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Stress from Digital Work: Toward a Unified View of Digital Hindrance Stressors

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Abstract. There are many models with various sets of hindrance technostressors. Researchers and practitioners face the challenge of selecting a model or mixing several models without guidance on their relative advantages and suitability for contemporary digital work. None of the existing models captures the full conceptual breadth of hindrance technostress, and the existing models typically offer suboptimal power to explain the negative psychological responses or outcomes of technostressors. We synthesize the fragmented works on hindrance technostressors and propose a unified hierarchical model of digital hindrance stressors. We provide an extensive and parsimonious measurement model with high predictive power. This work builds on technostress and occupational stress theory using a quantitative-dominant mixed-methods study. The empirical part of the study includes a qualitative prestudy and multiple surveys with more than 5,800 participants. The data support the modeling, validation, and benchmarking of the new models we introduce. We discuss the relative advantages of the models for research and practice and guide their selection.

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1. Introduction

The way we work is constantly changing, driven by the ongoing advancements of digital technologies and their use. Although digital technology use at work promises benefits in terms of access to information, communication and collaboration, and automation, it can contribute to stress at the individual level. Whereas *challenge* stressors are tied to achieving work-related goals and are often perceived as beneficial, *hindrance* stressors are linked to obstacles to work-related activities and are broadly viewed as harmful (Cavanaugh et al. 2000, Hargrove et al. 2013). Recent literature on technostress has considered this dichotomy (Tarafdar et al. 2019; Benlian 2020, 2022; Califf et al. 2020), but the research on challenge technostress is relatively new. This study builds on the vast body of information systems (IS) research on hindrance technostress (also termed techno-distress; Tarafdar et al. 2019) and focuses specifically on the *adverse effects* of technostressors on individuals' behavior and health. Although stress can arise in any domain of life, we choose to examine technostress in the work context. In contrast to the private context, digital technologies used in the organizational context are work tools without which various work tasks cannot be performed. Employees thus do not have the same freedom of choice regarding their use of technology at work as they do in their private lives. Therefore, our discussions of stress in this paper specifically refer to the *negative aspects of occupational stress.*

The term *technostress* was first coined in the 1980s (Brod 1982, 1984) to describe the human costs associated with the computer revolution. Two decades later, the IS perspective on technostress was shaped by the seminal papers of Tarafdar et al. (2007), Ragu-Nathan et al. (2008), and Ayyagari et al. (2011). The core framework centers on a misfit between the demands of technology and technology-mediated environments and a person's ability to cope with those demands, which leads to the emergence of technostressors, contributing to negative psychological responses and outcomes (Califf et al. 2020) such as poor well-being, exhaustion, strain, burnout, lack of productivity, job satisfaction, and organizational commitment (Tarafdar et al. 2019).

Technostress has been extensively studied in IS research: For example, technostress has been examined in work (Ayyagari et al. 2011, Day et al. 2012) and private life (Maier et al. 2022, Salo et al. 2022) contexts. Studies explored the processes of appraisal and coping (D'Arcy et al. 2014, Salo et al. 2022), inhibitors (Ragu-Nathan et al. 2008, Tarafdar et al. 2011), the psychological responses and outcomes of technostress (Ayyagari et al. 2011, Benlian 2020, Califf et al. 2020), and the implications for IS design (Adam et al. 2017). Central to this research is an understanding of technostressors, the demands placed on individuals by technology that require a change (Tarafdar et al. 2019). Against the background of this vital stream of technostress literature, this study has a twofold motivation: (1) to test whether the hindrance technostressors considered in the literature are still up-to-date and (2) to produce a unified model that represents the breadth of the conceptual domain of technology-related hindrance stressors at work.

The conceptual domain of a construct is the set of phenomena and conditions that it represents, determining how it is understood, measured, and applied in research and practice (MacKenzie et al. 2011). Beyond the prominent technostressor models of Tarafdar et al. (2007) and Ragu-Nathan et al. (2008),[1] there is a multiplicity of other hindrance technostressor models that focus on fewer, more, or different stressors and use different terminology (e.g., Ayyagari et al. 2011, Day et al. 2012, Benlian 2020). This fragmented state of knowledge on technostressors creates challenges for researchers. Whether they are examining the antecedents or consequences of technostress, appraisal, coping, inhibitors, prevention, or IS design, researchers working on hindrance technostress (the majority of technostress research) typically need a theoretical perspective and/or a measurement model to account for hindrance technostressors. Researchers are forced to either "pick and choose" from constructs across the models or choose a "favored model." Although merging multiple models could lead to theoretical inconsistencies and measurement problems, selecting a single model ignores the important contributions of other models. For practice, this fragmented state of technostressor research makes it difficult for occupational health and safety professionals to address the significant health implications of technostress for employees.

