From frequency to fatigue: Exploring the influence of videoconference use on videoconference fatigue in Singapore

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A B S T R A C T

The use of videoconferencing platforms has increased drastically as a result of the COVID-19 pandemic. As a result of work-from-home orders, many employees found themselves attending meetings through virtual communication technologies instead of usual face-to-face discussions. As employees spend more time on videoconferencing, there have been increasing concerns of users affected by an occurrence we define as *videoconference fatigue* (VF). In this study, we explore the link between frequency of videoconferencing and VF. We further explore videoconference users' satisfaction with their internet connection as a moderator of this relationship. We study these in the context of the Technology Acceptance Model (TAM), which provides a framework for us to understand the factors leading to VF. A survey was conducted in Singapore with 1145 respondents who use videoconference apps. Results from structural equation modeling supported a model where perceived ease of use of videoconference apps led to perceived usefulness of these apps, which led to an increased frequency of use. There was a significant relationship between frequency of use and feelings of videoconference fatigue, with this relationship moderated by users' perceived satisfaction with their internet connection. When usage frequency is low, having a reliable internet connection helps mitigate the impact of use on VF. However, high levels of usage can override the mitigating impact of internet satisfaction. We discuss the implications of these findings, which lend understanding into potential factors that can result in VF.

Introduction

The use of videoconferencing platforms increased drastically during the COVID-19 pandemic. As a result of work-from-home orders, many employees found themselves attending meetings through virtual communication technologies instead of usual face-to-face discussions. Daily users for Zoom, a popular videoconferencing software, rose from 10 million in December 2019 to more than 300 million in April 2020 (Evans, 2020). As employees spend more time daily on videoconferencing (Brynjolfsson et al., 2020), there have been increasing concerns of users affected by an occurrence we define as *videoconference fatigue* (VF).

VF has been linked to several negative consequences on health and wellbeing (Pathak, 2020), including feelings of tiredness, burnout, and stress (Jiang, 2020; Murphy, 2020). A recent study found that VF can manifest in a few dimensions: physical, emotional, cognitive and social (Li & Yee, 2022). These can include exhaustion (physical), anxiety (emotional), inability to focus (cognitive), and depersonalization

(social).

We have identified two research gaps in current literature on videoconference fatigue. First, despite the rising interest in VF, most studies were conducted in Western countries (e.g., Bennett et al., 2021; Shahrvini et al., 2021; Shockley et al., 2021). To our knowledge, only two other studies were conducted in Asia, in particular Philippines (Oducado et al., 2021a; 2021b). With evidence suggesting that White individuals experience less VF than other groups, including Asians (Fauville et al., 2021a; Ratan et al., 2022), it is important to study the extent of VF and the antecedent factors among Asian populations. Singapore, a small but technologically advanced nation, presents itself as an interesting Asian country to study. 60 per cent of Singaporeans used videoconferencing for business purposes as a result of the pandemic (Zoom Video Communications, 2021), while almost 50 per cent of all Singapore employees worked remotely in 2020 (Ministry of Manpower, 2021). These figures suggest that Singaporeans spend a significant proportion of their time using videoconferencing tools, yet their experience of VF remains a topic that is largely unexplored.

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Second, while some studies suggest a link between videoconference frequency and VF, the propositions have centered on the impact of nonverbal mechanisms and visual cues during videoconference use (Fauville et al., 2021a; 2021b), and how the overall satisfaction with individuals' internet use may amplify or reduce the relationship between frequency of use and fatigue is missing. This is an important point documented by scholars studying technology and impact on mental well-being, as one's communication infrastructure (e.g., access to internet, internet connectivity) are social determinants that will ultimately influence inequities in negative outcomes of technology use among certain populations (Goulbourne & Yanovitzky, 2021; Lee et al., 2022). This is also recognized by scholars studying videoconferencing, and they have noted that user perception of videoconference software and their satisfaction with factors like internet connection are important considerations in their experience of VF (Bennett et al., 2021; Wegge, 2006). Hence in this study, we explore the link between frequency of videoconferencing and VF with these factors in mind. We further explore videoconference users' satisfaction with their internet connection as a moderator of this relationship. We study these relationships in the context of the Technology Acceptance Model (Davis, 1989) (TAM), which provides a framework for us to understand the factors leading to VF. Specifically, perceived ease of use and usefulness of technology are important concepts that may influence the use of videoconferencing software and subsequently on the impact of VF on users.

