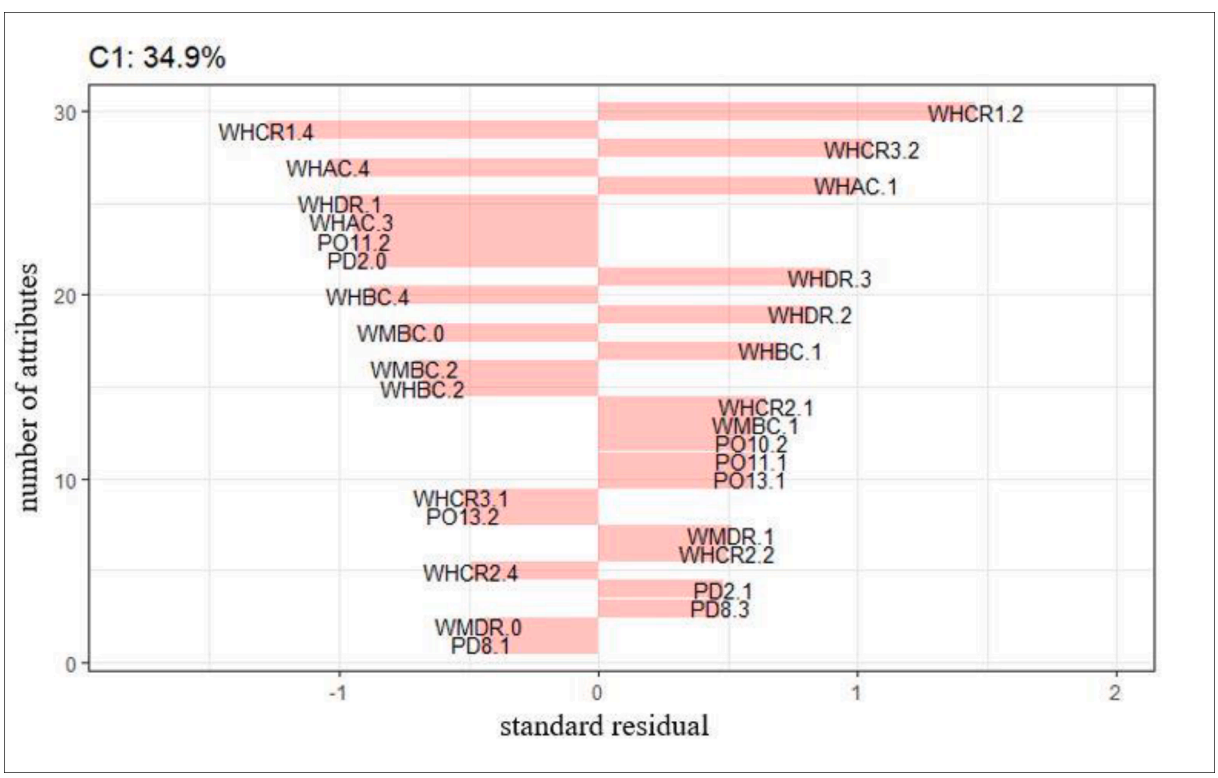

Fig. 2. Bar plot of Cluster 1 (C1).

tends to WFH several days a week (1–2 days or 3–4 days a week), but not every day during the pandemic (see Table 5 for details of the acronyms used in Fig. 2). The biggest concern of the individuals from this group is the compromised work performance when WFH. Three reasons are strongly associated with this pattern – inefficient online meetings, poor performance when they cannot interact with co-workers, and less discipline while WFH. Individuals from this group often have master's or higher degrees and short commute distances.

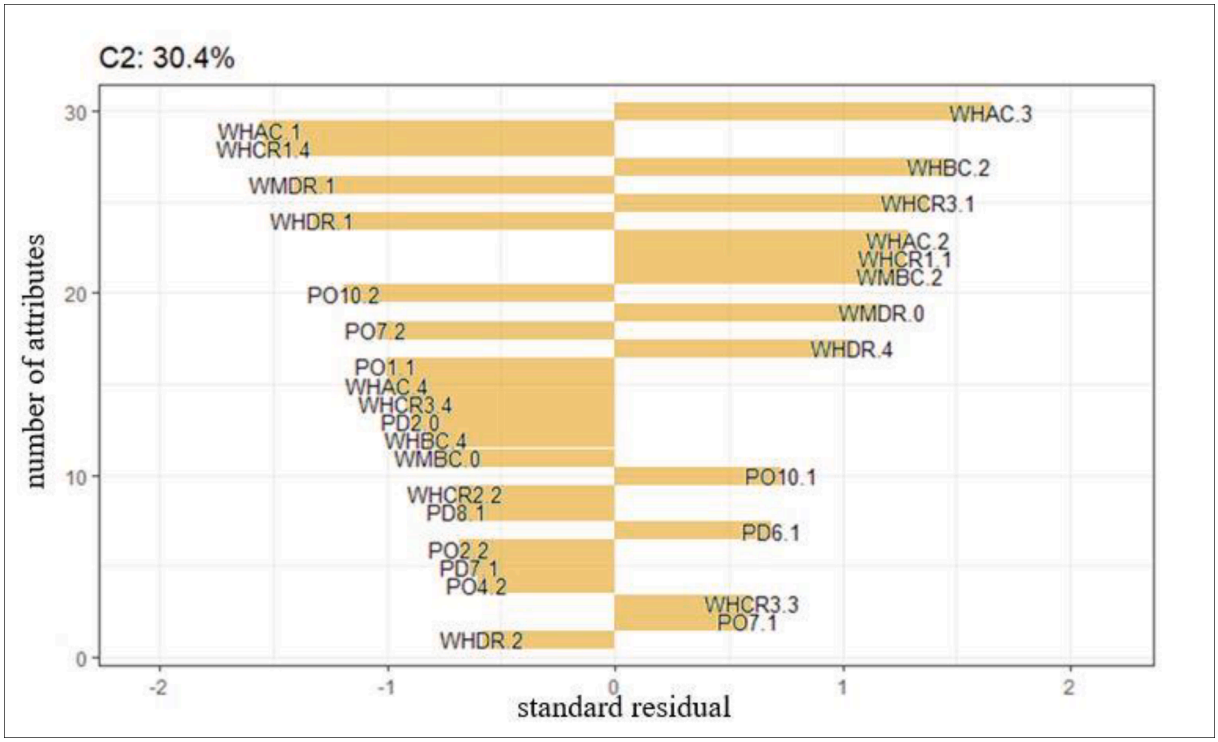

Fig. 3. Bar plot of cluster 2 (C2).