Today's digital work differs from previous information technology (IT)-based work (Colbert et al. 2016). Recent decades have seen a profound change in the nature, pervasiveness, and use of technologies at work. Given the rapid pace of technological change and the dramatic scale of technology-enabled organizational and societal change, Compeau et al. (2022) called for caution when applying constructs developed in very different technology, user, and organizational environments without questioning those constructs. One of the examples Compeau et al. (2022) provide for constructs at risk for obsolescence is technostress. Similarly, other research has called for an investigation into how individuals view the evolving digital landscape (Legner et al. 2017, Parviainen et al. 2017, Fischer et al. 2021). A central question is whether our traditional conceptualization of technology-related stressors at work fits the current context.

Many consider the model by Ragu-Nathan et al. (2008) to be the standard concept of technostress, especially in the organizational context (e.g., Benlian 2020, Califf et al. 2020, Salo et al. 2022). Califf et al. (2020, p. 812) succinctly summarize this view:

> "In IS research, technostress is composed of five dimensions. These dimensions, which are considered detrimental to individual and workplace outcomes, are collectively referred to as technostressors […] The five technostressors are techno-overload, techno-invasion, techno-complexity, techno-insecurity, and techno-uncertainty (Ragu-Nathan et al. 2008)."[2]

When this standard concept was published in 2007/2008, IT-enabled work was primarily shaped by the extensive diffusion of PCs and the Internet. Social computing was in its infancy. Google's chief executive officer (CEO) first used the term "cloud computing" in 2006 (Regalado 2011), and mobile computing emerged in 2007 with the first iPhone. These nomadic technologies (smartphones, tablets, ultralight computers) contributed to a fundamental transformation of the spatiotemporal organization of (knowledge) work into what we know today (Loup et al. 2021). In addition, social computing and cloud computing have transformed collaboration in many fields. Because of the changing nature of digital technologies, the stress individuals experience when working with these technologies is also evolving (Tarafdar et al. 2019). Thus, the established models may not fully account for the specificities of modern digital work.

Three examples from the technostress literature illustrate issues concerning the breadth of the conceptual domain: (1) Califf et al. (2020) studied technostress among nurses. In the qualitative phase and their literature review, they identified five primary hindrance technostressors.[3] Although four of the five technostressors overlap with Ragu-Nathan et al. (2008), Califf et al.

(2020) dropped *invasion* and included *unreliability*. In the operationalization, they mixed items from Ragu-Nathan et al. (2008) and Jiang et al. (2002). This is an example of "picking and choosing" from prior technostressor models. Although Califf et al.'s selection of technostressors might be an excellent fit for the specific context, this example shows the insufficiency of simply choosing to use a single model.

(2) Benlian (2020) studied how occupational technostress spills over to the home domain. He noted that some hindrance stressors in contemporary work—for example, ICT (information and communication technology) as an interrupter/obstacle or a lack of access to system resources—are related to select prior technostress studies but not explicitly covered by classical technostressors. Furthermore, he noted that the general work stressors of obstacles, resource constraints, and role or task conflict only somewhat overlap with classical technostressors. Based on this mediocre fit between classical technostressors (Tarafdar et al. 2007, Ragu-Nathan et al. 2008) and contemporary work, Benlian developed a new measurement scale for hindrance technostressors.[4]

(3) Nastjuk et al. (2023) presented a meta-analysis of the effect of technostressors on behavioral and health outcomes, focusing on the classical five technostressors from Ragu-Nathan et al. (2008). This led to the exclusion of many research studies that defined or measured technostressors differently. For example, the work of Benlian (2020) could not be included in the meta-analysis due to a different conceptualization of technostressors. Similarly, Tams et al. (2018), focusing on technology-mediated interruptions, was also excluded from the meta-analysis. For studies that include some of the technostressors from Ragu-Nathan et al. (2008), the meta-analysis excluded the reported effects on other technostressors from the same primary studies. For example, four of their five technostressors from Califf et al. (2020) were included in the meta-analysis, but unreliability was not. Although Nastjuk et al.'s study is certainly valuable for its insights into five technostressors, a more consistent treatment covering the breadth of the conceptual domain of technostressors presented in primary analyses and meta-analyses would build a stronger cumulative body of knowledge on an important phenomenon.

