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Research Article

Exploring time-lagged effects and gendered differences of videoconference fatigue on work-family conflict and emotional well-being

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ABSTRACT

While videoconferencing has become an integral part of many individuals' lives, less is known regarding how individuals' experience of videoconference fatigue (VF) and work-family conflict (WFC) affects their emotional well-being over time. We examine the changes in VF, WFC, loneliness, and well-being across time, through the lens of the stressor-strain-outcome framework. A two-wave online panel survey was conducted at two time points (T1 and T2) with 203 respondents in Singapore. Findings showed that the experience of VF at T1 negatively impacted emotional well-being at T2. A significant relationship was also found between WFC at T1 and VF at T2. Findings also revealed gender differences, with the negative relationship between VF at T1 and emotional well-being at T2 being stronger in women, while men experience greater WFC at T2 from the lagged effect of VF at T1.

Keywords: videoconference fatigue, time-lagged, well-being, stressor-strain-outcome, work-family conflict, loneliness

INTRODUCTION

Videoconferencing tools have become an integral part of modern work environments, enabling effective communication and collaboration across distances. With the advancement of communication technologies, hybrid and virtual work formats will become prevalent with the benefits telecommuting brings to both organizations and employees (Chuang et al., 2024). Beyond studies examining the benefits such as convenience, autonomy, and better work-life balance with the introduction of videoconferencing tools and telecommuting in current work styles, recent literature have started exploring its possible negative effects. Physiological, socio-psychological and mental stress which includes eye exhaustion, burnout, anxiety, counterproductivity (Labban & Bizzi, 2023), social disconnection (Lee, 2020) and even conflict within home

space (Li et al., 2022a), have amalgamated in the phenomenon known as videoconference fatigue (VF) (Li & Yee, 2023).

Working from home has become increasingly common, especially as organizations continue to embrace hybrid work arrangements. However, this widespread adoption of remote work has also intensified its associated challenges, including heightened stress and fatigue among employees (Rajah, 2021). The blurring of boundaries between work and family life often results in work-family conflict (WFC), driven by imbalances in role demands and expectations between these domains (Golden et al., 2006; Molino et al., 2020; Sadiq, 2020). A study found that working from home and the higher frequency of videoconferencing use exacerbate experiences of VF, resulting in a greater tendency of WFC during the pandemic (Li et al., 2022b). Moreover, individuals working from home may not only feel pressure to maintain social ties and responsibilities but also feel isolated and lonely (Chuang et al., 2024). The compound effect from strains in social ties and negative emotions was found to have undesirable effects on the individual's well-being and, consequently, work performance (Chuang et al., 2024; DiMaria et al., 2020).

As videoconferencing becomes increasingly integral to work and life across industries, its adoption continues to shape modern work practices. From an era of compulsory work-from-home arrangements to the current prevalence of hybrid work formats, videoconferencing remains a key tool, offering agility and flexibility to both employers and employees. While past studies have explored the link between VF and WFC, they mainly employed cross-sectional data collection and analyses, which do not preclude alternative explanations. Could WFC lead people to feel more VF? Moreover, little is known regarding how individuals' experience of VF and WFC during the periods of extensive remote work influences individuals' well-being and loneliness in the context of hybrid work arrangements. Are there lingering effects? Could their experience working from home during government-mandated lockdowns have an influence on their current emotional well-being?

Existing literature has framed VF as a form of technostress (Ayyagari et al., 2011; Tarafdar et al., 2020; Anh et al., 2023) to explore possible adverse effects on the physical, social, and emotional aspects of users of videoconferencing tools. The transactional theory of stress (Lazarus & Folkman, 1984) posited that the relationship between stressors and strains is a phenomenological process. Under this theory, stress is characterized as the stimuli or external trigger that create disharmony in an individual from the excessive use of communication technologies, a knowledge gap in performing tasks using higher technologies, and adverse effects of using such technologies on environment and culture (Ragu-Nathan et al., 2008; Ahn et al., 2023), and strains are effects of stressors which can be physiological and psychological (Maier et al., 2015; Ahn et al., 2023). Since studies have suggested that strains accumulated from VF have negative impacts on individuals' well-being and job performance (Chuang et al., 2024; DiMaria et al., 2020), this study introduces the stressor-strain-outcome (SSO) framework as a theoretical foundation to explore these relationships.

In summary, this study examines changes in VF, WFC, loneliness, and well-being, comparing the period of widespread remote work with the subsequent transition to hybrid work formats, through the lens of the SSO framework. Through a panel survey, the current study hopes to contribute to a more nuanced understanding of VF and its effects.

LITERATURE REVIEW

The Stressor-Strains-Outcome Framework

The SSO framework was first developed to reconceptualize burnout amongst employees in organizational work settings (Koeske & Koeske, 1993), where overworking or challenging work events leads to strains in the form of emotional exhaustions, social relationships, and physiological and consequently, negative attitudinal and behavioral outcomes such as intention to quit (Shagirbasha et al., 2023). Within the SSO framework, there are three components: the stressor, the strain, and the outcome (Koeske & Koeske, 1993). A stressor is an environmental stimulus considered by the individual as annoying or disruptive. Such stressor then leads to negative psychological and behavioral responses related to the stimulus known as strains. Strains are formed as a result of the stressor, and in turn, the strains lead to negative outcomes, which affect the individual's emotions, physiology, behaviors, and social relationships (Khan, 2021; Shagirbasha et al., 2023). Furthermore,

Koeske and Koeske (1993) have highlighted the mediating effect of strain on the relationship between stressor and outcome.