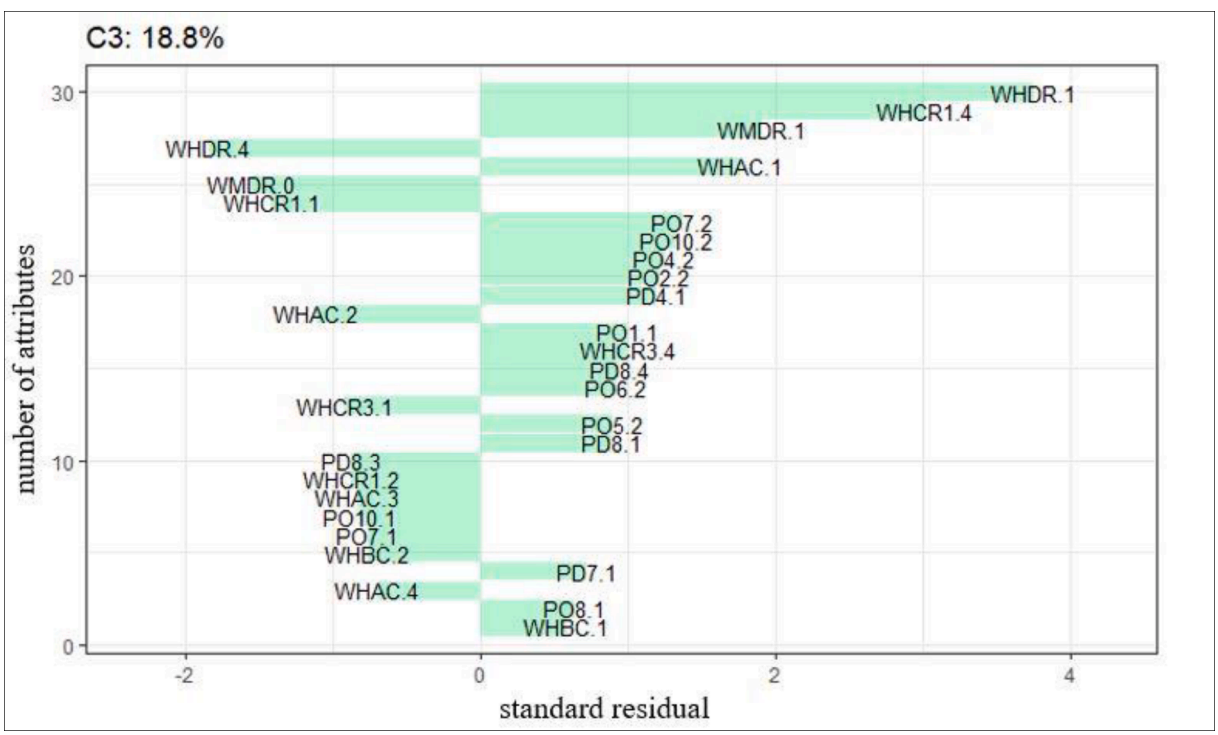

Fig. 4. Bar plot of cluster 3 (C3).

This cluster demonstrates that, for those who have no experience with working from home before the COVID-19 pandemic, individuals with relatively higher education and who are being forced to WFH due to external reasons (government rules and employer policies) are often against WFH after the pandemic, given how adapting to the new WFH mode during the pandemic was not very successful. This group of workers is eager to interact with coworkers and rely on the 'normal' work environment to maintain their productivity. Even during the pandemic, these individuals are not fully committed to the WFH mode, and they choose and have an option to work in the 'normal' work environment at least one day per week. This one day allows workers to continuously interact with the previous 'normal' work experiences, impeding the adaption process to being fully remote. For these individuals, having the opportunity of working in their "normal" working