In summary, developing a unified model of hindrance technostressors at work would greatly benefit technostress research and organizational risk assessments on digital work. To this end, we first review and synthesize the existing models and pose two research questions: *Which occupational hindrance technostressors have been considered in research, and are they relevant to today's digital work environment? (RQ1). How should these stressors be combined into a unified stressor model? (RQ2).*

Based on a mixed-methods design, the key contributions of this paper are (1) testing whether the traditional models of hindrance technostressors are still relevant in contemporary digital work settings, (2) developing a unified model of digital hindrance stressors at work with 12 first-order and 5 second-order stressors that capture the full breadth of the conceptual domain, (3) providing both an extensive and a short-scale measurement model for digital hindrance stressors, and (4) guiding researchers and practitioners on when to use which model of hindrance technostressors or digital hindrance stressors.

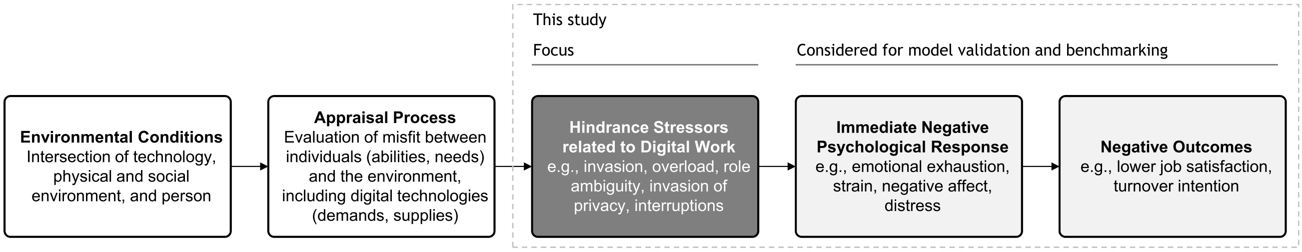
2. Theoretical Background on Occupational Technostress

Technostress theory primarily conceptualizes stress by focusing on the relationship and fit between individuals and the environment (Lazarus and Folkman 1984). The technostress concept presented by Ragu-Nathan et al. (2008, pp. 417–418) focuses explicitly on the workplace, stating that "technostress relates to the phenomenon of stress experienced by end users in organizations as a result of their use of ICTs. It is caused by an individual's attempts to deal with constantly evolving ICT and the changing physical, social, and cognitive processes demanded by their use." According to this view, stress is an ongoing process that involves individuals interacting with their environments (McGrath 1976, Ragu-Nathan et al. 2008). Digital technologies play a key role in technostress as important environmental factors. Digital technologies are "combinations of information, computing, communication, and connectivity technologies" (Bharadwaj et al. 2013, p. 471). These technologies either place demands on individuals directly or mediate demands from the social-interpersonal environment.

Building on prior theories on stress and technostress, Califf et al. (2020) proposed "a holistic technostress model." We leverage this model, focus on its distress subprocess and add nuance to the person-environment fit based on the technostress model from Ayyagari et al. (2011). The resulting perspective is consistent with much of prior stress and occupational stress theories and with the conceptualization of Benlian (2020) of technostress and the role of stressors. Figure 1 presents the resulting hindrance stress model, described in more detail in the following.

Environmental conditions represent the intersection of the physical-technical environment, the social-interpersonal environment, and the person-system or self-system. They denote the relationship between a person and the environment. Individual employees appraise the environmental conditions regarding person-environment fit or misfit (Lazarus and Folkman 1984, Ayyagari et al. 2011, Califf et al. 2020). Various types of person-environment fit, like person-job fit, person-supervisor fit, and person-organization fit,

Figure 1. Hindrance Stress Model with Focus on Digital Work



have been considered in general stress research. The focus of Ayyagari et al. (2011) is specifically on person-technology fit. Individual abilities may or may not fit environmental demands, and environmental resources may or may not fit an individual's needs. In the appraisal process, fit or misfit can be assessed as irrelevant, positive, or demanding. For demanding situations, a further subdivision takes place: as a positive challenge—that is, something is strenuous but considered interesting or rewarding—as a hindrance or a threat or as harm already suffered (Lazarus and Folkman 1984). According to Califf et al. (2020), appraisal triggers either a eustress or a distress subprocess. We focus on the distress subprocess related to hindrances, threats, and harms.

How a person perceives an environmental condition or what they find to be stressful can vary from person to person and within a person (Ayyagari et al. 2011, Tarafdar et al. 2019, Benlian 2020, Califf et al. 2020). When an individual appraises an environmental condition strongly related to digital technology as hindering, threatening, or harming, the condition becomes a hindrance technostressor. A hindrance technostressor results in an intrapersonal decision process, resulting in immediate negative psychological responses like negative affect and emotional exhaustion (Brown et al. 2014, Califf et al. 2020). A further intrapersonal process determines the resulting adverse outcomes, such as adverse health outcomes (Lazarus and Folkman 1984), lower job satisfaction, or higher attrition (Califf et al. 2020).