The SSO framework was subsequently applied in the computer-mediated setting to investigate impacts of excessive use of social media or overload from the social networking sites has led to strains and negative impacts perceived by users (Masood et al., 2022). Scholars examining the later stream of research have extended the SSO framework by referring to theories of technostress, reframing strains aspects and outcomes into unfavorable workplace issues (Ayyagari et al., 2011; Anh et al., 2023) or academic performance amongst students (Masood et al., 2022).

With the increasing reliance on videoconferencing tools to support communication and collaboration in modern work environments, employees have experienced significant shifts in their work practices. Extant studies have uncovered the consequences of excessive videoconferencing, resulting in physiological fatigue and strains in social relationships while working from home (Li et al., 2022a; Shagirbasha et al., 2023). While recent studies have employed the SSO framework to explore the effects of VF during the pandemic, these studies tended to employ a cross-sectional design and limited to explorations with the direct antecedents and outcomes of VF, with VF as a strain instead of a stressor (Anh et al., 2023). Hence, this study will use a longitudinal approach with the SSO framework as the theoretical undergirding, to illuminate the effects of VF on WFC (Anh et al., 2023).

Work-Family Conflict as Strain

As opposed to in-person work, the convenience of videoconferencing may inadvertently result in more blurring of work-home boundaries and time spent working from home. Nonetheless, studies have demonstrated that working from home added to greater demands on individuals, inadvertently resulting in the adverse impacts of telework (Shagirbasha et al., 2023). These impacts include greater sense of isolation (Hickman, 2019), diversions and reduced capacity for familial commitments (Allen et al., 2015), difficulty in differentiating work and family, and increased WFC (Li et al., 2022b).

WFC occurs when conflict arises between the working individuals and their direct family members due to the stress accumulated from responsibilities and expectations from work and family (Carlson et al., 2000; Golden et al., 2006). Time-based conflict happens when the amount of time spent on work is greater or eats into the time dedicated to the individual's family responsibilities (Golden et al., 2006). Such conflicts have been evident in causing strains between an individual's work and family, leading to emotional and physical burnout, which "is psychologically and physically draining, hindering or preventing an individual's ability to cope and leading to feelings of being overwhelmed" (Golden, 2012, p. 256). Since the pandemic, studies have shown that working from home has led to greater work-family tensions amongst individuals (Shagirbasha et al., 2023). Moreover, the excessive use of information and communications technologies such as videoconferencing tools compounded with greater workload and workplace isolation are highly associated with WFC (Molino et al., 2020; Shagirbasha et al., 2023).

The increased reliance on videoconferencing blurs the boundaries between work and private space, as well as the identities tied to each, creating an "always on culture" where employees are expected to be responsive and connected all the time (Okabe-Miyamoto et al., 2021). The blurred boundaries between work and home are emotionally and functionally draining as individuals multitask and juggle commitments and expectations of different roles across the two domains (Ashforth et al., 2000). Existing literature suggested that the use of videoconferencing tools has led to role conflict and increasing difficulty in resolving work-family tensions among working parents and caregivers (Palumbo, 2020), even more so amongst working mothers with multiple children (Pennington et al., 2022). Especially, the physical and mental fatigue manifested during and after excessive videoconferencing use has been found to be an antecedent of WFC; it is logical that VF, as a result of telework, causes both strain-based and time-based WFC.

Under the translational theory of technostress, techno-strains are the negative impacts of techno-stressors (Laumer & Maier, 2021; Tuan Anh et al., 2023). Building on prior literature highlighting the association between VF and WFC, VF as a form of stressor is evident in causing emotional strains (e.g., Pennington et al., 2022), and in social relationships (Li et al., 2022b). Hence, this study hypothesizes that:

H1. VF is positively associated with WFC (i.e., greater feelings of VF will lead to greater WFC).

Loneliness and Emotional Well-being as Outcomes

Loneliness is defined as "a misalignment between an individual's desired and actual levels of social interaction in society" (Chuang et al., 2024, p. 3). This negative response, thus, affects an individual's psychological health and was found to be linked with stress, and anxiety (Owczarek et al., 2022). Studies have highlighted that loneliness is a key concern amongst remote employees (Peterman et al., 2020), especially those who are single may feel greater feelings of loneliness due to lack of familial connections, social exclusion, and isolation (Carnevale & Hatak, 2020). Especially with the pandemic, the abrupt transition of workspace to remote work may increase greater feelings of isolation due to the loss of social presence and interactions from conventional office life (Rodríguez-Modrono & Lopez-Igual, 2021). Such sense of disconnection from familial working conditions was found to increased employees' stress levels, enhancing the sense of isolation felt among employees when working remotely (Bloom et al., 2015).

Studies have suggested that workplace isolation due to remote work further aggravates WFC, as boundaries between work and family have been eroded and the lack of camaraderie and social interactions with co-workers to help address work issues and distract from loneliness (Shagirbasha et al., 2023). However, it is noteworthy that there have been few studies to explore the effects of WFCs on loneliness. Adolescent loneliness, disruptive family environment, or decreased familial cohesion were found to be associated with a greater sense of loneliness among adolescents (Johnson et al., 2001). In the context of telework, the disconnection from a conventional workspace has resulted in individuals feeling isolated from a social group (i.e., workplace social relationships). Hence, with evidence from earlier literature, WFC may result in straining relationships between individuals and family members, resulting in social avoidance due to the strain in familial relationships, leading to a greater sense of loneliness. Hence, it is logical to refer that WFC, which reduces familial cohesion, may increase individuals' loneliness. Thus, this study proposes that:

H2. WFC is positively associated with loneliness.

