Case Study on the Relationship Between Socio-Demographic Characteristics and Work-from-Home Behavior Before, During, and After the COVID-19 Pandemic

Xiaoqiang Kong[1] (iD)**, Zihao Li[1]** (iD)**, Yunlong Zhang[1], Xun Chen[2], Subasish Das[3]** (iD)**, and Abbas Sheykhfard[4]** (iD)

Abstract
Many studies have explored the impact of the COVID-19 pandemic on work-from-home (WFH) behavior from different perspectives. However, it is rare to find studies focusing on how the newly adopted WFH practices will affect commuting patterns in the post-pandemic era. This study defines two mediation factors to capture the perceptions of pandemic severity and work environment at home and further investigates their impacts on future WFH adoption. This study utilizes a comprehensive survey and a path analysis method known as structural equation modeling (SEM) to explore the association between demographic factors, perception of COVID-related issues, and WFH behavior before, during, and after the pandemic. The results show that motherhood negatively affected WFH experiences in the before, during, and after periods of the pandemic. It was also found that being forced to WFH and mixing the working environment with their children made mothers less likely to WFH in the post-pandemic era. The results also show that older workers are less appreciative of the WFH approach and are less likely to continue to WFH in the post-pandemic era. The findings also confirmed the association between WFH during and after the pandemic with other factors, such as age and education. The positive or negative experiences with WFH during the pandemic will significantly shape workers' decisions on continuing to WFH in the post-pandemic era. These findings could help transportation agencies understand the impacts of these factors on the choices of WFH during and, more importantly, after the pandemic era.

The COVID pandemic has changed almost every aspect of our daily lives, including education, work, and travel. Many studies have been conducted to explore the short-term and long-term impacts of this pandemic on people's behaviors, such as working from home (or work-from-home, WFH). WFH has become a new norm for many people since the pandemic started, and it has tremendously affected commute-related travel. More emphasis on WFH is closely associated with the reduction of commute-related trips, especially during the morning and evening peak hours. Many studies have documented that COVID-19 has changed commute patterns across the world (*1, 2*). This newly adapted work mode has reshaped the commuting pattern during the pandemic and is expected to change the existing pattern in the post-pandemic era.

[1]Zachry Department of Civil & Environmental Engineering, Texas A&M University, College Station, TX
[2]Industrial and System Engineering, Texas A&M University, College Station, TX
[3]Civil Engineering Program, Ingram School of Engineering, Texas State University, San Marcos, TX
[4]Department of Civil Engineering, Babol Noshirvani University of Technology, Babol, Mazandaran, Iran

Corresponding Author:
Subasish Das, subasish@txstate.edu

In the United States, policies for the lockdown of mass public places were implemented in March 2020, and the average daily trips of individuals across the United States dropped by about 50% by the end of April 2020 (*2*). The changing commute pattern has had significant impacts on traffic patterns (*2*). Brynjolfsson et al. (*1*) reported that more than half of the people employed before the pandemic switched to WFH following the initial outbreak. Of those who began to WFH in response to the outbreak, 35.2% were used to commuting before switching to WFH. Bick et al. (*3*) collected information from a nationwide online survey platform, Real-Time Population Survey, and found that the share of WFH-only from the entire employed population was 7.6% before the pandemic. This rate quadrupled to 31.4% during the first wave of COVID-19 in May 2020, and the rate dropped to 24.3% in June 2020. This trend continuously declined afterward until the second wave of COVID-19 arrived. The share of WFH-only bounced back slightly during the second wave, and the rate of WFH-only employees was less than in the first wave as a result of fatigue at social distancing (*2*). However, the long-term impact of this surge in WFH may already have forever changed the perception and adoption rate of the WFH approach. Even before the pandemic, WFH was a viable option for many occupations and employees. However, the WFH adoption rate was low because of the modern perception of work—work is at a physical location rather than at home. The pandemic forced workers who could WFH to adapt to this approach. After months of unwilling practice, many workers started to realize the benefits of WFH, such as saving time and costs of commuting without compromising productivity (*3, 4*). However, not every worker who is forced to adopt the WFH option wants to continue WFH when the option of going back to work in the previous working locations becomes available again. The continuously dropping rate of WFH is evidence of this statement. Therefore, investigating the long-term impact of the pandemic on the WFH approach is a crucial step to understanding the commute patterns in the post-pandemic period since the WFH adoption rate is directly associated with commute patterns.

Existing studies have investigated the potential factors affecting WFH adoption during the pandemic. These factors are the number of children in the household (*5–7*), the level of education (*3*), in-person college interaction (*5*), self-discipline and time management skills (*8*), income (*9*), age (*10*), and so forth. Despite the extensive pandemic-related articles published during the COVID-19 pandemic, there are still gaps in the research. The majority of the studies have discussed the correlations between these factors and WFH adoption during the pandemic, but not as many studies have investigated

how these factors might change the WFH adoption rate in the post-pandemic era. Another list of factors that are not commonly discussed in the existing studies is the sentiment indicator of COVID-19 and experiences of WFH during the pandemic. The sentiment indicator relates to how serious individuals think COVID is and how positive or negative experiences with WFH during COVID-19 would directly affect the adoption of WFH. Furthermore, the questions about how these factors affect the WFH adoption rate and further affect the commuting pattern during and after the pandemic are not yet answered.