3. Reflections on Hindrance Technostressors

Compeau et al. (2022) provide a process for evaluating and updating constructs by (1) evaluating the existing construct and its context of use, (2) conceptualizing a new construct, and (3) conceptually and empirically comparing the constructs. Either conceptual or empirical limitations of a construct may call for its reconceptualization. In the following, we elaborate on the limitations of prior conceptualizations of hindrance technostressors (HTSs), where we adopt the wording *stressors*, which is now common in IS literature. Tarafdar et al. (2007) used the term *stress*, and Ragu-Nathan et al. (2008) referred to *stress creators*. Next, we reconceptualize the existing hindrance technostressor construct(s) using a literature review, a qualitative prestudy, and a quantitative study, resulting in a digital hindrance stressors construct consisting of 12 first-order and 5 second-order digital hindrance stressors (DHSs). Finally, we compare this new construct to existing constructs.

Following step 1 of the process of Compeau et al. (2022), we identify the conceptual limitations of the existing HTS construct. In general, such limitations arise from the dynamic nature of the IS research context. In our case, we note that the technostressor construct may need an update due to changes in the nature of digital technologies since the initial works on technostressors were published. Although these changes have led to different views of HTSs in recent studies (Benlian 2020, Fischer et al. 2021), these studies did not evaluate the contemporary relevance of classical HTSs but directly developed new models instead. Thus, we aim to reconcile the different existing views.

The term *technostress* was introduced in the early 1980s. Since then, the definition has been revised and expanded (see illustrative definitions in the Online Appendix, which is structured according to the sections of this paper). These definitions focus on the user's inability to deal with technology appropriately. However, some HTSs do not address this (in)ability. For example, technology-related stress may result from the lack of appropriate technology to perform a task (nonavailability). In this case, technostress is not caused by a person's improper use of technology but by the lack of availability of the technology itself. Likewise, job insecurity is not related to the use of technology by the stressed person but to the fear of losing one's job due to organizational changes related to the use of (potentially not yet available) technology. A broader definition of technostress is needed to account for such dimensions of technology-related stress. Accordingly, the set of stressors not impacting individuals is broader than implied by many traditional definitions of technostress.

Furthermore, although the definition of technostress has been revised and expanded over time, the terminological and theoretical framework is closely related to its period of origin. Since this time, technology, its use, and its perception have changed drastically. Although the Internet has become a universal source of information, new additional digital technologies such as mobile computing, social media, cloud computing, advanced analytics, artificial intelligence, and the Internet of Things have found their way into digital work. Therefore, because of changing perceptions about and interactions with technologies, "the term of technostress acquires a new meaning" (Chiappetta 2017, p. 359).

As noted previously, several slightly different technostress constructs and technostressor models focus on specific aspects of technology use and resulting stress. Although each of these elements can be useful in its particular field, this fragmentation can hinder the field's ability to fully understand the contemporary phenomenon of digital work. In the spirit of Compeau et al. (2022), we propose an updated unifying construct for hindrance technostressors. To avoid both narrowing assumptions and confusion about the basis of the updated construct and to better reflect the current breadth of the concept in its entirety, in the naming, we adopt the term *digital hindrance stressors* (DHSs) instead of *hindrance technostressors*.

Digital hindrance stressors lead to *digital stress*, that is, stress induced or mediated by digital technologies. Although we are unaware of any use of the term digital stress in IS journals, it has already been used in the discourse of other disciplines. Examples are presented in the Online Appendix.