The objective of the study is twofold: First, to provide deeper understanding of the experience of VF and the contributing factors among Asian populations, with a focus on Singapore. Second, to draw upon TAM as a theoretical framework to investigate the relationships between videoconference use, user perceptions of videoconference technology and experience of VF. We explain our conceptual reasoning and hypotheses development in the following section.

Theoretical framework and hypotheses

TAM provides an important framework to understand the impact of videoconferencing use on VF. The model examines factors that influence user's acceptance of technology. Since the formulation of its theoretical propositions, TAM has been widely applied to examine acceptance or rejection of technology use across different platforms, such as mobile apps, smartphones, and websites like patient portals or e-commerce platforms (Kim et al., 2009; Lunney et al., 2016). According to TAM, two primary factors influence a user's decision to use new technology: (a) perceived ease of use and (b) perceived usefulness, which collectively shape behavioral intentions that lead to technology use.

Perceived ease of use can be defined as the degree to which a person believes that using a particular system would be free of effort or relatively effortless (Beldad & Hegner, 2018). When individuals perceive that a technology is easy to use and navigate, it increases the likelihood of adopting it. Perceived usefulness, on the other hand, is defined as the degree to which a person believes that using a particular system would enhance their life (Beldad & Hegner, 2018). When individuals perceive that a particular technology is useful in improving various aspects of their lives (e.g., work productivity, health), the likelihood of them adopting it will be higher (Kwee-Meier et al., 2016).

Consistent with the original theoretical tenants of TAM, there is a direct relationship between perceived ease of use and perceived usability (Davis, 1989). In the context of using videoconferencing platforms, the more individuals perceive such platforms are easy to use, the more likely they will find it useful. For instance, the exponential growth of *Zoom* during the COVID-19 pandemic, overtaking many longstanding videoconferencing platforms, could be attributed to its navigability, such that it was easy to download and setup, and the ability to facilitate small to large group meetings (Dooley, 2020). Such features appear attractive to companies and organizations that were pivoting from the pre-pandemic face-to-face work to online platforms in a way that were least disruptive. Naturally, when individuals find videoconferencing

platforms easy to use and useful, they will use them more. As such, we postulate:

H1. Perceived ease of use of videoconference software is positively associated with perceived usefulness of videoconference software.

H2. Perceived ease of use of videoconference software is positively associated with frequency of use.

H3. Perceived usefulness of videoconference software is positively associated with frequency of use.

A key antecedent of VF appears to be the frequency of videoconference meetings, where users show signs of VF from prolonged use of videoconferencing software (Wiederhold, 2020). Longer time spent videoconferencing increases the cognitive load on users, as they have to manage the additional burden of producing and interpreting nonverbal cues, which eventually leads to exhaustion (Bailenson, 2021; Fauville et al., 2021a). Hence, we propose the following hypothesis:

H4. Perceived frequency of use of videoconference software is positively associated with videoconference fatigue.

However, besides frequency of use, an important factor that may affect VF is satisfaction with, or frustration over, the reliability of internet facilities. Indeed, technical issues such as connection and latency problems have been identified as a potential factor that can aggravate the experience of VF (Li & Yee, 2022). Meetings can be terminated and important pieces of dialogue can be misheard or unheard at all as a result of unstable internet connections or poor internet speeds. This can affect the levels of emotions, frustration and fatigue from videoconferencing use (Bennett et al., 2021; Wegge, 2006). Recent studies have found that frustration from unstable internet connections and technical issues may result in exhaustion (Robert Half International, 2020; Rump & Brandt, 2020). Therefore, we believe the level of satisfaction users have with their internet connection may play a role in the influence of videoconferencing frequency on VF and propose the following hypothesis:

H5. Satisfaction with internet connection moderates the relationship between frequency of videoconference software use and videoconference fatigue.

Fig. 1 presents the conceptual model and proposed hypotheses.

Method

Data collection and sample

The study was approved by the Institutional Review Board of Nanyang Technological University. An online nationwide survey was conducted in Singapore in December 2020. A total of 1606 responses was collected, of which 1145 respondents (525 females - 45.9%; $M_{age} = 38.8$, $SD = 10.7$) who had indicated that they used videoconferencing apps before as well as answered all questions were shortlisted for analysis in this study. Respondents were at least 21 years old, and were either citizens (82.0%), permanent residents (13.5%), or foreigners (4.5%) residing in Singapore. To account for the multi-racial society in Singapore, our sample contains responses from different racial groups: Chinese (75.5 per cent), Malay (13.9 per cent), Indians (6.1 per cent) and other races (4.5 per cent). Most respondents in the sample (64.0 per cent) reported that they were earning a personal income between S$2000 and S$7000. On average, respondents reported that they spent about three days working from home ($M = 3.23$, $SD = 1.99$) in a typical week and spending about 9 h each day working ($M = 8.81$, $SD = 3.43$).