This study utilizes survey data from the Puget Sound Region (King, Snohomish, Kitsap, and Pierce counties) in Washington State, USA, and explores the impacts of household income, motherhood, age, and other factors on WFH during and after the pandemic era. Two mediation factors were considered in the study. The mediation factor is the latent variable that cannot be directly observed but can be measured by other factors, such as the perception of the working environment (work environment factor) and the seriousness of the COVID-19 pandemic (pandemic factor). This study applied structural equation modeling (SEM) to analyze these factors' direct and indirect effects, including two mediation factors, on WFH adoption behavior.

Literature Review

Some recent studies have explored the impacts of COVID-19 and demographic factors on WFH patterns. The majority of the study results pertain to the following four major factors: (i) household income, (ii) motherhood, (iii) education, and (iv) age.

Household Income

People with a higher income are more likely to adopt the WFH approach based on the data analysis results of the early stages of the COVID-19 pandemic (*11*). The reason for this could be that people with a lower income may work at a job that cannot be fulfilled at home. Another study also reported similar findings. Jay et al. (*12*) found that people living in higher income neighborhoods spent more time staying at home during the pandemic than those living in lower-income neighborhoods because lower-income individuals are more likely to work at a job that requires workers to be present in specific locations, such as being a cashier in a supermarket. The research results also indicate that individuals with high income experienced a greater decrease in the number of trips, average trip distance, and the average number of places visited per day (*13*).

Parenting

Some parents who work, predominantly mothers, choose to WFH full-time or part-time to take care of children even before the pandemic. Others may have been forced to adopt this new method during the pandemic. Starting from March 2020, many schools and daycare facilities were closed to mitigate the spread of the COVID-19 pandemic. With children not going to school during the day, adult supervision is a necessity. Parents were forced to multi-task and simultaneously both to work and supervise their children (7, 14), and to mix work and parenting (5, 6). Therefore, the responsibilities of childcare played an important role for working parents during the pandemic. Parents with children have less flexibility in their working schedules compared with men and with women without children (15). The study also showed that being a parent (specially woman) with children living at home might have a negative effect on an individual's working discipline and productivity.

Education

Highly educated industrial workers are more likely to WFH during the pandemic (3). A study also found WFH to be much more productive for these highly educated workers than workers with relatively lower education (16). They are more likely to undertake skilled professional work, thus facing less productivity loss during WFH. Masayuki (17) used survey data in Japan to reveal similar findings—groups with higher education, income, and social status favor the WFH option, even though the mean value of productivity dropped about 30% compared with working on site. The study also pointed out that individuals with higher education and income exhibited the smallest reduction in productivity. The results of this study (17) about the effects between education level and WFH efficiency revealed that highly educated groups were more likely to maintain or only have a small reduction in previous productivity.

Age

Many researchers believe that older workers prefer to work in the usual workplace because they have relatively lower adaptability to new technologies than younger workers. However, this conclusion may vary when more factors are considered in the study. Individuals who are older males, highly educated, and higher paid had a higher chance of WFH during the pandemic (9). Older people (65 years and over) appeared to be more productive in WFH because they usually had more self-discipline and were less likely to be distracted while working at home (10). These studies suggest that older people may have a better perception of WFH. However, other findings contradict this view and suggest that older workers were worse off when WFH was a necessary option for most people during the pandemic. Younger people were found to favor WFH more than older people (1). Also, older people were reluctant to abandon traditional working tools (18). In comparison, WFH during the pandemic means new technologies and less interaction with colleagues, which older people were less receptive to. Older workers faced an economic crisis during the COVID-19 pandemic and were not positive about seeking a new job when they were out of work (19). More studies revealed that older people were possibly more affected by the pandemic, but if older people were highly educated and had a high income, they would be less affected during this period when WFH.

The literature review reveals that demographic factors affected the choice of WFH during the pandemic. However, there are a few questions that are rarely studied in the existing research. First, aside from these demographic factors, how does the perception of the seriousness of the COVID pandemic affect WFH decisions? Second, how does the perception of the WFH environment and WFH experiences before and during the pandemic influence WFH decisions? Third, how do these factors affect people's perceptions of WFH in the post-pandemic era? The absence of data or a comprehensive survey makes reliable information and knowledge hard to obtain. This study aims to mitigate this gap by using a comprehensive survey analysis with the application of SEM.

Methodology

Data Overview

The dataset used for this research is from a survey conducted by the University of Washington in June 2020. The purpose of the survey was to collect travel-related decisions of the residents in the Puget Sound Region in Washington State. There were 2,018 residents of this region that participated in the survey, and 1,389 of them finished the survey. The original data were cleaned by data analysts at the University of Washington. The data cleaning process contained multiple steps. Individuals with the same correspondence emails or phone numbers were removed and only one record was kept. Second, duplicated rows or participants who chose the same option for each question were dropped. More details about the data cleaning process can be found in the report published based on this data (20). To fulfill the purpose of our study, only participants with a full-time job or part-time job were considered. Students, retirees, and participants with non-work occupations were excluded from the data. After data cleaning, 748 valid survey responses were kept. Variables that are related to the model description in the methodology were selected for research.