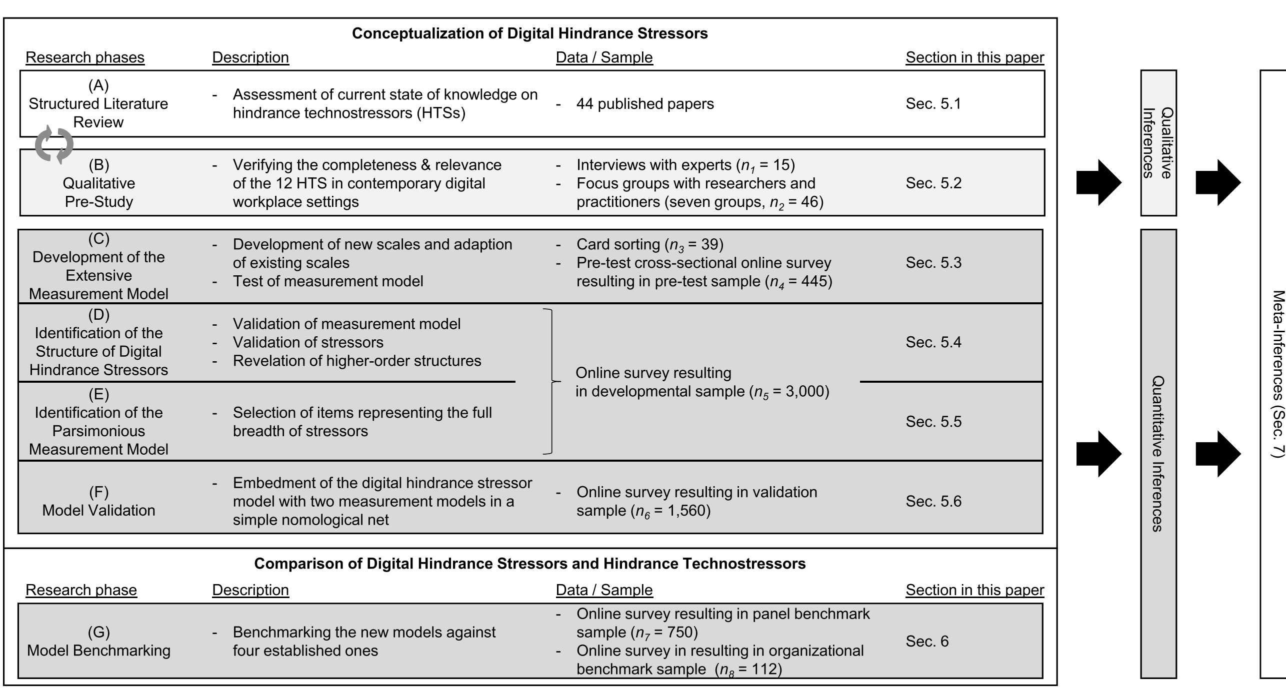
4. Method of Reconceptualization and Comparison of Digital Hindrance Stressors

We applied several steps and research methods to (1) conceptualize digital hindrance stressors and (2) compare them with existing models of hindrance technostressors, according to Compeau et al. (2022) (Figure 2). For this, we conducted a structured literature search and followed a quantitative-dominant sequential mixed-methods design with a developmental purpose.

Starting with the conceptualization of DHSs, we conducted a structured review of IS and related literature on HTSs (Phase A). We iteratively checked the empirical relevance of the identified HTSs through a qualitative prestudy consisting of interviews with experts from various fields and focus group discussions with employees and researchers (Phase B). The literature review and the qualitative study were not strictly sequential but overlapped, with only some results of the literature review being known at the time of conducting the qualitative study and the qualitative results informing the further progress of the literature review. After subsequent phases, we updated the literature review during the review process.

Following Phases A and B, we turned to the dominant quantitative part (Phases C–G) of the research (Tashakkori and Teddlie 1998; Venkatesh et al. 2013,

Figure 2. Mixed-Methods Research Process



2016), including the theoretical conceptualization of 12 DHSs, testing and refining our model and benchmarking it against established models of HTSs. Data used in our quantitative part primarily originate from five conducted surveys with 5,867 employees. Sample characteristics are provided in the Online Appendix. All survey data and analysis scripts are available online (https://doi.org/10.17605/OSF.IO/7YJQ4).

For the extensive measurement model of DHSs required in the quantitative part of our research, we used validated scales from the literature when possible. We developed multi-item scales for identified DHSs when necessary. We conducted a card-sorting exercise with IS researchers and pretested our measurement model on an initial cross-sectional sample with 445 participants (Phase C). Next, we used cross-sectional survey data from 3,000 participants working in Germany (developmental sample) to validate our measurement model. We uncovered higher-order structures useful to understanding the multilevel structure of DHSs (Phase D) and developed a parsimonious measurement model (Phase E). For Phases C–E, cross-sectional data were adequate, as the analysis focused on the correlational structure of survey items and DHSs.

We validated the model of DHSs and its two measurement models in a simple nomological net, including a psychological response to stressors (Phase F). For this step, we used data from a longitudinal survey of 1,560 participants (validation sample), which provided data on DHSs at one point in time and on emotional exhaustion as a negative psychological response at a second time approximately one year later. For Phase F, we separated the surveys on the DHSs (independent variables) and the negative psychological responses and outcomes (dependent variables) to avoid common-method bias. All participants from the pretest sample, the developmental sample, and the validation sample have been randomly recruited via a professional research panel focusing on the German workforce.