There has been a growing focus on mental health issues in multiple fields, and mental health is not just about mental illnesses (Lamers et al., 2011). Mental health refers to "a state of well-being in which the individual realizes his or her abilities, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to his or her community" (World Health Organization, 2004, p. 12). The definition of mental health was built upon the two main traditions of defining how well a life is lived (Deci & Ryan, 2008). The hedonic tradition focuses on well-being consisting of happiness and pleasant emotions, which is reflected by a research stream on emotional well-being (Lamers et al., 2011). Additionally, emotional well-being includes a cognitive appraisal of satisfaction with life in general (Keyes, 2009). On the other hand, the eudemonic tradition focuses on optimal psychological functioning of life which is often evaluated by using psychological well-being and social well-being, reflecting the extent in which an individual perceives themselves as functioning well in life (Lamers et al., 2011). To understand the individuals' satisfaction with life in general, this study focuses on the emotional well-being of the individual.

Research on telework suggests that WFCs and loneliness pose significant health risks that may be more intense than those in physical workplaces (Carnevale & Hatak, 2020). Previous work demonstrated that high levels emotional and psychological strains from WFC have direct and indirect negative effects on individuals' well-being (Chuang et al., 2024). With loneliness negatively affecting individuals' psychological health resulting in stress and anxiety, such negative emotions from loneliness inadvertently leads to reduced pleasant emotions, and hence, lower emotional well-being (Owczarek et al., 2022). With the above evidence, this study proposes the following hypotheses:

H3. WFC is negatively associated with emotional well-being.

H4. Loneliness is negatively associated with emotional well-being.

Our proposed conceptual model is shown in **Figure 1**. As videoconferencing has become a popular and enduring mode of communication, it is crucial to explore how long-term use and the accompanying VF may affect individuals over time. To address this gap, we designed a longitudinal study to examine the effects of VF on social and emotional outcomes. More specifically, we hope to shed light on how VF as a form of technostress would strain family relationships and consequently affect their emotional responses and well-being. Furthermore, as extant studies demonstrated that women tended to feel more VF compared to their

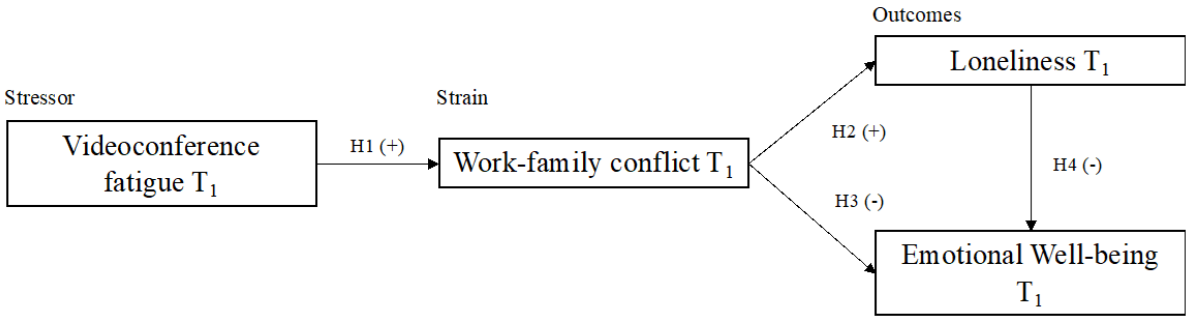

Figure 1. Proposed conceptual model (Source: Authors)

male counterparts (Fauville et al., 2021; 2023; Pennington et al., 2022; Shockley et al., 2021), this study hopes to further elucidate if such gendered differences remained across time. With the longitudinal design, this study contributes to theory by elucidating the prolonged effects of VF and the possibility of a cyclic effect with WFC over time. With the above context of the study, we propose the following research questions (RQs):

1. **RQ1.** Do VF, WFC, loneliness, and well-being remain stable across time?
2. **RQ2.** What are the cross-lagged relationships of VF, WFC, loneliness, and well-being across time?
3. **RQ3.** Are there any gender differences in work-from-home outcomes across time?

METHOD

Procedure

A two-wave online panel survey was conducted in Singapore in 2021 and 2022 to understand the internet consumption patterns of its residents and non-residents. Respondents were recruited from an online panel managed by a local market research firm. Quota sampling, according to Singapore's population census in 2020, was employed to ensure the demographic representativeness of the sample. Time 1 (T1) survey (N = 800) was conducted in July 2021, while the time 2 (T2) survey was conducted in December 2022. Of the original T1 respondents, 203 also completed T2. Respondents had an average age of 42.7 years (standard deviation [SD] = 11.1) at T2, of which 88 were female (43.3%). The sample identified as 91.6% Chinese, 5.4% Malay, 2.0 % Indian, and 1.0% Others. On average, respondents spent 3.78 hours daily on videoconferencing at T1. The hours dropped to 1.92 hours daily at T2.