Table 1. Variables Used in the Analysis for Work-from-Home (WFH) Decisions

Variables		Description
WHBC		WFH before COVID-19: 1 = more than two days/week, 0 = never or seldom.
WHDR		WFH during COVID-19: 1 = more than two days/week, 0 = never or seldom.
WHAC		WFH after COVID-19: 1 = more than two days/week, 0 = never or seldom.
Age		Respondent's actual age (divided by 10 during the modeling process).
MOT		Motherhood, i.e., being female and living with children: 1 = yes or 0 = no.
HIN		Household yearly income higher than $50,000: 1 = yes or 0 = no.
Edu		The highest degree or level of school: 1 = Some college/technical training, 2 = bachelor's degree, 3 = Master or higher, 0 = high school or lower.
Pandemic factor (PF): the negative perception of pandemic severity	MedEX	The media is exaggerating the spread of the coronavirus: 1 = strongly agree, 6 = strongly disagree.
	FaceCov	Wearing face covering should be mandatory. 1 = strongly agree, 6 = strongly disagree.
	BShutDown	Shutting down businesses to prevent the spread of the coronavirus is not worth the economic damage that it causes. 1 = strongly agree, 6 = strongly disagree.
	StHome	Everyone should stay at home as much as possible until the coronavirus has subsided. 1 = strongly agree, 6 = strongly disagree.
	PhyDist	Physical distancing is an efficient approach for controlling the coronavirus. 1 = strongly agree, 6 = strongly disagree.
	FamHealth	I am concerned that friends or family will experience serious health issues if they catch the coronavirus. 1 = strongly agree, 6 = strongly disagree.
Work environment factor (WEF): the positive perception of WFH	MissCommute	I miss my commute. 1 = strongly agree, 6 = strongly disagree.
	OnlMeet	I can efficiently replace most in-person work meetings with online meetings. 1 = strongly agree, 6 = strongly disagree.
	CoInt	Perform better when interacting with coworkers. 1 = strongly agree, 6 = strongly disagree.
	WfhDisp	WFH makes me less disciplined self-controlled. 1 = strongly agree, 6 = strongly disagree.

Data Description

Table 1 shows the 17 variables selected for this analysis. Three of the variables are WFH decisions before (WHBC), during (WHDR), and after (WHAC) the pandemic. The WFH decisions before and during the pandemic have already happened, and the answers state the fact. The WFH decision in the post-pandemic era is the anticipation of each respondent. The four demographic variables used are age, motherhood, household income, and education. The rest of the variables are variables used for constructing the mediator factors: Pandemic Factor (PF) and Work Environment Factor (WEF). PF is the mediator factor represented by six variables, which indicate the respondent's perception of the severity of the pandemic. Six variables are questions listed in the survey asking about the participants' opinions about COVID-19-related issues, such as if the respondent thinks the media is exaggerating the spread of COVID-19, if wearing face coverings should be mandatory, and so forth. WEF is another mediator described by four variables,

which demonstrates the participants' preferences on commuting, in-person meetings, interaction with coworkers, and self-discipline while WFH.

Table 1 gives a brief description of each variable. WHBC, WHDR, and WHAC are binary variables. Zero indicates that the participant never or seldom WFH, and one means WFH at least two days a week. Two demographic variables, motherhood and household income, are binary variables. For motherhood, if the participant is a female and living with children, then the variable equals 1, otherwise it equals 0. For household income, if a household income is higher than $50,000 per year, then the variable equals 1, otherwise it equals 0. The age factor represents the actual age of the participants. All other variables are either binary variables or have a perception score from 1 to 6. To ensure that all variables are at a similar scale, the value of the age variable is divided by 10. The education variable has four categories to represent: some college/technical training, bachelor's degree, master's degree or higher, or high school or lower.

Table 2. Descriptive Statistics of Variables

Variable	Categories	Count	Percentage	Variable	Categories	Count	Percentage
WHBC	1	174	23.26%	PhyDist	1	407	54.41%
	0	574	76.74%		2	215	28.74%
WHDR	1	608	81.28%		3	84	11.23%
	0	140	18.72%		4	15	2.01%
WHAC	1	403	53.88%		5	22	2.94%
	0	345	46.12%		6	5	0.67%
MOT	1	88	11.76%	FamHealth	1	485	64.84%
	0	660	88.24%		2	162	21.66%
HIN	1	680	90.91%		3	58	7.75%
	0	68	9.09%		4	11	1.47%
EDU	1	56	7.49%		5	23	3.07%
	2	290	38.77%		6	9	1.20%
	3	296	39.57%	MissCommute	1	35	4.68%
	0	106	14.17%		2	46	6.15%
MedEX	1	31	4.14%		3	87	11.63%
	2	32	4.28%		4	195	26.07%
	3	64	8.56%		5	96	12.83%
	4	175	23.40%		6	289	38.64%
	5	81	10.83%	OnlMeet	1	195	26.07%
	6	365	48.80%		2	183	24.47%
FaceCov	1	583	77.94%		3	158	21.12%
	2	93	12.43%		4	75	10.03%
	3	28	3.74%		5	67	8.96%
	4	11	1.47%		6	70	9.36%
	5	16	2.14%	Colnt	1	176	23.53%
	6	17	2.27%		2	191	25.53%
BShutdown	1	34	4.55%		3	189	25.27%
	2	40	5.35%		4	70	9.36%
	3	78	10.43%		5	86	11.50%
	4	208	27.81%		6	36	4.81%
	5	129	17.25%	WfhDisp	1	83	11.10%
	6	259	34.63%		2	111	14.84%
StHome	1	438	58.56%		3	153	20.45%
	2	166	22.19%		4	174	23.26%
	3	87	11.63%		5	91	12.17%
	4	6	0.80%		6	136	18.18%
	5	35	4.68%	Age (years)	Minimum 18, maximum 69, mean 42.6, std deviation 12.3		
	6	16	2.14%				