Procedures and measures

Informed consent was sought from the respondents prior to their attempt of the survey. Participation in the survey was entirely voluntary. Respondents first answered some screener questions to ensure that they
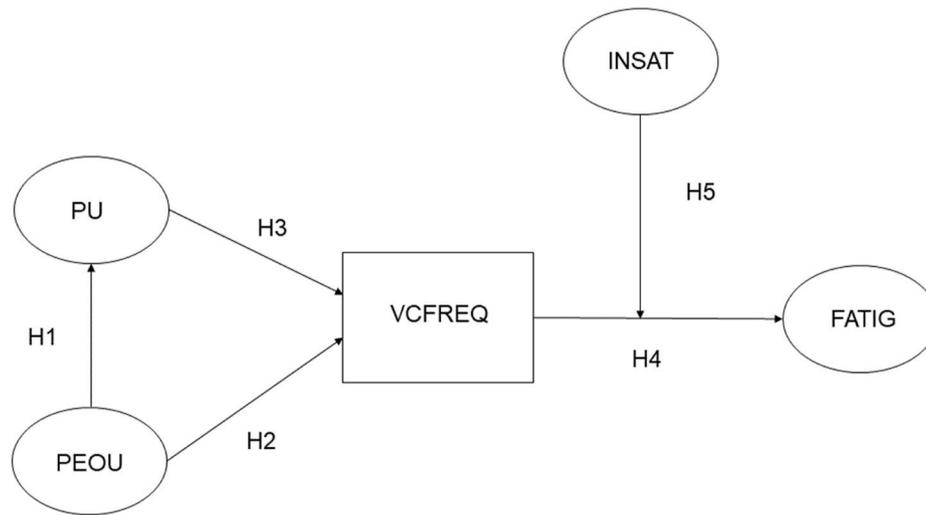
Fig. 1. Conceptual model and proposed hypotheses. PEOU – Perceived ease of use of videoconference applications, PU – Perceived usefulness of videoconference applications, VCFREQ – Frequency of videoconference use, INSAT – Satisfaction with Internet connection, FATIG – Videoconference fatigue.

are eligible to participate. Next, they answered questions pertaining to the key measures for this study. The respondents completed the survey by answering some demographic profile questions. They were remunerated by the polling company for completing the entire survey. Table 1 summarizes the descriptive statistics for the key variables measured in this study.

To measure respondents' frequency of use of videoconferencing apps in a typical week (VCFREQ), respondents were asked to rate, on a 5-point scale, from "1 = *Never*" to "5 = *Very often*" on how often they use different brands of videoconferencing apps which are popular in Singapore (e.g., *Zoom, Microsoft Teams*). Scores for the six items were summed to develop an additive score ($M = 17.5$, $SD = 4.81$).

Both perceived ease of use (PEOU; $M = 3.76$, $SD = 0.66$, $\alpha = 0.83$)

and perceived usefulness (PU; $M = 3.63$, $SD = 0.65$, $\alpha = 0.72$) of videoconferencing apps are each measured with three items (Davis, 1989) using a 5-point scale: from 1 = '*Strongly agree*' to 5 = '*Strongly disagree*'. As no established scale of VF was yet available when the study was conducted (e.g., Fauville et al., 2021b), we relied heavily from research in social media fatigue and exhaustion (Bright et al., 2015; Cramer et al., 2016), which examined how high usage is associated with an individual's sense of being overwhelmed with information. Hence, videoconference fatigue (FATIG; $M = 3.21$, $SD = 0.92$, $\alpha = 0.85$) was measured with three items on a 5-point scale, adapted from Nawaz et al. (2018). Satisfaction towards internet connection (INSAT) was measured with three items relating to respondents' satisfaction towards internet reliability, speed, and coverage ($M = 3.78$, $SD = 0.76$, $\alpha = 0.85$) using a 5-point scale: from 1 = '*Very dissatisfied*' to 5 = '*Very satisfied*'. In addition to the key variables as mentioned above, control variables, such as gender, age, hours spent on work, number of days working from home in a typical week as well as personal income level were also included in this study.