The study was approved by the Institutional Review Board at Nanyang Technological University. Participation was completely voluntary. Informed consent was first sought from the respondents prior to data collection, and at the end of the data collection at T1, for their consent to invite the respondents for a second round of data collection at T2. The market research firms provided remuneration to the respondents as points redeemable for vouchers for completing both surveys.

Measures

Respondents were asked to fill out the number of days they spent in a typical week working from home (mean [M_{T1}] = 3.35, SD_{T1} = 1.99; M_{T2} = 2.35, SD_{T2} = 1.93), and the number of hours they spent in a day using videoconferencing tools (M_{T1} = 3.78, SD_{T1} = 3.28; M_{T2} = 1.92, SD_{T2} = 2.30).

VF was measured using an abridged version with two items that were developed for this study, based on the psychological dimensions of VF that were described in other studies (Bennett et al., 2021; Li & Yee, 2023). The items ("I feel like I have to attend more videoconferences than I would like to" and "I often feel overloaded with communication from videoconferencing") were measured on a five-point Likert scale and averaged to form an overall score for VF (M_{T1} = 3.16, SD_{T1} = 0.98, α_{T1} = 0.80; M_{T2} = 3.28, SD_{T2} = 0.95, α_{T2} = 0.71).

WFC was measured using four items adapted from Carlson et al. (2000) and slightly rewarded to fit the context of working from home. This measure has been employed and validated by previous studies (Golden, 2012; Li et al., 2022a). Items, for example, "Due to all the pressures from work-from-home, sometimes I am too stressed to do the things I enjoy," and "I have to miss family activities due to the amount of time I must

Table 1. Summary of descriptive statistics and correlations

	M	SD	1	2	3	4	5	6	7	8
1. VF T1	3.16	0.98	1	.609**	.243**	-0.037	.414**	.391**	.230**	-.184**
2. WFC T1	3.26	0.87	.609**	1	.293**	0.002	.561**	.410**	.325**	-0.065
3. Loneliness T1	2.79	1.00	.243**	.293**	1	-.240**	.243**	.235**	.655**	-.199**
4. Emotion well-being T1	3.46	0.78	-0.037	0.002	-.240**	1	0.066	-0.017	-0.123	.540**
5. VF T2	3.21	0.91	.414**	.561**	.243**	0.066	1	.588**	.370**	0.009
6. WFC T2	3.28	0.95	.391**	.410**	.235**	-0.017	.588**	1	.315**	-0.049
7. Loneliness T2	2.77	1.01	.230**	.325**	.655**	-0.123	.370**	.315**	1	-0.120
8. Emotion well-being T2	3.47	0.79	-.184**	-0.065	-.199**	.540**	0.009	-0.049	-0.120	1

Note. **Correlation is significant at the 0.01 level (2-tailed)

Table 2. Autoregressive links between key variables from T1 to T2

VCF autoregressive links	β
VCF T1 --> VCF T2	.210**
WFC T1 --> WFC T2	.360***
Loneliness T1 --> Loneliness T2	.600***
Emotional well-being T1 -> Emotional well-being T2	.520***

spend on work-from-home responsibilities", were also measured on a five-point Likert scale and averaged to form an overall score for WFC (M_{T1} = 3.26, SD_{T1} = 0.87, α_{T1} = 0.90; M_{T2} = 3.21, SD_{T2} = 0.91, α_{T2} = 0.87).

Loneliness was measured with the three-item scale derived from Hughes et al. (2004). Items (e.g., "How often do you feel left out?" and "How often do you feel isolated from others?") were measured on a five-point scale (1 = Never, 5 = Very Often). Items for each wave were averaged to form the respective score (M_{T1} = 2.79, SD_{T1} = 1.00, α_{T1} = 0.91; M_{T2} = 2.77, SD_{T2} = 1.01, α_{T2} = 0.91).

Emotional well-being was measured using the mental health continuum-short form (Lamers et al., 2011) and consists of three items measured on a five-point Likert scale (1 = never, 5 = very often), (e.g., "During the past month, how often do you feel happy?"). Items for each dimension were averaged to form the respective score for emotional well-being (M_{T1} = 3.46, SD_{T1} = 0.78, α_{T1} = 0.87; M_{T2} = 3.47, SD_{T2} = 0.79, α_{T2} = 0.86). A summary of the descriptive statistics and correlations of the key variables are presented in **Table 1**.

RESULTS

Confirmatory factor analysis was first conducted to analyze how well the observed indicators measure the latent variables and explore the distinctiveness between variables. Results showed a good fit (χ^2/df (331.219/224; p < .001) = 1.479, CFI = .965, TLI = .953, RMSEA = .049). Structural equation modelling (SEM) using AMOS (v.23) was then performed on a cross-lagged model that allows testing the effect of a variable measured at an earlier time point on another variable measured later point, accounting for the stability of each variable over time (Finkel, 1995). The use of the cross-lagged model also allowed us to answer **RQ1** by testing autoregressive links between variables to measure the stability of the construct over time. The error terms among the variables were allowed to covary in the models. We treated all model components as observed variables and controlled demographic factors (age and gender) to exogenous variables. The cross-lagged model below had acceptable model fit according to Hu and Bentler's (1999) cut-off values for acceptable structural model fits (χ^2/df (50.452/24; p < .001) = 2.102, CFI = .982, TLI = .958, RMSEA = .074).

Testing the autoregressive relationships (in orange) on the VF, WFC, loneliness, and emotional well-being illuminates whether these constructs were stable from one measurement point to the next point. The stability coefficients for the variables were all positive and statistically significant from T1 to T2 (p < .01). The results provided answers to **RQ1**, revealing that these variables were stable across time (see **Table 2**).