Note: WHAC = work from home decisions after the pandemic; MOT = motherhood; HIN: household yearly income; Edu: the highest degree or level of school; MedEx: opinion on media exaggeration; FaceCov: opinion on face covering use; BShutDown: opinion on business shutdowns; StHome: opinion on staying at home; PhyDist: opinion on physically distancing; FamHealth: concerns about family health; MissCommute: missing commute; OnlMeet: opinion on online meetings; Colnt: coworker interaction; WfhDisp: how work from home affects discipline.

Variables describing the mediator factors are measured by the degree of agreement (1 = strongly agree, 2 = agree, 3 = somewhat agree, 4 = somewhat disagree, 5 = disagree, 6 = strongly disagree). For the variable "CoInt" the statement is "Perform better when interacting with coworkers." If the response is "strongly agree," that indicates the respondent strongly agrees that he/she performs better when interacting with coworkers.

Descriptive Statistics of Selected Variables

Table 2 presents the descriptive statistics of the variables. The age factor is a continuous variable with a minimum of 18 years, a maximum of 69 years, and a mean of 42.6 years. The rest of the COVID-19 opinion-related variables have six levels to describe the magnitude of the agreement toward certain opinions: strongly agree = 1, strongly disagree = 6. The counts of each category are also reported in Table 2.

Descriptive Statistics of WFH Behavior

Table 3 shows the preferences for WFH before, during, and after the pandemic era. The percentage of WFH during the pandemic (about 70%) is much higher than before the pandemic (less than 30%). Moreover, the rate

Table 3. Changes in Work-from-Home (WFH) Decisions and COVID-19

Frequency of WFH	WFH before COVID-19	WFH during COVID-19	WFH after COVID-19
Never or seldom	72.65%	31.05%	52.55%
More than two days per week	27.35%	68.95%	47.45%
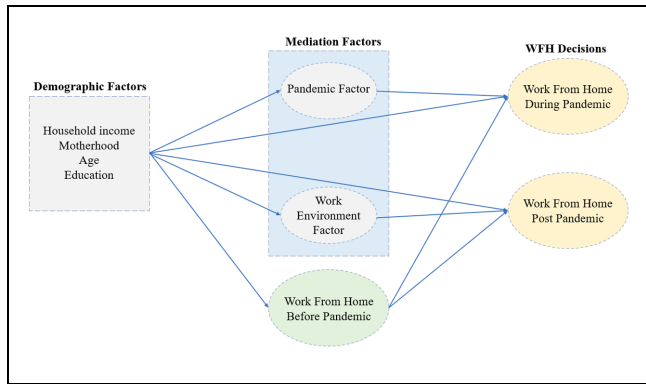
Figure 1. Problem formulation.

of WFH in the post-pandemic era is about 50%, which is much higher than the rate before the pandemic. This indicates that the WFH adoption rate has been permanently changed because of the WFH experiences during the pandemic. Another fact worth mentioning here is that the WFH rate before COVID-19 was about 30%, which is much higher than the 7.6% reported by Bick et al. (3). This is because Bick et al.'s study considers the WFH-only approach wherein all five workdays per week must be WFH. In our study, the WFH rate includes any WFH behavior of more than two days per week.

SEM Framework

Figure 1 presents the research framework. In this framework, based on the literature review of the existing studies, we propose that household income and motherhood status can affect WFH decisions both directly and indirectly. Multiple factors (household income, age, gender, motherhood, education, and two mediation factors) were considered in this SEM process. The mediation factor stands for a latent variable that cannot be observed directly but can be represented by multiple other variables. Two mediation factors are the pandemic factor (PF) and the work environment factor (WEF). The assumption is that people who are serious about the pandemic would prefer to WFH when this option is viable, whereas those who are less serious about the pandemic may choose not to WFH even if this option is available for them. WEF is the factor that captures the worker's positive perception of the working environment while

working at home. For workers who enjoy their commute and interacting with colleagues in person, and are more productive when present in the office environment, WEF could be a significant factor affecting the adoption of WFH during and after the pandemic era. Several demographic variables such as gender, age, education, race, and full-time job were selected as control variables.