Analysis & results

Prior to the main analyses in this study, we checked for discriminant validity between the constructs. To test for discriminant validity, the square roots of the average variance extracted (AVEs) for each of the latent constructs were compared with their correlation coefficients (Fornell & Larcker, 1981). As observed in Table 2, the values of the square root of AVEs are greater than the correlation coefficients, indicating sufficient discriminant validity between the latent constructs. We adopted the Heterotrait-Monotrait (HTMT) criterion (Henseler et al., 2015) to further confirm our test results for discriminant validity. As observed in Table 3, the HTMT values are less than 0.90, indicating discriminant validity between the constructs. Further, these constructs also demonstrated convergent validity (see Table 4) as their Cronbach's alpha (α) values are greater than 0.70, with outer loadings of greater

Table 1
Descriptive statistics for key variables.

Variable	Items	M	SD	α
VCFREQ	How often do you use each of the following video-conferencing apps in a typical week? (1. Zoom, 2. Facebook messenger, 3. WhatsApp, 4. Microsoft Teams, 5. Skype, 6. Google Hangouts Meet)	17.1	4.86	.75
PEOU	1. I feel comfortable in my ability to use video-conferencing platforms. 2. I find it easy to get video-conferencing platforms to do what I want it to do. 3. Overall, I find video-conferencing platforms easy to use.	3.75	.66	.84
PU	1. Video-conferencing platforms help improve the relationships with my friends, colleagues, and family. 2. Video-conferencing platforms support critical aspects of my learning/work. 3. Overall, I find video-conferencing platforms useful	3.62	.65	.75
FATIG	1. I am frequently overwhelmed by the number of video-conference calls I have to make or attend. 2. I feel drained from activities that require me to use video-conferencing platforms. 3. I feel tired from my video-conferencing calls.	3.18	.93	.85
INSAT	How satisfied are you with the following when connected to the internet? (1. Internet reliability, 2. Internet speed, 3. Internet coverage)	3.77	.76	.86

Note. VCFREQ was additively computed (Min. = 6.0, Max. = 30.0). All items were measured using 5-point scales.

Table 2
Correlation coefficients and square root of AVEs for latent constructs.

	PEOU	PU	FATIG	INSAT
PEOU	**.79**			
PU	.64***	**.66**		
FATIG	.10***	.22***	**.82**	
INSAT	.30***	.25***	- .008	**.81**

Note. ***$p < .001$. Square root of the AVEs is presented in the diagonals.

Table 3
Heterotrait-monotrait ratio of correlations for latent constructs.

	PEOU	PU	FATIG	INSAT
PEOU	**1.00**			
PU	.83	**1.00**		
FATIG	.11	.27	**1.00**	
INSAT	.36	.32	.052	**1.00**

Table 4
Composite reliability, average variance extracted, and outer loadings of latent constructs.

Construct	Outer Loadings*	AVE	Alpha
PEOU	PEOU_1 = .81	.62	.83
	PEOU_2 = .80		
	PEOU_3 = .70		
PU	PU_1 = .53	.44	.75
	PU_2 = .63		
	PU_3 = .73		
FATIG	FATIG_1 = .94	.68	.85
	FATIG_2 = .68		
	FATIG _3 = .60		
INSAT	INSAT_1 = .83	.66	.85
	INSAT_2 = .85		
	INSAT_3 = .74		

Note: * Standardized loadings.

than 0.50.

To test the hypotheses, the responses were subjected to structural equation modeling, using a data analytics software, *R (Lavaan package)*, version 3.6. This research chooses to use the covariance-based SEM approach because of the strong theoretical focus in this research. According to Roldán and Sánchez-Franco (2012), this approach is preferable especially when the research model is oriented toward how constructs and indicators would relate to one another in a theoretical model (in this case, the TAM). Covariance-based SEM was also employed as the unique variance indicators are estimated – this is not so for variance-based SEM (MacCallum & Austin, 2000). Research also showed that covariance-based SEM is more robust than variance-based SEM when the same size is larger than 250 (Reinartz et al., 2009). SEM analysis was conducted by fitting all key latent constructs and a single observed variable (VCFREQ) in the specified model and running all regressions for the indicated direct effects, simultaneously. Fig. 2 shows the results of the analyses. The fit indices for the structural model demonstrated a good fit: CFI = 0.95, TLI = 0.94, RMSEA = 0.046. The overall Q^2 value is 0.20 (greater than zero), indicating predictive relevance for this structural model.