Testing for cross-sectional links (**Table 3**) of the variables in the model, the results showed that at T1, VF has a significant positive effect on WFC (β = .61, p < .001). WFC was found to only have a significant positive effect on loneliness (β = .29, p < .001), but not for emotional well-being. Loneliness at T1 was detected to have a significant negative relationship on emotional well-being at T1 (β = -.26, p < .001). For cross-sectional relationships at T2, VF was detected to have a significant positive effect on WFC (β = .42, p < .001). While no statistically significant relationship was found between WFC and emotional well-being at T2, significant

Table 3. Cross-sectional links between key variables

VCF cross-sectional links	β
VCF T1 --> WFC T1	.610***
WFC T1 -> Loneliness T1	.290***
WFC T1 -> Emotional well-being T1	.080 ns
Loneliness T1 --> Emotional well-being T1	-.260***
VCF T2 --> WFC T2	.420***
WFC T2 -> Loneliness T2	.210***
WFC T2 -> Emotional well-being T2	.049 ns
Loneliness T2 --> Emotional well-being T2	-.017 ns

Table 4. Cross-lagged links between key variables from T1 to T2

VCF cross-lagged links	β
VCF T1 --> WFC T2	.020 ns
VCF T1 --> loneliness T2	-.034 ns
VCF T1 --> emotional well-being T2	-.200**
WFC T1 --> VC Fatigue T2	.260**
WFC T1 --> loneliness T2	.053 ns
WFC T1 --> emotional well-being T2	.046 ns
Loneliness T1 --> VC Fatigue T2	.110 ns
Loneliness T1 --> WFC T2	.055 ns
Loneliness T1 --> emotional well-being T2	-.041 ns
Emotional well-being T1 -> VCF T2	.023 ns
Emotional well-being T1 -> WFC T2	.086 ns
Emotional well-being T1 -> loneliness T2	0.006 ns

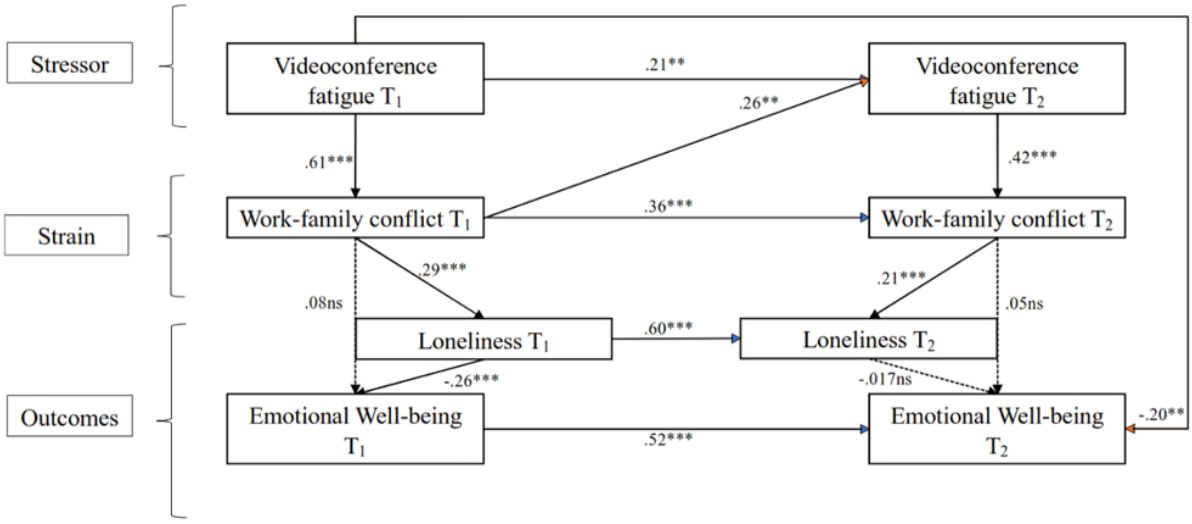

Figure 2. Final model showing relationships between T1 and T2 (Source: Authors)

positive relationship was found between WFC and loneliness at T2 (β = .21, p < .001). No statistically significant relationship was identified between loneliness and well-being at T2.

Finally, for testing for cross-lagged links of the variables in the model (**Table 4**), WFC at T1 was found to have a significant effect on VF at T2 (β = .26, p < .01). VF at T1 has a significant cross-lagged effect on emotional well-being at T2 (β = -.20, p < .01). No other cross-lagged relationships were detected to be statistically significant. The final structural model is shown in **Figure 2**.