Except for these mediation factors, the relationship between other factors and WHAC could also be complex. One factor could directly affect WHAC and also indirectly affect WHAC through another factor. For example, the age factor could affect WHAC directly, and it could also indirectly affect WHAC through the WEF mediation factor. To handle these complex relationships, the traditional regression method is not a desirable option. This study adopts an SEM framework for the analysis. SEM is a path analysis method, and it is commonly practiced in the social science field. Path analysis can systematically reveal the direct and indirect relationship between the latent variables and observed variables.

Estimation Model

The response variables in the research model, WHDR and WHAC, are categorical data. The researchers used a generalized SEM estimation strategy (21). In the estimation model, the researchers specified latent continuous responses as $y_j^*(j = 1, 2)$, where j indicates WFH intentions during and after the pandemic era, such that

$$y_j = \begin{cases} 0 & \text{if} \quad y_j^* \leqslant 0 \\ 1 & \text{if} \quad y_j^* > 0 \end{cases} \quad (1)$$

where y_1, y_2 are the categorical respondent variables WHDR and WHAC, respectively. This threshold model is combined with a utility model described below:

$$y_j^* = \alpha + \beta_1 \eta + \beta_2 X + \epsilon_j, \, j = 1, 2 \quad (2)$$

where α is the intercept, X is a vector of exogenous variables, including Age, MOT, HIN, Edu, and WHBC, and η is a vector of latent variables (η_1, η_2) estimated from the observed explanatory variable factors f.

$$\eta_i = \mu + B f_i + \xi_i \quad (3)$$

Table 4. Latent Variables and Loadings

Latent variable	Definition	Items	Standard loadings	Standard error
PF	Pandemic factor: the negative perception of pandemic severity	MedEX	−0.9	0.05
		FaceCov	0.8	0.04
		BShutDown	−0.78	0.05
		StHome	0.84	0.04
		PhyDist	0.50	0.04
		FamHealth	0.69	0.04
WEF	Work environment factor: the positive perception of WFH	MissCommute	0.55	0.06
		OnlMeet	−0.86	0.09
		CoInt	0.14	0.02
		WfhDisp	0.82	0.07

Note: WFH = work from home; PF = pandemic factor; WEF = work environment factor.

where η_1 represents the pandemic factor, that is, the negative perception of pandemic severity, which is measured by f_1 = (MedEX, FaceCov, BshutDown, StHome, PhyDist, FamHealth). η_2 represents the WEF, the positive perception of WFH, which is measured by f_2 = (MissCommute, On1Meet, CoInt, WfhDisp).

When the logit link is used for Equation 2, a generalized latent variable with logit links can be used. Unlike continuous responses, maximum likelihood estimation cannot be identified by the empirical covariance matrix of the observed respondent variables. In contrast, the likelihood function must be calculated by numerically integrating the latent variables. The package OpenMX in R provides a way to specify the generalized SEM with categorical responses. This study utilizes this R package and constructs corresponding matrix forms to represent the links among these variables.

Results

Mediation Factors and Latent Variables

The purpose of creating mediator factors is discussed in the methodology section, above. The pandemic factor (PF) is measured by multiple variables (MedEX, FaceCov, BShutDown, StHome, PhyDist, FamHealth) related to participants' opinions toward COVID-19. The level of agreement on COVID-19-related issues is measured from 1 to 6 (strongly agree = 1, strongly disagree = 6). An increasing value for each variable means the participant has a stronger disagreement. WEF demonstrates the positive perception of the working environment at home. WEF is associated with four questions related to participants' perceptions of WFH: MissCommute, On1Me, CoInt, and WfhDisp.

Table 4 presents the standard loadings of each item on each latent variable. The standard loading represents the correlation coefficient between a latent variable and the items. A positive standard loading value means the association between the item and the latent variable is positive. Commonly, 0.7 or higher means that the factor represents the sufficient variance of that latent variable.

For example, MedEX, which represents perception of whether the media exaggerates the spread of the coronavirus, is measured by numbers 1 to 6, where 1 = strongly agree and 6 = strongly disagree. The standard loading of MedEX to PF is −0.9, which demonstrates the strong negative associations between PF and disagreement with the opinion of media exaggeration. In plain words, participants who do not agree with the idea that the media is exaggerating the pandemic are very unlikely to have a negative perception of the seriousness of the pandemic. The loading values in the Table 4 vary, which indicates the changing magnitude of associations among the items and mediation factors. The ideal scenario is that all items have a very strong association with the latent variable. However, to ensure the fairness of the representation of these items, multiple items with relatively small loading values are included, such as CoInt, which perform better when survey participants interact with colleagues. For WEF, the workers who do not miss commuting, think online meetings are effective, and maintain productivity while WFH have a positive perception of WFH.
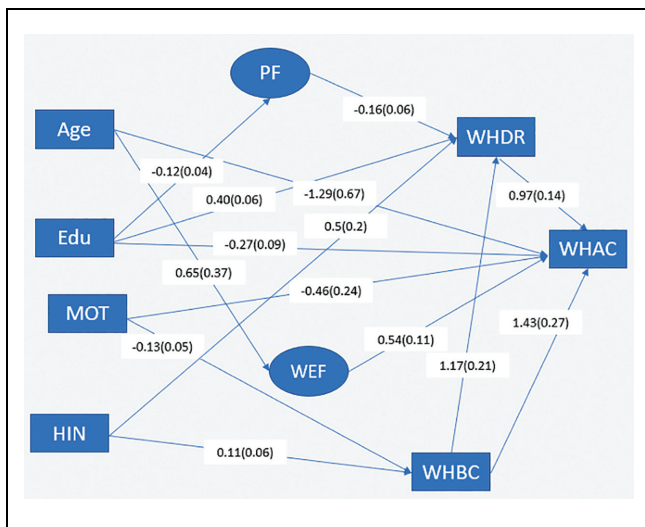
SEM Results