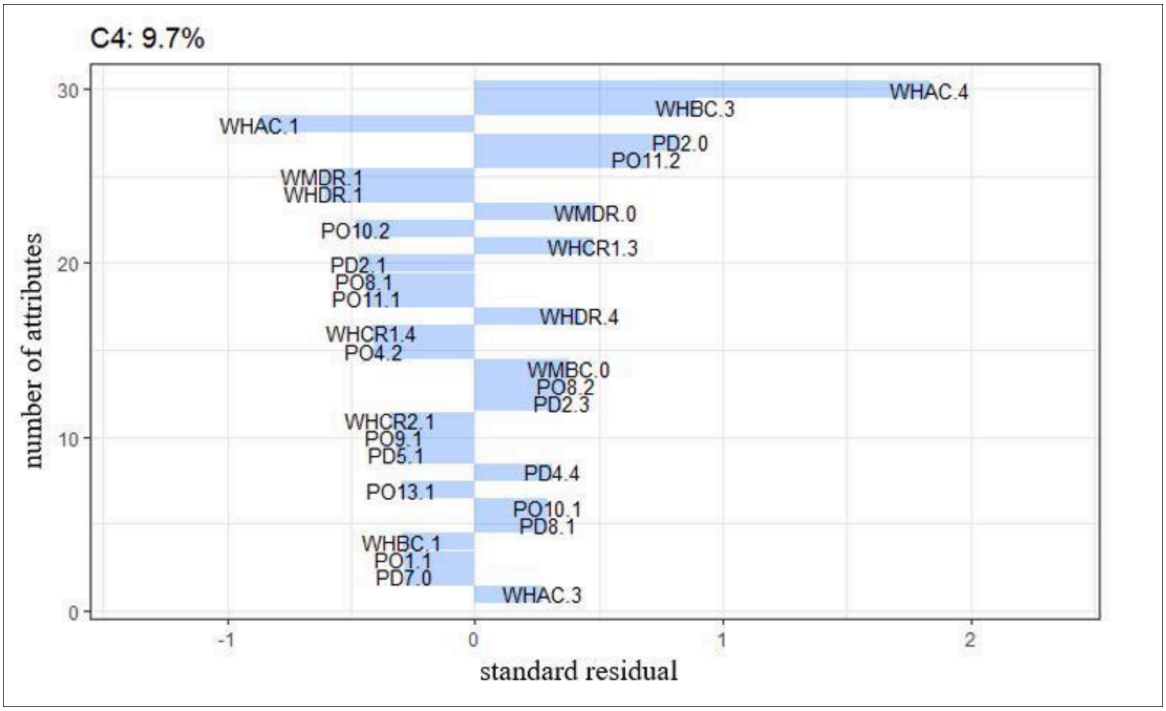

Fig. 5. Bar plot of cluster 4 (C4).

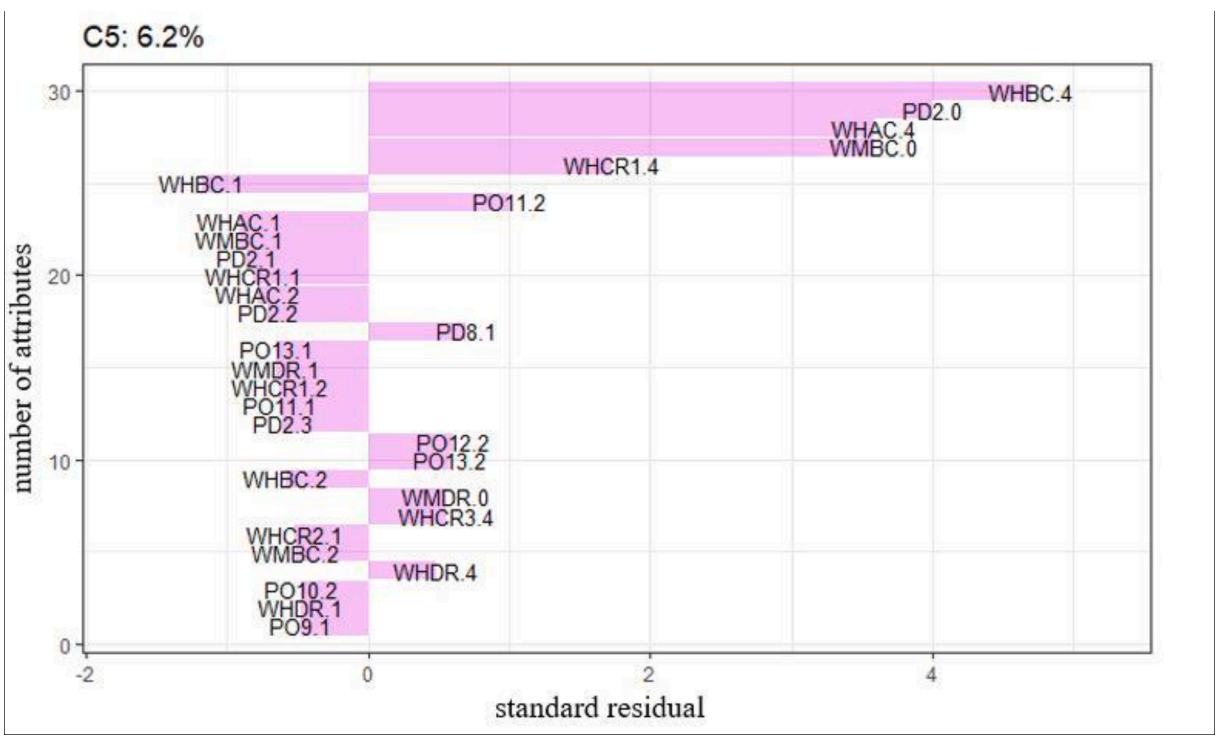

Fig. 6. Bar plot of cluster 5 (C5).

environment, such as the office, during the pandemic could reinforce their negative perception of WFH, as it is highly possible that these individuals will find out they have higher productivity while working in the "normal" work environment, compared with WFH.

4.2. C2 –Moderately support WFH

C2 is the cluster that presents the pattern of people who plan to WFH several days a week after the pandemic. This group had experiences with WFH 1–2 days a week before the pandemic outbreak, and their work mode switched to WFH every day during the pandemic due to their employers' policies. Some individuals of this group will maintain their previous WFH frequency – 1–2 days a week after the COVID-19 pandemic. Some of them are expecting to increase their WFH frequency to 3–4 days a week after the pandemic.

The attributes listed in Table 6 show the pattern of the individuals

Table 5
Detailed information of positive attributes in cluster 1 (C1).

Attributes	Details
WHCR1.2	WFH change reason – government rule
WHCR3.2	Work trip mode change reason – government rule
WHAC.1	Perception of WFH frequency after COVID-19 – never
WHDR.3	WFH frequency during COVID-19 – 3-4 days a week
WHDR.2	WFH frequency during COVID-19 – 1-2 days a week
WHBC.1	WFH frequency before COVID-19 – never
WHCR2.1	WFH change reason – employers' policies
WMBC.1	Work trip travel mode before COVID-19 – drive alone
PO10.2	Efficiently replace meeting with online meetings – disagree
PO11.1	I perform better when interacting with coworkers in person – agree
PO13.1	WFH makes me less disciplined – agree
WMDR.1	Work trip travel mode during COVID-19 – not applicable
WHCR2.2	Work hours change reason – voluntarily
PD2.1	Commute distance – less than 10 miles
PD8.3	Master or higher degree

Note: Before During After

Table 6
Detailed information of positive attributes in cluster 2 (C2).