In Phase G, we embedded different DHS and HTS models in a more elaborate nomological net. We benchmarked them to compare the DHSs with existing models of HTSs in terms of adequacy and relative strengths. For this, we conducted two additional surveys. The first sample, consisting of 750 participants (panel benchmark sample), was recruited via an online panel provider targeting participants from the U.S. workforce. The second sample, composed of 112 participants (organizational benchmark sample), was recruited within a German knowledge work organization. Both samples increase the heterogeneity of participants and sampling procedures in our overall set of empirical studies, which results in a more meaningful benchmark and an increase in the robustness of our findings.

Finally, we concluded our mixed methods study by integrating the findings from our research's qualitative and quantitative parts and deriving meta-inferences.

5. Conceptualization of Digital Hindrance Stressors

5.1. Review of Prior Research on Hindrance Technostressors (Phase A)

By reviewing the extant models of technostress, we sought to assess the current state of knowledge on HTSs. The technostress literature relies heavily on five HTSs from Ragu-Nathan et al. (2008). These five first-order HTSs with a second-order superordinate technostressor construct are considered a classical model of technostressors (Benlian 2020, Califf et al. 2020). However, previous work has also examined other HTSs (e.g., Ayyagari et al. 2011, Galluch et al. 2015), and recent IS technostress research moved away from this classical technostressor model (e.g., Benlian 2020, Califf et al. 2020).

We identified relevant literature from two perspectives. (1) Tarafdar et al. (2019) reviewed the literature on workplace technostress published between 1995 and 2016 in leading IS and non-IS journals. We included their final list of 27 papers in our search. (2) To ensure adequate coverage of recent developments, we used the same strategy as Tarafdar et al. (2019) from 2017 to 2023 (see the Online Appendix for the search strategy). This search returned 162 papers. We reviewed the full text of all 189 papers using five exclusion criteria. First, we excluded four papers with no research articles but, for example, editorials. Second, we excluded 62 papers because they did not refer to human stress but "bank stress testing," for example. Third, we excluded 56 papers that did not address technostress but non–technology-related work stress, for example. Fourth, we excluded 17 papers that did not consider a work context but solely a private context (especially private social media use). Fifth, we excluded seven papers that did not identify specific technostressors. In summary, this process resulted in 43 papers that include models of HTS.

The qualitative prestudy (Phase B; see Section 5.2) conducted in parallel with the literature review hinted at an additional stressor not found in the technostress literature relating to the *sense of achievement* when working with digital technologies. With this in mind, we searched beyond the aforementioned structured search and beyond technostress literature, finding a paper by Bessière et al. (2006) in the related research stream of computer frustration; we added this paper to our review.

Overall, this process resulted in 44 papers that include stressor models, including 12 different stressors related to digital work (see the Online Appendix for the list of papers and stressors per paper). We mapped the constructs from the papers to the 12 stressors by analyzing the conceptual definitions and considering the operationalization in quantitative studies. According to Califf et al. (2020) and many others, negative psychological responses and further adverse outcomes are a consequence of hindrance stressors. Thus, we included the immediate negative psychological responses and long-term adverse psychological, physiological, and behavioral outcomes investigated in the original papers and the moderators of the relationships.

Table 1 defines the 12 stressors resulting from this process and lists how many of the 44 models reviewed include the respective stressors. The stressors we identified include the five stressors from Ragu-Nathan et al. (2008). These are listed first in Table 1 and are used frequently (14 to 33 times in 44 models). The other stressors are used more sporadically in the literature reviewed. Analyzing the 44 models for their coverage of the breadth of the conceptual domain of technology-related hindrance stressors at work resulted in the following observations: Nine of the 44 models use the exact set of stressors from Ragu-Nathan et al. (2008). No model uses more than seven stressors, not to mention all 12.

5.2. Qualitative Prestudy (Phase B)

The qualitative prestudy supports the contemporary relevance of the stressors identified in the literature. We were interested in the suitability, timeliness, and completeness of the identified stressors in contemporary digital work settings. Therefore, we conducted expert interviews (semi-structured, $n_1 = 15$) and focus-group discussions with employees and researchers ($n_2 = 46$; seven focus groups, five to eight participants each). To gain an understanding of the scope and relevance of HTSs in contemporary digital workplace settings, we selected experts whose knowledge and expertise would contribute to the aim of the qualitative study (e.g., a head of a human resource department, a head of competence field occupational safety, a scientific director of a federal institute focusing

Table 1. Definition of the 12 Hindrance Stressors Related to Digital Technologies