The SEM results are presented in Table 5 and Figure 2. Only statistically significant results are reported. The significance level is 0.05 in this study. The relationship between each variable, mediation factors, and the WFH decisions are reported and interpreted. The positive coefficient indicates the positive association and vice versa. Each factor has multiple statistically significant correlations with mediators or response variables. For example, the age factor connects with the WHAC and WEF. In other words, age affects workers' feelings about the working environment at home and the decisions of WFH in the post-pandemic era. The education factor connects three entities: PF, WHDR, and WHAC, which suggests

Table 5. Structural Equation Modeling Results

Variables	Relationship	Coeff.	Standard error	P-value
Age – WHAC	Increase in age has a negative relationship with workers' willingness to work from home (WFH) in post-pandemic era	−1.29	0.67	0.026
Age – WEF	Increase in age has a positive relationship with the working environment factor	0.65	0.37	0.040
Edu – PF	Workers with higher education level feel less severity of pandemic effect	−0.12	0.04	0.002
Edu – WHDR	Workers with higher education level are more likely to WFH during the pandemic	0.40	0.06	0.000
Edu – WHAC	Workers with higher education level are less likely to WFH in post-pandemic era	−0.27	0.09	0.001
MOT – WHAC	Female workers with children are unwilling to WFH in post-pandemic era	−0.46	0.24	0.030
MOT – WHBC	Female workers with children were unwilling to WFH before the pandemic	−0.13	0.05	0.003
HIN – WHDR	Workers with higher household income are more likely to WFH during the pandemic	0.50	0.19	0.005
HIN – WHBC	Workers with higher household income were more likely to WFH before the pandemic	0.11	0.06	0.026
WHBC – WHDR	WFH before the pandemic increases the possibility of WFH during the pandemic	1.17	0.21	0.000
WHBC – WHAC	WFH before the pandemic increases the possibility of WFH in post-pandemic era	1.43	0.27	0.000
WHDR – WHAC	WFH during the pandemic increases the possibility of WFH in post-pandemic era	0.97	0.14	0.000
PF – WHDR	Negative perception of pandemic severity decreases the possibility of WFH during the pandemic	−0.16	0.06	0.003
WEF – WHAC	Positive perception of WFH increases the possibility of WFH in post-pandemic era	0.54	0.11	0.000

Note: "−" indicates variable for a certain condition. WHAC = work from home decisions after the pandemic; WEF = working environment factor; PF: pandemic factor; Edu = the highest degree or level of school; WHDR = work from home decisions during the pandemic; MOT = motherhood; HIN = household yearly income; WHBC: work from home decisions before the pandemic.

Figure 2. Structural equation modeling (SEM) results. The numbers on the links are coefficients and standard errors.

that education level significantly influences the pandemic factor (seriousness of the pandemic and the decisions about WFH during and after the pandemic era).

These relationships are also mapped in Figure 2, which provides a visual approach to understanding the results of path analysis. More discussions about the findings can be found in the following section.

Findings and Discussion

Figure 2 shows all the variables and links with statistically significant associations (significant level = 0.05). The numbers on the links are coefficients and standard errors. The major findings and discussion of them are presented below.

To begin with, several factors may contribute to older people, people with higher education, and parents with children being less likely to engage in WFH in the post-pandemic era. There may be established routines and social connections at the workplace for older people that they might not want to abandon (*22*). Moreover, older people are less likely to feel comfortable using the technology required for WFH (*23*). In addition, higher-educated individuals may be less likely to engage in WFH in the post-pandemic era, since their jobs may require face-to-face interaction, such as

teaching, research, or consulting (*24*). As well as that, people with higher education may be more likely to value the social and intellectual stimulation that comes from the workplace (*25*). Those with children may also be less likely to engage in WFH in the post-pandemic era since they may have difficulty balancing work and homeschooling (*26*). Moreover, WFH may not provide parents with the same opportunities for social interaction and professional development as in their traditional workplace (*25*). On the contrary, people with higher incomes may also be more likely to WFH after the COVID-19 pandemic for various reasons. A person with a high income may be employed in a job that allows WFH, such as those in knowledge-based industries such as finance, technology, and consulting (*27*). It is often feasible to WFH in these industries since they require minimal face-to-face interaction. A second reason is that people with greater incomes may be able to afford high-speed internet access, laptops, and software applications that are essential for WFH (*28*). By having this access, they are able to work effectively from any location, whether it is their home or a remote location. Third, people with higher incomes may be able to balance work and personal commitments better, as they have more autonomy and control over their work schedules (*29*).