Mediation Analyses

Based on the cross-lagged links, serial mediation analyses were conducted using PROCESS macro (Model 6) for SPSS (Hayes, 2013), with age and gender entered as covariates to identify any significant mediation effect. The model tested two different parts of the overall model. First to address **RQ2**, we tested serial mediation from VF at T1 to WFC at T1 to VF at T2 and finally to WFC at T2. Holistically, the bias-corrected bootstrap 95% confidence for the indirect effect did not include zero (b = .34, SE = .062, 95% CI = .22 to .46),

Table 5. Results of serial mediation analyses

Antecedent	Coefficient	SE	p	Bootstrap 95%	
				Lower	Upper
		M1 (WFC T1)			
Age	-0.008	0.004	0.076	-0.017	0.001
Gender (1 = male, 2 = female)	-0.109	0.098	0.269	-0.303	0.085
X (VF T1)	0.520	0.050	< 0.001	0.420	0.619
Constant	2.115	0.321	< 0.001	1.481	2.748
	R^2 = 0.384, F (3, 199) = 41.260, p < 0.001				
		M2 (VF T2)			
Age	-0.009	0.006	0.115	-0.020	0.002
Gender (1 = male, 2 = female)	0.134	0.122	0.275	-0.107	0.374
X (VF T1)	0.209	0.077	0.007	0.057	0.361
M1 (WFC T1)	0.290	0.088	0.001	0.117	0.462
Constant	1.858	0.438	< 0.001	0.994	2.721
	R^2 = 0.216, F (4, 198) = 13.640, p < 0.001				
		y (WFC T2)			
Age	-0.010	0.004	0.030	-0.018	-0.001
Gender (1 = male, 2 = female)	0.056	0.095	0.559	-0.132	0.244
X (VF T1)	0.013	0.061	0.836	-0.108	0.133
M1 (WFC T1)	0.382	0.070	< 0.001	0.244	0.521
M2 (VF T2)	0.391	0.056	< 0.001	0.282	0.501
Constant	0.971	0.357	0.007	0.267	1.675
	R^2 = 0.483, F (5, 197) = 36.790, p < 0.001				

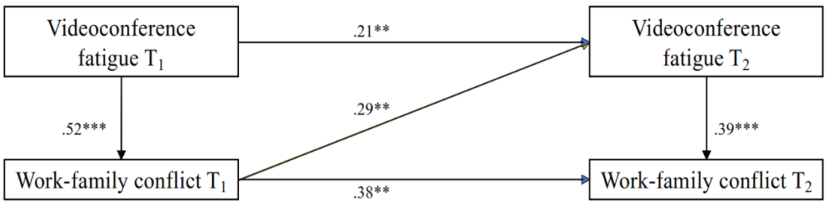

Figure 3. Results of serial mediation from VF and WFC at T1 to VF and WFC at T2 (Source: Authors)

while the bias-corrected bootstrap 95% confidence for the direct effect included zero (*b* = .013, *SE* = .061, 95% CI = -.108 to .133), thereby supporting the serial mediation model. A summary of the unstandardized regression coefficients and model information is presented in **Table 5** and **Figure 3**, respectively.

The second model then tested the serial mediation on the cross-lagged effects of videoconferencing via loneliness and well-being at T1 on well-being at T2. More specifically, we tested the serial mediation from VF at T1 to WFC at T1 to loneliness at T1, emotional well-being at T1 and finally to emotional well-being at T2. When emotional well-being T2 is set as the dependent variable, both the bias-corrected bootstrap 95% confidence for the indirect effect (*b* = -.016, *SE* = .01, 95% CI = -.041 to -.001) and the bias-corrected bootstrap 95% confidence for the direct effect from VF at T1 did not include zero (*b* = -.15, *SE* = .059, 95% CI = -.26 to -.031), supporting the serial mediation model. These results are presented in **Table 6** and **Figure 4**.

Multigroup Analysis

As prior studies have indicated that women tend to more affected by VF (Fauville et al., 2021, 2023; Shockley et al., 2021), we used multigroup analysis in SEM to test for group differences in path coefficients involving latent variables. We group the sample into the two genders: male (*n* = 115) and female (*n* = 88). Configural invariance achieved acceptable model fit (CFI = .946, TLI = .930, RMSEA = .043, $\chi 2$/df = 1.37, $\chi 2$ = 634.72, df = 464). Comparing the measurement weights of the unconstrained and constrained models, there was a non-significant difference (CMIN =16.152, df = 16, *p* = .442), indicating measurement invariance across the two groups. To identify group differences in path coefficient strengths, we then constrained individual paths in the model (i.e., cross-group equality constraints), comparing each constrained model against the baseline model. Significant chi-square change indicates model fit improvement with a model that allows a path coefficient to change between groups. Several pathways were identified to be different between genders.

Table 6. Results of serial mediation analyses

Antecedent	Coefficient	SE	p	Bootstrap 95%	
				Lower	Upper
M1 (WFC T1)					
Age	-0.008	0.004	0.076	-0.017	0.001
Gender (1 = male, 2 = female)	-0.109	0.098	0.269	-0.303	0.085
X (VF T1)	0.520	0.050	< 0.001	0.420	0.619
Constant	2.115	0.321	< 0.001	1.481	2.748
R^2 = 0.384, F (3, 199) = 41.260, p < 0.001					
M2 (loneliness T1)					
Age	-0.019	0.006	0.002	-0.031	-0.007
Gender (1 = male, 2 = female)	0.156	0.133	0.243	-0.106	0.419
X (VF T1)	0.087	0.084	0.302	-0.080	0.253
M1 (WFC T1)	0.235	0.096	0.015	0.046	0.424
Constant	2.329	0.479	<.001	1.384	3.273
R^2 = 0.143, F (4, 198) = 8.248, p < 0.001					
M3 (emotional well-being T1)					
Age	0.001	0.005	0.863	-0.009	0.011
Gender (1 = male, 2 = female)	-0.091	0.109	0.403	-0.306	0.124
X (VF T1)	-0.028	0.069	0.689	-0.163	0.108
M1 (WFC T1)	0.084	0.079	0.288	-0.072	0.240
M2 (loneliness T1)	-0.197	0.058	<.001	-0.311	-0.082
Constant	3.915	0.413	<.001	3.101	4.730
R^2 = 0.068, F (5, 197) = 2.868, p = 0.016					
y1 (emotional well-being T2)					
Age	0.007	0.004	0.128	-0.002	0.015
Gender (1 = male, 2 = female)	0.164	0.094	0.081	-0.021	0.349
X (VF T1)	-0.148	0.059	0.013	-0.264	-0.031
M1 (WFC T1)	0.077	0.068	0.261	-0.058	0.211
M2 (loneliness T1)	-0.027	0.051	0.593	-0.128	0.074
M3 (emotional well-being T1)	0.535	0.061	< 0.001	0.415	0.656
Constant	1.395	0.428	0.001	0.551	2.238
R^2 = 0.339, F (6, 196) = 16.764, p < 0.001					