Hindrance stressor	Definition	Use
Invasion	Invasion "describes the invasive effect of [digital technologies] in terms of creating situations where users can potentially be reached anytime, employees feel the need to be constantly 'connected,' and there is a blurring between work-related and personal contexts" (Tarafdar et al. 2007, p. 315).	20
Overload	Overload "describes situations where [digital technologies] force users to work faster and longer" (Tarafdar et al. 2007, p. 315).	33
Complexity	Complexity "describes situations where the complexity associated with [digital technologies] makes users feel inadequate as far as their skills are concerned and forces them to spend time and effort in learning and understanding various aspects of" digital technologies (Tarafdar et al. 2007, p. 315).	18
Insecurity	Insecurity "is associated with situations where users feel threatened about losing their jobs as a result of new [digital technologies] replacing them, or to other people who have a better understanding of" digital technologies (Tarafdar et al. 2007, p. 315).	14
Uncertainty	Uncertainty "refers to contexts where continuing changes and upgrades in [a digital technology] unsettle users and create uncertainty for them" (Tarafdar et al. 2007, p. 315).	16
Unreliability	Unreliability describes situations where individuals "face system malfunctions and other … hassles" with digital technologies (Fischer and Riedl 2015, p. 1462).	9
Role ambiguity	Role ambiguity is associated with situations where "there is uncertainty as to whether an individual should expend his or her resources to perform the task requirements at work or to acquire new skills" for working with digital technologies (Ayyagari et al. 2011, p. 842).	2
Invasion of privacy	Invasion of privacy refers to situations in which individuals "are becoming increasingly concerned that their privacy could be invaded by" digital technologies (Ayyagari et al. 2011, p. 841, based on Best et al. 2006).	1
Interruptions	Interruptions describe situations where an individual's attention is shifted away from a current task by an external, digital-technology-based source (Galluch et al. 2015).	6
Performance monitoring	Performance monitoring describes situations where individuals feel digital technologies are used to monitor and assess their performance (based on Aiello and Kolb 1995, Sprigg and Jackson 2006, Day et al. 2012).	5
Nonavailability	Nonavailability refers to situations where individuals are impaired in their activities because digital technologies, which might facilitate or ease work processes, are unavailable due to technological or organizational restrictions, safety, or monetary reasons (based on Benlian 2020, Vaziri et al. 2020).	5
Lacking a sense of achievement	Lacking a sense of achievement refers to situations where individuals feel they hardly make work progress due to the intangible nature of tasks performed using digital technologies.	1

Notes. Use refers to the inclusion of the respective stressor in 44 prior hindrance technostressor models. See the Online Appendix for details. *Lacking a Sense of Achievement* is not drawn from a technostressor model but from an analysis of computer frustration. It was included based on the findings of the qualitative prestudy.

on occupational safety and health). The interviewers asked the interviewees and focus group participants for their perspectives on the psychological demands of contemporary work with digital technologies without presenting lists of HTSs from the literature. The interviews were transcribed and analyzed for technostress-relevant aspects either covered by stressors known from literature or not covered by the existing constructs.

We used a qualitative deductive approach to analyze transcripts and field notes using the MAXQDA software. The codebook initially contained the seven HTSs from the models by Ragu-Nathan et al. (2008) and Ayyagari et al. (2011) but not the other five stressors presented in Section 5.1. Coders analyzed the transcripts and field notes and found evidence for the seven HTSs initially included in the codebook and evidence for five additional stressors. Four of these five are discussed in prior technostress literature but were not known to the coders at the time of coding. The final stressor emerging from coding is *lacking a sense of achievement* when working with digital technologies. Therefore, we included this as a stressor and found a relation in computer frustration literature (see Section 5.1). The Online Appendix describes methodological details and information on the experts and focus groups.

Summarizing this investigation, experts suggested that the 11 stressors identified in technostress literature—including the less-studied stressors—are stress-relevant aspects of daily work with digital technologies in their organization. Confirming the experts' views, the employees participating in the focus groups described specific experiences with demanding situations at work that mapped on the stressors. In addition, this qualitative prestudy hinted at a 12th stressor—*lacking a sense of achievement*.

5.3. Development of the Extensive Measurement Model (Phase C)

Although validated survey scales exist for most of the stressors, scales measuring *performance monitoring*, *nonavailability*, and *lacking a sense of achievement* had to be newly developed. We followed the guidelines of Hinkin (1998) and MacKenzie et al. (2011) for developing and evaluating measurement instruments. These new scales showed good psychometric properties and worked well alongside established scales for the other stressors. We assessed content validity, convergent validity, discriminant validity, reliability, and model goodness of fit. The resulting extensive measurement model for 12 hindrance stressors passed all validation tests. Details are provided in the Online Appendix.