As a result of these findings, it appears that an individual's perception of a certain phenomenon might change after experiencing it for the first time. People who WFH during the pandemic were more likely than others to return to their workplaces afterward. It might be necessary to offer multiple incentives to successfully encourage the continuation of WFH shifts. To encourage or discourage WFH, some policies should be location-specific and take into account residential location. It is possible that residents of large cities are more likely to continue WFH post-pandemic than those living in small towns.

Overall, remote work has become an attractive option for many people, including those with higher incomes. Remote work may make it easier for employees to adjust their work schedules to accommodate childcare or caregiving commitments. Employees who value flexibility and autonomy in their work arrangements may be more likely to stay with employers who offer remote work options. In spite of its many benefits, such as greater flexibility and work-life balance, remote work may not be suitable for everyone. It is important for employers to consider the diverse needs and preferences of their workforce when implementing remote work policies post-pandemic.

The age factor is positively associated with WEF and negatively with WHAC. This positive relationship between age and WEF suggests that older workers have more positive feelings about the working environment at home. This may suggest that older workers are more disciplined and are simply distracted less by changing the working environment to telework mode (*30*). The negative association between age and WHAC demonstrates that older workers have less intention of WFH in the post-pandemic era (*31–33*). Furthermore, younger workers show a stronger desire to WFH (*31*). They prefer the advantages of teleworking more than older generations (*30*). Older workers would get tired of telecommuting and meeting virtually, which is a relatively new experience for those who have been forced to adapt to new communication tools. Thus, the results suggest that older people have more positive impressions of the working environment at home, however, older workers are less likely to continue WFH in the post-pandemic era for other reasons, such as ineffective online meetings.

The education factor is negatively associated with PF and WHAC and positively associated with WHDR. The results suggest that individuals with higher education are less likely to have a negative perception of the seriousness of the pandemic and more likely to choose WFH during the pandemic, which agrees with many existing studies (*3, 17*). In general, individuals with higher education often have less doubt about the seriousness of the pandemic. They are more confident with making independent decisions when working from home (*30*). Employees with higher education levels are more willing to telecommute (*33*). Interestingly, these individuals are eligible for WFH but do not always favor WFH in the post-pandemic era. This finding matches the overall trend of WFH adoption. The WFH adoption rate spiked at the beginning of the pandemic during the first half of 2020, and the rate then gradually fell as many workers eligible for WFH were willing to go back to work on site. This could be because workers with higher education levels may work in roles that require more collaboration and social interaction with colleagues.

Being female with children living at home (MOT factor) is negatively associated with WHBC. This is a reasonable observation, as previous studies have found that female parents often find it hard to WFH while children are around. During the pandemic, it was a challenge for mothers to take care of children who had to study at home, because of the simultaneous closure of schools and the initiation of WFH (*30, 34*). MOT also negatively connects with. This is also understandable because mothers may have experienced conflicts with family members while WFH during the pandemic, so they prefer returning to the previous mode to keep their work-life balance (*30*). Also, the coefficient of MOT-WHAC is higher than the previous link, MOT-WHBC, which indicates that the desire to avoid WFH grows even higher in the post-pandemic era. One observation worth mentioning is that the coefficient between MOT and WFH during the

pandemic is not statistically significant. The reason for this might be that WFH during the pandemic may not be a choice for many mothers.

Household income (HIN) positively affects the WHBC and WHDR choices. One finding is that individuals with higher household incomes are more likely to have had experience of WFH before the pandemic. Employees with higher incomes were more likely to have had the experience of WFH before the COVID-19 pandemic and are more likely to maintain the same working mode (*35, 36*). These WFH experiences could facilitate WFH adoption during the pandemic (*37*), although there is no doubt that the number of employees WFH during the pandemic still increased, compared with the number of WHBC (*35*). Both household income and education have a positive effect on WHDR. The results show that people with higher incomes are more likely to WFH. This trend also appears among people with higher education. Therefore, people with higher educational qualifications are less likely to attend a workplace in person. These two issues indicate that higher salaries are usually paid to people with higher education degrees.

Pandemic factor (PF) and work environment factor (WEF): The pandemic factor states the negative perception of pandemic severity by individuals. This factor is negatively associated with WHDR. People who strongly disagreed with the seriousness of the COVID-19 pandemic had less willingness to WFH during the pandemic. Conversely, those who feared the severity of the COVID-19 pandemic were not willing to work physically (*38, 39*). WEF has had a positive effect on WFH in post-pandemic era. A more positive perception of the working environment at home encourages workers to adopt the WFH option in the post-pandemic era (*35*). This group of workers enjoys the benefits of WFH—saving time from the lack of commute and effective online meetings while maintaining productivity. Also, having the appropriate workspace eased people's concerns when WFH during the pandemic (*24*). These experiences will further positively affect their probability of WFH adoption in the post-pandemic era.