Attributes	Details
WHAC.3	WFH frequency after COVID-19 - 3-4 days a week
WHBC.2	WFH frequency before COVID-19 - 1-2 days a week
WHCR3.1	Work trip travel mode change reason – employers' policy
WHAC.2	WFH frequency after COVID-19 – 1-2 days a week
WHCR1.1	WFH change reason – employers' policy
WMBC.2	Work trip mode before COVID-19 – public transit
WMDR.0	Work trip travel mode during COVID-19 – not applicable
WHDR.4	WFH frequency during COVID-19 – every day
PO10.1	Efficiently replace meeting with online meetings – agree
PD6.1	Living with spouse
WHCR3.3	Work trip travel model change reason – voluntarily
PO7.1	My family expects me to WFH – agree

Note: Before During After

anticipating working from home several days a week after the pandemic. Existing experience with working from home facilitates the transition from WFH 1–2 days a week to WFH every day in response to the COVID-19 outbreak. The change of WFH frequency during the pandemic was enforced by their employers' policy. Previous experiences, such as with online meetings, make the transition to WFH every day smoother than those who were not familiar with WFH before the pandemic. However, the change from WFH 1–2 days a week to WFH every day inspired some of them to want to work from home more frequently after the pandemic. Another factor that helps this transition is family support (i.e., their family expects them to be present at home, working remotely, during the pandemic). While some of them still maintain previous WFH frequency (1–2 days a week), this may be caused by their work nature, which may not allow them to work from home more often than before once the pandemic concludes. However, the everyday WFH experience does not negatively influence their experience with WFH, since these people had experiences with WFH before the outbreak and have family support.

4.3. C3 –Strongly oppose WFH due to their distrust in COVID-19 spreading

Apart from patterns shown in C1, C3 states another pattern for the individuals who are unwilling to WFH after the pandemic. This cluster illustrates that some individuals consistently worked onsite before and during the COVID-19 pandemic every day, and they anticipate working onsite every day after the pandemic.

Table 7 lists the items related to this pattern. The primary reason this group of people did not WFH during the pandemic might be the nature of their work. The pattern shows the age of this group is relatively young (less than 20 years old), and individuals of this group have some college education or technical training. The nature of their work may not offer an option to WFH, such as essential workers (e.g., grocery store employees). However, other characteristics of this group also promote this 'never WFH' pattern. First, the group of individuals tends to distrust the seriousness of the COVID-19 pandemic. The survey shows that they believe the media exaggerates the spread of the COVID-19 virus and that non-pharmaceutical countermeasures (i.e., staying at home when

Table 7
Detailed information of positive attributes in cluster 3 (C3).

Attributes	Details
WHDR.1	WFH frequency during COVID-19 - never
WHCR1.4	WFH change reason – employer's policies
WMDR.1	Work trip mode during COVID-19 – drive alone
WHAC.1	Perception of WFH frequency after COVID-19 - never
PO7.2	My family expect me to WFH - disagree
PO10.2	Efficiently replace meeting with online meetings - disagree
PO4.2	Everyone should stay at home if possible – disagree
PO2.2	Face cover mandatory - disagree
PD4.1	Younger than 20 years old
PO1.1	Media exaggerating the spread of COVID-19 - agree
WHCR3.4	Work trip mode change reason - employer's policies
PD8.4	Education - others
PO6.2	Concern about family health if infected - disagree
PD5.2	Race - white
PD8.1	Education – some college/technical training
PD7.1	Household income, not answered
PO8.1	WFH increase family conflict - agree
WHBC.1	WFH frequency before COVID-19 - never

Note: Before During After

possible and face-coverings) should not be mandatory. Second, individuals of this group agree that WFH increases family conflicts, and their families do not expect them to WFH. They generally have less concern about their family members contracting the COVID-19 virus. Another explanation could be that their family members have no underlying health issues or compromised immune systems, making them less concerned about COVID-19 infections. Third, this group prefers in-person meetings and questions the effectiveness of online meetings. The meeting preferences may reflect their work nature. With technical training and relatively lower education levels, the nature of their work may require a lot more onsite work and in-person meetings.

4.4. C4 – Strongly support WFH

C4 presents the pattern for the individuals who choose to WFH every day or at least 3–4 days a week after the pandemic (see Table 8 for details of the acronyms used in Fig. 2). This group of people tends to WFH extensively (3–4 days a week) before the pandemic and WFH every day during the pandemic. WFH every day after the pandemic is the attribute that dominates this pattern since some of them are still expecting to WFH 3–4 days a week after the pandemic as before.

This group of individuals who have been WFH extensively, even before the outbreak, normally have a relatively long commute distance (longer than 20 miles) and older age (older than 60 years old). These individuals are not enthusiastic about in-person interactions, and their prior experience with working from home, most likely increasing

Table 8
Detailed information of positive attributes in cluster 4 (C4).

Attributes	Details
WHAC.4	WFH frequency after COVID-19 – every day
WHBC.3	WFH frequency before COVID-19 – 3-4 days a week
PD2.0	Commute distance - no applicable
PO11.2	I perform better when interacting with in-person – disagree
WMDR.0	Work trip travel mode during COVID-19 – not applicable
WHCR1.3	Work hours change reason – Voluntarily
WHDR.4	WFH frequency during COVID-19 – every day
WMBC.0	Work trip travel mode before COVID-19 – not applicable
PO8.2	WFH increase family conflict - disagree
PD2.3	Commute distance – longer than 20 miles
PD4.4	Older than 60
PO10.1	Efficiently replace meeting with online meetings - agree
PD8.1	Education – some college/technical training
WHAC.3	WFH frequency after COVID-19 – 3-4 days a week

Note: Before During After

Table 9
Detailed information of positive attributes in cluster 5 (C5).

Attributes	Details
WHBC.4	WFH frequency before COVID-19 – every day
PD2.0	Commute distance - not applicable
WHAC.4	WFH frequency after COVID-19 – every day
WMBC.0	Work trip mode before COVID-19 – no applicable
WHCR1.4	WFH change reason - others
PO11.2	I perform better when interacting with in-person – disagree
PD8.1	Education – some college/technical training
PO12.2	Enjoy social interaction with my colleagues - disagree
PO13.2	WFH make me less discipline - disagree
WMDR.0	Work trip travel mode during COVID-19 – not applicable
WHCR3.4	Work trip travel mode change reason – others
WHDR.4	WFH frequency during COVID-19 – every day

Note: Before During After

familiarity with things like online meetings, made the transition to WFH every day during the pandemic smoother. Moreover, continuing their WFH pattern during the outbreak does not cause more family conflict, and they are generally against the opinion that WFH increases family conflicts.