Consistent with the TAM, perceived ease of use positively influenced perceived usefulness of videoconferencing platforms ($\beta = 0.93$, $p < .001$). Therefore, H1 is supported. However, only a significant positive relationship was detected between perceived usefulness of the videoconferencing platforms and users' frequency of use of videoconferencing platforms ($\beta = .75$, $p < .001$), whereas no significant relationship exists between perceived ease of use on the same observed variable ($\beta = -.39$, $p = .121$), providing support for H3 but not for H2. Nonetheless, it was found that perceived usefulness of the videoconferencing platforms fully mediated the relationship between perceived ease of use and frequency of use of videoconferencing platforms ($\beta = .70$, $SE = 1.19$, $p = .005$). This suggests that one's perceived usefulness of the videoconferencing platforms is integral to one's frequency of usage given that it is easy to use. As expected, increased use of videoconferencing platforms may result in higher level of VF ($\beta = 0.47$, $p < .001$). Therefore, H4 is supported. This relationship holds when controlling for respondents' age ($\beta = -.10$, $p < .001$), gender ($\beta = -0.03$, $p = .248$), personal income levels ($\beta = 0.021$, $p = .472$), number of days they spent working from home in a typical week ($\beta = 0.092$, $p < .001$) as well as the number of hours they spent working in a typical day ($\beta = -0.007$, $p = .793$).

It was hypothesized that the interactive effects between users' videoconferencing frequency and their satisfaction with the internet would positively influence VF (H5). To test this hypothesis, an interaction term was first created in the model by computing the product of the mean-centered items for both variables. The "satisfaction with the internet" variable was treated as a pure moderator. The SEM results showed that this interaction term has a positive effect on VF ($\beta = 0.10$, $p = .002$), providing support to H5. This interaction effect suggests that satisfaction with the internet can strengthen the relationship between frequency of usage of videoconferencing platforms and VF. In other words, one's feeling of satisfaction with the internet may exacerbate the adverse effects of prolonged use of videoconferencing platforms: videoconferencing fatigue.

Discussion

The widespread use of videoconferencing for work as cities around the world went into lockdown during the COVID-19 pandemic has raised concerns over the potentially negative impact of frequent use of videoconferencing tools. Specifically, studies have begun to examine factors
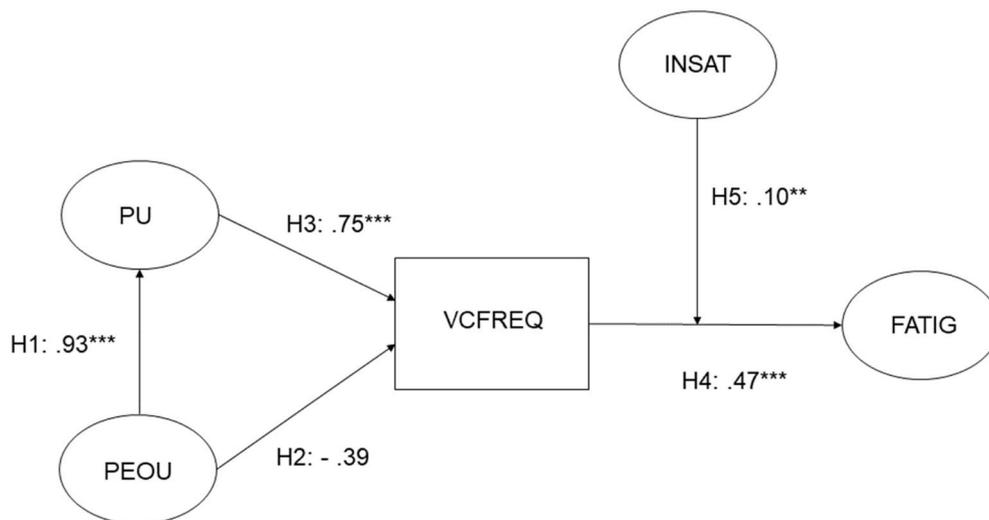

Fig. 2. Final structural model. *Note.* Standardized coefficients (β) were presented. For simplicity paths from the control variables to FATIG were removed. **$p < .01$, ***$p < .001$.

that may lead to VF (Li & Yee, 2022). Guided by the framework of TAM as well as previous work on VF, this current study examined factors that lead to use of videoconferencing as well as VF. To contribute to the expanding work on this area, this study also focused on the potential role of satisfaction with internet facilities in facilitating or mitigating VF.