Three links connect the three WFH choices: WHBC, WHDR, and WHAC. It is obvious to observe that WHBC positively affects the choice of WHDR and WHAC, and WHDR positively affects the WHAC choice (*27*). WHBC was a voluntary choice, and whoever chose to WFH before the pandemic indicates they were eligible for WFH when it became necessary. With more experience in WFH, these individuals who were eligible for WFH before the pandemic were more willing to WFH during and after the pandemic era, especially the higher income employees (*36*). Moreover, for these people who first experienced WFH during the pandemic,

their experiences with WFH positively affected their later preference for WFH in the post-pandemic era (*35*).

Conclusion

This study utilized a novel survey and established an SEM framework to investigate the long-term impacts of many factors, such as motherhood, household income, education, age, and prior WFH experiences on WFH behavior during and after the pandemic era.

Numerous studies have been conducted to understand the changes in traffic patterns before, during, and after the pandemic era. Some studies have found that implementing WFH can have a positive impact on sustainable development during the pandemic and in the long term (*40, 41*). With the possibility of mitigating the negative externalities of transportation, it is considered beneficial. WFH arrangements have reduced trip distances and travel times significantly, which has reduced fuel consumption and pollution emissions (*42, 43*). As teleworkers increase their use of active transportation, traffic carbon emissions will also decline. There has also been a significant shift in the time when people commute in the morning, and commutes to high-density areas have been significantly lower than those to low-density areas (*44, 45*). While numerous articles have been published on pandemic-related topics during the COVID-19 pandemic, there are still gaps in the knowledge. WFH adoption during the pandemic has been studied extensively, but fewer studies have examined how these factors might change the WFH adoption rate in the post-pandemic period. There are other factors that are not commonly discussed in existing studies, such as COVID-19 sentiment and WFH experiences during the pandemic. Furthermore, it is not yet clear as how these factors affect the WFH adoption rate and commute patterns during and after the pandemic. The contribution of the present study can be divided into several points. As a first point, the results show how common factors such as age, income, and education influence WFH eligibility and preferences. Second, the present study explored mediation factors like perceptions of the pandemic era. Furthermore, the present study answers questions about how sentiment factors affect WFH adoption rates and further affect commuting patterns before, during, and after the pandemic era.

Many interesting findings were revealed. For example, motherhood is negatively associated with WFH behavior, and was even before the pandemic. Being forced to WFH during the pandemic reinforced this association, and female workers with children became more unwilling to WFH in the post-pandemic era. This finding clearly states that being forced to WFH during the pandemic and mixing the working environment

with taking care of children negatively affects their WFH experiences. However, WFH experiences during the pandemic positively correlate with the preferences of WFH in the post-pandemic era. It is found that older workers have positive feelings about the working environment at home. It is also found that individuals with a higher household income are more likely to have had WFH experience before the pandemic. However, the SEM model also produces some less intuitive results. For example, higher education is negatively associated with WFH in the post-pandemic era. This may be caused by the nature of work for highly educated individuals requiring more collaboration and social interactions. A more in-depth investigation is needed in the future to validate this assumption.

These findings are crucial for researchers to understand the impacts of these factors on WFH behaviors. WFH patterns directly change commute patterns. Knowing people's changes in preferences for WFH could help transportation agencies understand the traffic pattern changes during and after the pandemic era. Moreover, it could also help the agencies prepare for changes in the post-pandemic era.

There are several limitations of this study. First, it is limited to a specific geographic area with around 1,000 participants. For a survey, this sample size is not small. However, a future survey with more geographically diverse participants would help to generalize the results. Moreover, the design of the questionnaire meant that there is some information that may affect the results but was not collected. For example, detailed information about the participants' occupations may have an impact on WFH behavior in the long run. Second, another key issue is public health concerns. There is a need to explore the health and psychological impacts of WFH. Third, even though structural modeling is a good fit for this study, one still needs to be very cautious about turning the parameters. Just like logistic regression, including or not including certain factors would affect the coefficients of other variables. We retained multiple loading factors with coefficients less than 0.7 to ensure reasonable factors were not being ruled out for two mediator factors because of a slightly short coefficient, for example, 0.5. However, these factors could potentially slightly change the coefficients of other factors. Future studies may test all possible combinations and adopt more robust statistical methods to rule out or keep certain factors before performing the SEM model. Fourth, some of the variables, such as age and education, can be further explored using multi-level categorization, which was not done in this study. Finally, SEM is a good fit for this study. However, the modeling results are still presented as correlations. Correlation is not necessarily interchangeable with causation. Therefore, future studies may perform more in-depth analyses to identify causations.

Author Contributions

The authors confirm contribution to the paper as follows: study conception and design: X. Kong, S. Das; data collection: X. Kong; analysis and interpretation of results: X. Kong; draft manuscript preparation: X. Kong, Z. Li, Y. Zhang, X. Chen, S. Das, A. Sheykhfard. All authors reviewed the results and approved the final version of the manuscript.

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ORCID iDs

Xiaoqiang Kong (ID) https://orcid.org/0000-0002-8120-0754
Zihao Li (ID) https://orcid.org/0000-0002-7521-4957
Subasish Das (ID) https://orcid.org/0000-0002-1671-2753
Abbas Sheykhfard (ID) https://orcid.org/0000-0002-9536-3108

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