4.5. C5 –Very strongly support WFH

The pattern in the following figure is for these individuals who WFH every day before, during, and after the pandemic (see Table 9 for details of the acronyms used in Fig. 2). The individuals voluntarily chose to WFH every day before the pandemic, and the change that comes with the outbreak does not pose an impact on their WFH choices.

For individuals who have been working from home, the common issues encountered by these individuals forced to adapt to the WFH mode during the pandemic do not exist. For example, their performances are not affected by the presence of coworkers, interacting with colleagues is not very relevant to these full-time WFH employees, and they often do not have discipline issues while working from home during the pandemic. This newly invented work mode, WFH, is not new for this group of individuals. The hard time of adapting to this new WFH mode for many workers is not an obstacle for this group of individuals at all. Therefore, it is not surprising to observe their intention to WFH every day after the pandemic.

5. Key findings and discussions

The key findings are discussed below:

- Without any prior WFH experience, WFH during the pandemic is largely associated with the anticipation of never WFH after the pandemic. Being forced to WFH in response to the COVID-19 pandemic is an abrupt change that affects not only the work environment but also the format of meetings and social interactions between co-workers. These disadvantages, brought with the sudden changes from never WFH to WFH frequently during the pandemic, drive these individuals to want to go back to the previous work environment.
- Having the option of continuously working in a previous work environment (or at least one day a week during the COVID pandemic) is another factor strongly associated with individuals who do not want to WFH after the pandemic. For individuals who can work at least one day a week in their previous work environments without being fully separated with the option of working at the previous 'normal' work environment, the adaption of the WFH mode becomes difficult. It is possible for these employees to find out that the productivity at a 'normal' work environment is significantly higher than WFH. Meanwhile, the separation from the home environment results in fewer family conflicts. Therefore, the advantages of working in a 'normal' work environment reinforce the affirmation of the idea of going back to work in a 'normal' work environment and never working from home after the pandemic. These individuals who never worked from home before and during the pandemic surely would not consider transitioning to WFH after the pandemic. The nature of the respondent's work and their view towards the seriousness of the COVID-19 virus are associated with their consistent WFH choices before, during, and after the pandemic.
- For individuals with some WFH experience before the pandemic, the transition to working from home every day during the pandemic is much smoother than for individuals with no WFH experience. The anticipated frequency of WFH after the pandemic often increases or stays the same compared to WFH frequency before the pandemic. For these employees with some WFH experiences before the pandemic, being forced to WFH every day during the pandemic has a positive influence on their view of WFH and encourages them to WFH more often after the pandemic.

6. Conclusions

WFH has become a new norm for many employees since the start of the COVID-19 pandemic in early 2020. Employees from different demographic groups, those with different experiences, and those with different work natures have had various responses to WFH. Some employees have quickly adapted to this new norm, while some are still struggling. Meanwhile, their ongoing experiences with WFH will further shape their WFH decisions after the pandemic. The question of how various factors will shape WFH patterns in the future remains unanswered. Correspondence analysis has been used by many researchers in recent years to address categorical data problems by providing interesting and latent patterns from unsupervised data. This study explored the latent patterns from survey data using a robust categorical data analysis method known as cluster CA.

The results show the patterns for employees with various anticipations of WFH frequency after the pandemic. The results show that

employees with some WFH experiences before the pandemic find WFH during the pandemic to be less challenging, and their WFH experiences during the pandemic encourage them to WFH more often after the pandemic. However, others have a more negative view of WFH. Individuals from this group generally had no experiences with WFH before the pandemic at all and have had difficulty coping with WFH during the pandemic. These individuals are often eager to go back to their 'normal' work environment and have no intention of WFH after the pandemic.

If another pandemic occurs in the future and requires eligible employees to WFH, policymakers or companies are needed to consider more flexible and supportive policies for employees, especially for these individuals who have no WFH experiences at all. Based on the results of our study, employees without WFH experiences and suffered low productivity due to the abrupt change during the pandemic are more eager to go back to the office. Therefore, for a company full of employees that strongly oppose WFH due to less productivity, it would be beneficial to include these WFH-related training into their professional training agendas. These training could be used for educating employees on how to have more effective and productive meetings using telecommunication tools like Zoom or training employees how to be less distracted in the non-office working environment. Another finding is that employees who had an option of working in the office at least once a week during the pandemic are more likely to prefer WFH after the pandemic. For companies who have employees in this category, it is not very concerning if there is another pandemic requiring employees to WFH to reduce the contacts. These employees may not prefer WFH, but it is still a feasible option for them. Companies may offer a monetary incentive or more anti-distraction training to accommodate their needs. For individuals who strongly oppose WFH due to the distrust of the spread of the pandemic, the company's policymakers or leadership may need to approach these employees more strategically rather than simply telling them about the information from the source they already distrusted. Moreover, companies could offer monetary incentives or other supporting sources to encourage them to WFH. Results also found a group of individuals who are willing to WFH even after the pandemic due to their familiarity with WFH before the pandemic and good experience with adapting to WFH during the pandemic. Companies could provide support and incentives to encourage these individuals to WFH more often when needed. Besides the actions taken by employers and companies to reduce the contacts, governments and authorities could also develop measures to incentivize companies and employees to WFH when needed based on the WFH patterns presented in the results section. For example, for these employees who strongly oppose WFH due to the drop in their productivity caused by their unfamiliarity with the WFH working style, the government could also offer free training and education on WFH-related issues (Emanuel and Harrington, 2021). Additionally, there are companies who need more on-site employees although many of them are reluctant to go on-site even after the pandemic. Incentives such as free lunch and other engaging incentives can attract employees to show up on-site workplaces.