First, when it comes to explaining frequency of use of videoconferencing tools, the study found that consistent with the literature, perceived usefulness was a significant antecedent. Indeed, those who perceive videoconferencing as useful were likely to use these tools. During the pandemic, when moving around was challenging and many employees were constrained to work from home, videoconferencing proved useful, especially to conduct meetings and coordinate with others. However, the analysis found that perceived ease of use was not a significant antecedent of frequency of use. This study was conducted in December 2020, almost a year after the pandemic hit Singapore. It is plausible that during data collection, the participants were already very much acquainted with videoconferencing tools, that whether or not they perceive these tools are easy to use or not no longer mattered when it comes to using them.

Second, the results also echo concerns about the phenomenon on VF; indeed, frequency of using videoconferencing tools is a strong antecedent of experiencing VF. Thus, it is crucial to examine what factors facilitate or mitigate such link. In this study, we focused on the role of technological infrastructure—specifically the role of satisfaction with internet connection as a potential moderator. The results showed that internet satisfaction was a significant moderator. When usage frequency is low, having a reliable internet connection helps minimize the impact of use on VF. This is important from the lens of communication inequalities, as research has shown that underserved and marginalized populations often bear additional costs of Internet usage that are considered minute from the average working class individual, one of such is known as *connection maintenance cost*–the additional time, energy, and resources the poor need to invest in order to stay reliably connected to their devices (Lee & Viswanath, 2020). If the communication infrastructure of the underserved (e.g., quality of internet connectivity and satisfaction) is lacking to begin with, the use of videoconference may inevitably place additional burden on them as they would face increased fatigue.

In addition, the effects of high levels of usage and internet satisfaction can exacerbate VF. Therefore, future studies should continue to explore other factors that may help cushion the impact of frequent use of videoconferencing tools on the experience of fatigue, as many employees continue to rely on these tools to carry out their daily work routines.

While we did not explicitly test for gender effects, results showed that gender as a covariate was not a significant antecedent of VF. This is notable as previous studies showed that women reported higher levels of VF as compared to men (Fauville et al., 2021a; Ratan et al., 2022). This suggests that gender differences in VF might be a Western phenomenon and may not apply in all cultures. Ratan et al. (2022) proposed that gendered beauty norms might pressure women to conform to these appearance norms, thereby experiencing greater facial dissatisfaction and anxiety when seeing their face continually on videoconferencing platforms. This then results in higher levels of VF among them. Findings from our study suggest that these norms may not be as prevalent in Singapore as compared to Western cultures. That being said, in light of the increasing focus on gendered norms (Liebelt, 2019), future studies examining the impact of VF among Asian countries should include gender as a potential avenue for inquiry.

The findings of this study must be examined in the context of several limitations. First, we only focused on one potential mitigating factor that can lessen VF that has not been sufficiently explored in the current literature on VF. Indeed, the reliability of internet infrastructure can affect user experience with technologies that rely on the internet—which is exactly what we found in this study. However, other factors that can attenuate or exacerbate the adverse impacts of videoconferencing

use need to be uncovered, for us to be able to devise appropriate intervention. Second, this study relied on a national survey involving more than 1600 adult participants; therefore, the data relies heavily on the ability and willingness of the participants to recall and report their experiences and perceptions regarding videoconferencing. Future studies can build on our findings to continue exploring this area by exploring other methods, such as in-depth interviews or even observations, as what individuals say they do and experience may not be always consistent with what they actually do and experience. Third, at the point of study development, there was no established scale measuring VF which we could employ. As such, we adapted a scale from literature on social media fatigue and reworded it to fit the context of our study. More established and validated scales have been introduced since then, for example the Zoom Exhaustion & Fatigue (ZEF) scale by Fauville et al. (2021b). Future work can validate our findings by using the ZEF scale, to test if the significant relationships identified here still hold.

All in all, the results of our study have shown that when studying new technologies such as videoconferencing, it is vital not to impose the old "hypodermic needle" model where we assume that high usage is inherently negatively. Clearly our study demonstrated that an individual's communication infrastructure (i.e., satisfaction with internet) plays an important role in explaining why some may experience fatigue, while others don't. Therein lies an opportunity for communication scholars to further explore what other aspects of individuals' communication infrastructure may amplify or attenuate the use of videoconferencing on fatigue and other mental well-being measures. As such, scholars should pay attention to issues of equity in videoconferencing—as research has shown that the negative impact of technology use is often disproportionately borne by the poor, while those reap the benefits are those with more resources. As such, scholars should drive research to understand the extent of how communication and information environment may function as social determinants of health, and to bring different stakeholders (e.g., policy makers, technology developers, community leaders, organizations, users) to the table to practically address the problems of videoconferencing fatigue from the get-go.

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