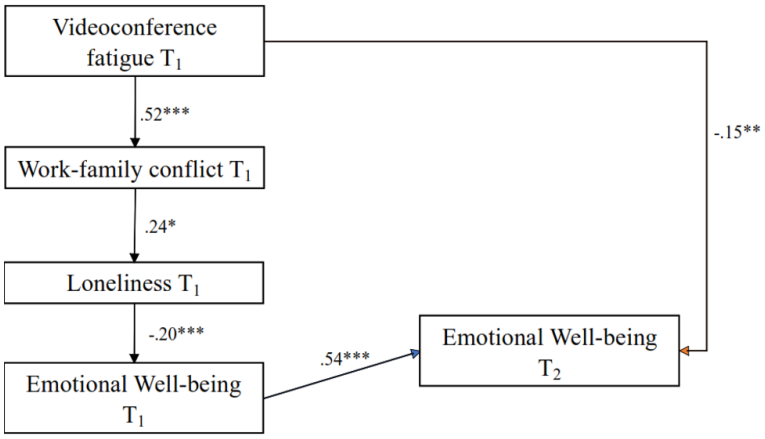

Figure 4. Results of serial mediation from VF and WFC at T1 to Emotional well-being at T2 (Source: Authors)

First, the two groups differed in the cross-lagged effects of videoconferencing at T1 on WFC at T2 ($\chi 2$ = 9.01, p = .003). Videoconferencing at T1, has a positive impact on WFC at T2 for male respondents (b = .222, p < .01) but no significant effect was identified amongst female respondents (b = -.16, p > .05) and for the whole sample (b = .020, p > .05). Second, VF at T1 has a significant negative effect on emotional well-being at T2 ($\chi 2$ = 8.64, p = .003). This effect is pronounced among female respondents (b = -.439, p < .001), but no significant effect was observed among male respondents (b = .052, p > .05).

Both groups also differed in their effects of loneliness on emotional well-being at T2. Interestingly, males were found to have a significant effect of loneliness at T2 on emotional well-being at T2 ($\chi 2$ = 8.09, p = .004; b = -.199, p < .05) but not for females (b = .250, p > .05) and the overall sample (b = -.017, p > .05). There was

significant difference in both groups in the autoregressive relationship of emotional well-being at T1 to emotional well-being at T2 ($\chi 2$ = 8.44, p = .004). More specifically, males exhibited a stronger effect of emotional well-being at T1 to T2 (b = .654, p < .001) than females (b = .379, p < .001) and the overall sample (b = .52, p < .001).

DISCUSSION

While virtual and hybrid work formats have brought upon greater flexibility, convenience, and other benefits to both employees and organizations, there are side effects to remote work on WFC, loneliness (Carnevale & Hatak, 2020), and individuals' well-being (Chuang et al., 2024). Based on the SSO framework, the current study focused on VF as a stressor in remote work during, and hybrid work formats after the pandemic to understand its cross-sectional and time-lagged effects on WFC, loneliness, and emotional well-being.

Our findings provided answers for **RQ1**. Through significant autoregressive links, all variables remained stable across time, which also determined the stability of the SSO framework in both waves. More specifically, looking at cross-sectional findings in both waves, VF aggravated WFC, which increased the individuals' sense of loneliness in both waves. Moreover, findings showed that loneliness negatively affected emotional well-being of individuals. While unlike prior studies where WFC was found to negatively affect individuals' well-being (Carnevale & Hatak, 2020), our findings did not find that WFC have direct effects on individuals' emotional well-being in both waves. Instead, we found that loneliness is a significant mediator on the relationship between WFC and individuals' emotional well-being for T1. This finding is supported with prior evidence, increased WFC led to greater sense of loneliness felt within individuals (Johnson et al., 2001), which negatively affects individual emotional well-being (Owczarek et al., 2022). The above findings suggest that loneliness is a key outcome within the SSO framework, highlighting the social and psychological effects of VF through WFC in the advent of virtual and hybrid work formats.