There are some limitations to this study. Although this survey reached a relatively large population, it is still risky to generalize these results worldwide. More data inputs and studies are required. Further, this dataset relies on respondents in the Puget Sound region in Washington State, which encompasses major cities in the Pacific Northwest, including Seattle, Tacoma, and Olympia. Washington State has voted Democratic in every presidential since 1988 — accordingly, one can assume that the sample represented in this survey likely skews liberal, which could impact how results could be generalizable to less urban or more conservative regions. Even so, there are strong results for even those who believe that the media is exaggerating the spread of COVID-19. Further, sample participants were mostly white and Asian, meaning that more data needs to be collected on other races to reflect the diversity of the United States. Another issue is that the survey data shows some participants may give inaccurate answers to the questionnaire. For example, some participants who claimed that they have been working from home every day since the pandemic started still chose a work trip mode, such as driving alone. Even though the percentage of these inaccurate answers is very small, it still poses some concerns during the analysis.

However, as the survey participants are from an urban area, the understanding of the participants' attitudes towards WFH in the post-COVID world can help sustainable city design in the post-COVID world. This study helps us to understand WFH patterns and what to expect in the future. As the choice to WFH becomes more popular, this pattern will change our society from many perspectives. For example, morning and afternoon peak hours in the urban area are recurrent traffic flow disruptions in cities that cause massive economic loss due to traffic congestion. In the future, as WFH becomes a new norm, this pattern could potentially and fundamentally change the peak hour scenario in the cities. In the meantime, the increasing acceptance of WFH for employees and employers could have more profound impacts on our society. For example, companies that do not require the physical presence of their employees have more options to hire better employees. Therefore, the understanding of WFH behavior is essential for experts from various fields, such as transportation and various industries, in order to accommodate the incoming changes brought by changing WFH habits.

CRediT authorship contribution statement

Xiaoqiang Kong: Conceptualization, Methodology, Data curation, Writing – original draft, Visualization, Investigation, Validation. **Amy Zhang:** Methodology, Writing – original draft, Investigation, Validation. **Xiao Xiao:** Methodology, Writing – original draft, Validation. **Subasish Das:** Methodology, Writing – original draft, Visualization, Supervision, Validation. **Yunlong Zhang:** Methodology, Supervision, Validation.

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 research conducted in this study.

Acknowledgment

Authors would like to express our gratitude to Dr. Don Mackenzie and other researchers from the University of Washington for sharing the survey data with the public.

References

Alon, T.M., Doepke, M., Olmstead-Rumsey, J., Tertilt, M., 2020. The impact of COVID-19 on gender equality. National Bureau of economic research.

Amekudzi-Kennedy, A., Labi, S., Woodall, B., Chester, M., Singh, P., 2020. Reflections on Pandemics, Civil Infrastructure and Sustainable Development: Five Lessons from COVID-19 through the Lens of Transportation (preprint). Engineering. https://doi.org/10.20944/preprints202004.0047.v1.

Angelucci, M., Angrisani, M., Bennett, D.M., Kapteyn, A., Schaner, S.G., 2020. Remote work and the heterogeneous impact of covid-19 on employment and health. National Bureau of Economic Research.

Arntz, M., Ben Yahmed, S., Berlingieri, F., 2020. Working from Home and COVID-19: The Chances and Risks for Gender Gaps. Intereconomics 55, 381–386. https://doi.org/10.1007/s10272-020-0938-5.

Atchison, C.J., Bowman, L., Vrinten, C., Redd, R., Pristera, P., Eaton, J.W., Ward, H., 2020. Perceptions and behavioural responses of the general public during the COVID-19 pandemic: A cross-sectional survey of UK Adults. MedRxiv.

Barbieri, D.M., Lou, B., Passavanti, M., Hui, C., Lessa, D.A., Maharaj, B., Banerjee, A., Wang, F., Chang, K., Naik, B., Yu, L., Liu, Z., Sikka, G., Tucker, A., Foroutan Mirhosseini, A., Naseri, S., Qiao, Y., Gupta, A., Abbas, M., Fang, K., Ghasemi, N., Peprah, P., Goswami, S., Hessami, A., Agarwal, N., Lam, L., Adomako, S., 2020. A survey dataset to evaluate the changes in mobility and transportation due to COVID-19 travel restrictions in Australia, Brazil, China, Ghana, India, Iran, Italy, Norway, South Africa, United States. Data in brief 33, 106459.

Barkowski, S., McLaughlin, J., Dai, Y., 2020. Young Children and Parents' Labor Supply during COVID-19. SSRN J. https://doi.org/10.2139/ssrn.3630776.

Barrero, J.M., Bloom, N., Davis, S., 2021. Why Working from Home Will Stick (No. w28731). National Bureau of Economic Research, Cambridge, MA. doi:10.3386/w28731.

Baudot, L., Kelly, K., 2020. A Survey of Perceptions of Remote Work and Work Productivity in the United States during the COVID-19 Shutdown. SSRN J. https://doi.org/10.2139/ssrn.3646406.

Béland, L.-P., Brodeur, A., Wright, T., 2020. The short-term economic consequences of Covid-19: exposure to disease, remote work and government response.

Berinato, S., Bloom, N., 2014. To raise productivity, let more employees work from home. Harvard Bus. Rev. 92, 28–29.

Bert, J., Schellong, D., Hagenmaier, M., Hornstein, D., Wegscheider, A.K., Palme, T., 2020. How COVID-19 Will Shape Urban Mobility. City 25, 28–31.

Bick, A., Blandin, A., Mertens, K., 2020. Work from home after the COVID-19 Outbreak.

Block, P., Hoffman, M., Raabe, I.J., Dowd, J.B., Rahal, C., Kashyap, R., Mills, M.C., 2020. Social network-based distancing strategies to flatten the COVID-19 curve in a post-lockdown world. Nature Hum. Behav. 4 (6), 588–596.

Bloom, N., 2021. Hybrid is the Future of Work. Stanford Institute for Economic Policy Research.