Looking at the cross-lagged relationships (**RQ2**), our findings identified that WFC at T1 affected VF at T2. The validation from this first serial model tested warrants future studies investigating a possible cyclic relationship between VF and WFC over time. This finding shows that, in addition to chronemic, technical, psychological, and organizational factors that lead to VF, through time, social factors such as WFC worsen VF, which further strains WFC later, and ultimately leads to a greater sense of loneliness felt among individuals. As compulsory remote work transitions into hybrid work formats, loneliness does not affect individuals' emotional well-being due to loneliness being alleviated with the social interactions in the individuals' life after lockdown. Our findings can also be presented as a comparison between remote work and hybrid work formats, highlighting that hybrid work formats may bring more benefits than remote work, as a possible form of coping behavior to alleviate strains and their negative effects. Additionally, the significant negative effect of VF at T1 on emotional well-being at T2 is noteworthy. Going beyond the SSO framework and current studies on VF, the findings highlighted the prolonged negative effect of VF on emotional well-being. The continual VF brings exhaustion affect the individual's emotions, physiology, behaviors, and social relationships (Khan, 2021; Shagirbasha et al., 2023), can ultimately reduce overall satisfaction in life, which is measured through the individual's emotional well-being in this study.

Our study has addressed **RQ3**, highlighting gender differences in the effects of VF, which has been investigated by prior literature. First, our findings confirmed that VF has a more pronounced effect on women than men, especially with the lagged effect of VF during T1 on women's emotional well-being in T2, which concurs with existing research (Fauville et al., 2023) on women feeling greater VF and hence, resulting in more prolonged effects than their male counterparts. Second, we identified that male counterparts feel greater WFC at T2 due to a lagged effect of VF at T1. Third, not significant in the overall sample, the multigroup analysis found that loneliness felt by male respondents at T2 has a significant negative effect on their emotional well-being at T2. While remote work has led to greater stress on female respondents due to their need to juggle both work and familial roles, the reopening of conventional workspaces and hybrid work formats may result in women heading back to the office, where there are greater chances of social interactions in physical settings. These social interactions may include casual conversations (e.g., small talk or lunch chats) and non-verbal communication, such as facial expressions and bodily movements, signaling social approval. Therefore, hybrid-style working formats may foster social interconnectedness, and thus a potential relief from loneliness.

However, as working women return to the office, the juggling of work and home may be borne by their partners. This finding supports existing studies on the general shift toward more egalitarian divisions of household labor, where both genders may feel an overall increase in household responsibilities and be affected by VF and the consequences of it (Chung et al., 2023). Current research has either found women feeling greater effects of VF or indicated inconclusive gendered differences (Fauville et al., 2023), the two-wave panel results allowed a more nuanced understanding on time-lagged effect of VF felt between both genders.

Study Implications and Future Research

This study extends current literature on VF. Existing studies have explored the various antecedents–frequency, duration, technical factors, and outcomes–physical tiredness, mental, and social strains of VF. Focusing on the Singapore context, this study used a two-wave panel and found support for the link between VF, WFC, loneliness, and emotional well-being based on the SSO framework, providing empirical evidence with a longitudinal study beyond the cross-sectional design that most studies have been based on. As videoconferencing tools remain actively utilized in existing work formats, this study has contributed to the current understanding of the time-lagged direct and indirect effects of VF on individual's emotional well-being. Results analyzed from the two-wave panel data offers insights to both academics and practitioners by allowing exploratory comparison between different work formats (i.e., compulsory remote work during pandemic vs. hybrid work format in post-pandemic) and that may influence effects of VF. In practical terms, this can mean that a hybrid work format may be more beneficial than a full remote work format, allowing space for actual social interactions beyond the home space, which are beneficial in alleviating loneliness felt by individuals. Should a crisis that calls for compulsory remote work happen again, organizations could make use of functions on virtual working tools or videoconferencing tools that allow for social interaction, for example, the use of avatars to minimize constant self-monitoring/ focused attention or hyper-gaze effects that are known to expend cognitive effort, driving mental fatigue. Likewise, the introduction of virtual coffee breaks to reduce meeting load and performative pressure may buffer stress and cognitive energy depletion. Moreover, the enforced informal time sessions in the breaks may also encourage informal interactions, thereby reducing social-evaluative pressure, which can alleviate loneliness which has been found to have downstream effects on emotional well-being.

In addition, this study employed the SSO framework, introducing VF as a technostress, WFC as a techno-strain in response to VF, and loneliness and emotional well-being as outcomes. While previous studies have often investigated how workplace isolation and loneliness during the pandemic has affected WFC, our study demonstrated that VF through WFC actually aggravates loneliness, which negatively affects individuals' emotional well-being across time. This study has answered the call for further research on loneliness in remote and hybrid work context (Carnevale & Hatak, 2020), highlighting the importance of loneliness as a key outcome and mediator in our research framework. Our study, thus, expanded the concept of VF beyond psychological outcomes, but negative social and mental outcomes, manifested through strains from a blurred work-family context and mental well-being of the individual.

Nevertheless, this study has several limitations that requires caution when interpreting our findings. First, the context of our study may have limited our sample to those who are only users of videoconferencing tools and respondents who work from home (fully remote and hybrid), despite collecting our data from a national sample that is representative of the demographic distribution of the Singapore adult population. Our data is also dependent on respondents' self-report measures on their personal experiences, habits, and perceptions. Hence, future research can build on our findings with other methodological approaches. Second, it has proposed a possible cyclic relationship between VF and WFC through time. The use of a two-wave panel, along with other variabilities that may confound the findings, may limit the validity of the cyclic relationship. Thus, further studies can consider an experimental approach in collaboration with industrial partners to undergo a panel study of more than three waves to confirm this relationship. Finally, in this paper we focused on the emotional aspect of well-being. As holistic well-being also includes social and psychological well-being, future research can examine how other aspects of well-being are affected by VF and its associated after effects.

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