Bloom, N., Roberts, J., 2015. A working from home experiment shows high performers like it better. Harvard Bus. Rev. 23.

Bloom, N., Liang, J., Roberts, J., Ying, Z.J., 2015. Does working from home work? Evidence from a Chinese experiment. Q. J. Econ. 130, 165–218.

Boland, B., Smet, A.D., Palter, R., Sanghvi, A., 2020. Reimagining the office and work life after COVID-19.

Brooks, M.M., Mueller, J.T., Thiede, B.C., 2021. Rural-Urban Differences in the Labor-Force Impacts of COVID-19 in the United States. Socius 7, 237802312110220. doi: 10.1177/23780231211022094.

Brynjolfsson, E., Horton, J.J., Ozimek, A., Rock, D., Sharma, G., TuYe, H.-Y., 2020. COVID-19 and remote work: An early look at US data. National Bureau of Economic Research.

Chinazzi, M., Davis, J.T., Ajelli, M., Gioannini, C., Litvinova, M., Merler, S., Pastore y Piontti, A., Mu, K., Rossi, L., Sun, K., Viboud, C., Xiong, X., Yu, H., Halloran, M.E., Longini, I.M., Vespignani, A., 2020. The effect of travel restrictions on the spread of the 2019 novel coronavirus (COVID-19) outbreak. Science 368 (6489), 395–400.

Cuerdo-Vilches, T., Navas-Martín, M.Á., March, S., Oteiza, I., 2021. Adequacy of telework spaces in homes during the lockdown in Madrid, according to socioeconomic factors and home features. Sustain. Cities Society 75, 103262. https://doi.org/10.1016/j.scs.2021.103262.

De Fraja, G., Matheson, J., Rockey, J., 2021. Zoomshock: The geography and local labour market consequences of working from home. COVID Econ. 64, 1–41.

Dorn, E., Hancock, B., Sarakatsannis, J., Viruleg, E., 2020. COVID-19 and Student Learning in the United States: The Hurt Could Last a Lifetime. McKinsey & Company.

Emanuel, N., and Harrington, E., 2021. Working Remotely? Selection, Treatment, and the Market Provision of Remote Work. Working paper. https://scholar.harvard.edu/eharrington/publications/working-remotely-selection-treatment-and-market-provision-remote-work.

Fereydooni, N., Walker, B.N., 2020. Virtual Reality as a Remote Workspace Platform. Opportunities and Challenges.

Figueroa, J.F., Wadhera, R.K., Mehtsun, W.T., Riley, K., Phelan, J., Jha, A.K., 2020. Association of race, ethnicity, and community-level factors with COVID-19 cases and deaths across US counties. Healthcare 9 (1), 100495.

Flaxman, S., Mishra, S., Gandy, A., Unwin, H.J.T., Mellan, T.A., Coupland, H., Whittaker, C., Zhu, H., Berah, T., Eaton, J.W., Monod, M., Perez-Guzman, P.N., Schmit, N., Cilloni, L., Ainslie, K.E.C., Baguelin, M., Boonyasiri, A., Boyd, O., Cattarino, L., Cooper, L.V., Cucunubá, Z., Cuomo-Dannenburg, G., Dighe, A., Djaafara, B., Dorigatti, I., van Elsland, S.L., FitzJohn, R.G., Gaythorpe, K.A.M., Geidelberg, L., Grassly, N.C., Green, W.D., Hallett, T., Hamlet, A., Hinsley, W., Jeffrey, B., Knock, E., Laydon, D.J., Nedjati-Gilani, G., Nouvellet, P., Parag, K.V., Siveroni, I., Thompson, H.A., Verity, R., Volz, E., Walters, C.E., Wang, H., Wang, Y., Watson, O.J., Winskill, P., Xi, X., Walker, P.G.T., Ghani, A.C., Donnelly, C.A., Riley, S., Vollmer, M.A.C., Ferguson, N.M., Okell, L.C., Bhatt, S., 2020. Estimating the effects of non-pharmaceutical interventions on COVID-19 in Europe. Nature 584 (7820), 257–261.

Galanti, T., Guidetti, G., Mazzei, E., Zappalà, S., Toscano, F., 2021. Work from Home during the COVID-19 Outbreak: The Impact on Employees' Remote Work Productivity, Engagement and Stress. J. Occup. Environ. Med. Publish Ahead of Print. https://doi.org/10.1097/JOM.0000000000002236.

Gallacher, G., Hossain, I., 2020. Remote work and employment dynamics under COVID-19: Evidence from Canada. Canadian Public Policy 46 (S1), S44–S54.

Gondim, J.A., Tanaka, T.Y., 2020. SEIRD model in heterogenous populations: The role of commuting and social inequalities in the COVID-19 dynamics. arXiv preprint arXiv: 2008.06718.

Gorlick, A., 2021. The productivity pitfalls of working from home in the age of COVID-19. Stanford News.

Gostin, L.O., Wiley, L.F., 2020. Governmental public health powers during the COVID-19 pandemic: stay-at-home orders, business closures, and travel restrictions. Jama 323, 2137–2138.

Goudreau, J., 2013. Back To the Stone Age? New Yahoo CEO Marissa Mayer Bans Working From Home. Forbes.

Haleem, A., Javaid, M., Vaishya, R., 2020. Effects of COVID-19 pandemic in daily life. Curr. Med. Res. Pract. 10, 78–79. https://doi.org/10.1016/j.cmrp.2020.03.011.

Hensvik, L., Le Barbanchon, T., Rathelot, R., 2020. Which jobs are done from home? Evidence from the American Time Use Survey.

Hernandez, Y.A.T., 2020. Remote Workers During the COVID-19 Lockdown. What Are We Missing and Why Is Important. J. Occup. Environ. Med. 62, e669–e672. https://doi.org/10.1097/JOM.0000000000002018.

Hu, Y., Barbour, W., Samaranayake, S., Work, D., 2020. Impacts of Covid-19 mode shift on road traffic. arXiv preprint arXiv:2005.01610.

Iio, K., Guo, X., Kong, X., Rees, K., Wang, X.B., 2020. COVID-19 and Social Distancing: Disparities in Mobility Adaptation by Income. arXiv preprint arXiv:2011.12510.

Ito, A., 2021. Companies are Reinventing Work for a Post-Office World. Business Insider. URL https://www.businessinsider.com/hot-new-perks-for-wfh-remote-hybrid-employees-work.

Jabbari, P., Ranjbari, A., MacKenzie, D., 2020. Transportation mobility and safety in response to COVID-19.

Kashem, S.B., Baker, D.M., González, S.R., Lee, C.A., 2021. Exploring the nexus between social vulnerability, built environment, and the prevalence of COVID-19: A case study of Chicago. Sustain. Cities Society 75, 103261. https://doi.org/10.1016/j.scs.2021.103261.

Keenan, J.M., 2020. COVID, resilience, and the built environment. Environ. Syst. Decis. 40, 216–221. https://doi.org/10.1007/s10669-020-09773-0.

Lades, L.K., Laffan, K., Daly, M., Delaney, L., 2020. Daily emotional well-being during the COVID-19 pandemic. Br. J. Health Psychol. 25 (4), 902–911.

Lai, C.-C., Shih, T.-P., Ko, W.-C., Tang, H.-J., Hsueh, P.-R., 2020. Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and coronavirus disease-2019 (COVID-19): The epidemic and the challenges. Int. J. Antimicrob. Agents 55 (3), 105924.

Markos, A., Iodice D'Enza, A., van de Velden, M., 2019. Beyond tandem analysis: Joint dimension reduction and clustering in R. J. Statistical Software (Online) 91.

Marks, A., Skountridaki, L., Mallett, O., 2020. People are missing their daily commute in lockdown-here's why.

Mazumder, A., Bandhu Kalanidhi, K., Sarkar, S., Ranjan, P., Sahu, A., Kaur, T., Kaur, D., Bhattacharya, A., Priyadarshini Suna, S., Prakash, B., Deb, K.S., Wig, N., 2021. Psycho-social and behavioural impact of COVID 19 on young adults: Qualitative research comprising focused group discussion and in-depth interviews. Diabetes Metab. Syndrome: Clin. Res. Rev. 15, 309–312. https://doi.org/10.1016/j.dsx.2020.12.039.

McLaughlin, E., Charron, N., Narasimhan, S., 2020. Automated defect quantification in concrete bridges using robotics and deep learning. J. Comput. Civ. Eng. 34, 04020029. https://doi.org/10.1061/(ASCE)CP.1943-5487.0000915.

Meena, S., 2020. Impact of novel Coronavirus (COVID-19) pandemic on travel pattern: A case study of India. Indian J. Sci. Technol. 13 (24), 2491–2501. https://doi.org/10.17485/IJST/v13i24.958.

Murat, M., Bonacini, L., 2020. Coronavirus Pandemic, Remote Learning and Education Inequalities. GLO Discussion Paper.

Nguyen, Q.C., Huang, Y., Kumar, A., Duan, H., Keralis, J.M., Dwivedi, P., Meng, H.-W., Brunisholz, K.D., Jay, J., Javanmardi, M., Tasdizen, T., 2020. Using 164 Million Google Street View Images to Derive Built Environment Predictors of COVID-19 Cases. IJERPH 17, 6359. https://doi.org/10.3390/ijerph17176359.

Ozimek, A., 2020. The future of remote work. SSRN J. https://doi.org/10.2139/ssrn.3638597.

Pawar, D.S., Yadav, A.K., Akolekar, N., Velaga, N.R., 2020. Impact of physical distancing due to novel coronavirus (SARS-CoV-2) on daily travel for work during transition to lockdown. Transportation research interdisciplinary perspectives 7, 100203.

Peters, D.J., 2020. Community susceptibility and resiliency to COVID-19 across the rural-urban continuum in the United States. J. Rural Health 36, 446–456. https://doi.org/10.1111/jrh.12477.

Ramani, A., Bloom, N., 2021. The doughnut effect of COVID-19 on cities. URL https://voxeu.org/article/doughnut-effect-covid-19-cities.

Rupani, P.F., Nilashi, M., Abumalloh, R.A., Asadi, S., Samad, S., Wang, S., 2020. Coronavirus pandemic (COVID-19) and its natural environmental impacts. Int. J. Environ. Sci. Technol. 17, 4655–4666. https://doi.org/10.1007/s13762-020-02910-x.

Savić, D., 2020. COVID-19 and work from home: Digital transformation of the workforce. Grey J. (TGJ) 16, 101–104.

Schwartz, N.D., Marcos, C.M., 2021. Return to Office Hits a Snag: Young Resisters. New York Times.

Toscano, F., Zappalà, S., 2020. Social Isolation and Stress as Predictors of Productivity Perception and Remote Work Satisfaction during the COVID-19 Pandemic: The Role of Concern about the Virus in a Moderated Double Mediation. Sustainability 12, 9804. https://doi.org/10.3390/su12239804.

US Bureau of Labor Statistics, 2018. Workers who could work at home, did work at home, and were paid for work at home, by selected characteristics, averages for the period 2017–2018. US Bureau of Labor Statistics MA.

van de Velden, M., D'Enza, A.I., Palumbo, F., 2017. Cluster correspondence analysis. Psychometrika 82 (1), 158–185.

Vogel, P., Kurtz, C., Grotherr, C., Böhmann, T., 2021. Fostering Social Resilience via Online Neighborhood Social Networks During the COVID-19 Pandemic and Beyond: Status Quo. Design Dilemmas and Research Opportunities. Presented at the Hawaii International Conference on System Sciences.

Weber, L., 2021. U.S. Workers Quit Jobs at Highest Rate Since 2000. Wall Street Journal.

Wilbur, M., Ayman, A., Ouyang, A., Poon, V., Kabir, R., Vadali, A., Pugliese, P., Freudberg, D., Laszka, A., Dubey, A., 2020. Impact of COVID-19 on Public Transit Accessibility and Ridership. arXiv preprint arXiv:2008.02413.