5.4. Identification of the Structure of Digital Hindrance Stressors (Phase D)

The definitions and number of stressors suggest they may not all be completely unrelated. For example, acute stressors such as *interruptions* and *unreliability* can be grouped, as can more chronic stressors such as *insecurity* and *uncertainty*. Similarly, *invasion of privacy* and *performance monitoring* involve third parties collecting or accessing personal data. Furthermore, Ragu-Nathan et al. (2008) conceptualized technostressors as multiple first-order factors and a single superordinate HTS construct. Thus, there is no theoretical reason to believe that the stressors are unrelated. On the contrary, there is a theoretical reason to believe that the stressors are related. Hence, there may be higher-order structures at play. Understanding the underlying structure is desirable because it leads to a stronger theory. Weber (2012) discussed a tradeoff between parsimony and the predictive and/or explanatory power of a theory and recommended that there should be no more than seven constructs to reduce complexity. Accordingly, we sought to condense our 12 stressors into a few higher-order stressors to highlight their interconnections. We model the hierarchical relationship between stressors as reflective on all levels (superordinate constructs; see the Online Appendix for the rationale).

5.4.1. Second-Order Model.

We empirically explored a second-order model. Extracting the 12 DHSs in exploratory factor analysis (EFA) with oblique rotation on the data from the developmental sample (n_5 = 3,000 workers) yielded high DHS correlations ranging from 0.21 to 0.64, suggesting a potential second-order structure. A multilevel EFA on the developmental sample revealed a possible higher-order structure (Naruz et al. 2015). We first applied an EFA with 12 factors and then used the factor score estimates as input to run another EFA (principal axis factoring with oblique rotation). Determining the number of factors to keep is a crucial step in EFA. Parallel analysis is one of the most accurate methods to inform this decision (Hayton et al. 2004). Parallel analysis suggested five factors for the second-level EFA. Thus, we ran an EFA with the specification to identify five factors and inspected the loadings of first-order stressors on these second-order factors. Two main loadings missed the conventional threshold of 0.4 (Table 2). We considered the lack of sufficient main loadings acceptable at this point for two reasons: First, especially for overload, the loading of 0.39 is not far from the 0.4 threshold. Second, we knew further confirmatory tests on other data sets would follow this exploratory identification of second-order factors. If the lack of empirical fit is not only a chance finding but substantive, it would appear again in future tests where we would aim to correct it or dismiss the model. Hence, in the absence of any EFA result meeting all conventional quality criteria, we decided to follow the result of the parallel analysis and retain five second-order factors.

Table 2. Factor Loadings for Five Second-Order Factors Identified in an Exploratory Factor Analysis (EFA) on the Developmental Sample (n_5 = 3,000)

First-order stressors	Technology-related overload	Technology-related task obstruction	Technology-related ineffectiveness	Technology-related surveillance	Technology-related rumination
Overload	**0.39**	0.26	0.14	0.13	0.19
Unreliability	0.01	**0.75**	0.00	0.02	0.04
Interruptions	0.10	**0.42**	0.34	0.21	−0.10
Nonavailability	<u>−0.28</u>	**0.33**	<u>0.26</u>	0.11	0.15
Role ambiguity	0.03	−0.01	**0.77**	−0.06	−0.04
Lacking a sense of achievement	−0.13	0.07	**0.65**	0.11	0.13
Complexity	0.10	0.04	**0.59**	0.04	0.16
Invasion of privacy	−0.09	0.00	−0.01	**0.89**	−0.03
Performance monitoring	0.19	0.00	0.00	**0.70**	0.08
Insecurity	0.01	−0.05	0.08	0.04	**0.84**
Uncertainty	0.09	0.24	−0.14	−0.02	**0.58**
Invasion	−0.18	0.07	0.21	0.01	**0.47**

Notes. Main loadings in bold font, and underlined values indicate cross loadings >50% of the major loading. Ordering of second-order factors according to theoretical considerations.

Based on theories of occupational stress and technostress and the empirical loadings of the first-order stressors, we interpreted the five second-order factors as technology-related overload, obstruction, ineffectiveness, surveillance, and rumination.

Technology-related overload. A contemporary understanding of occupational stress (independent of digital technologies) is based on role stress theory (Kahn et al. 1964, Kahn and Quinn 1970, Bliese et al. 2017, Morrissette and Kisamore 2020). In role stress theory, role overload describes scenarios where work expectations become too demanding, resulting in employees feeling overwhelmed by a heavy workload (Kahn and Quinn 1970, Beehr et al. 1976). Overload has a direct technological component. With communication, data, and decision-making tools being faster than ever, digital transformation can make work processes more efficient. This increased efficiency can sometimes lead to increased work intensity for employees, resulting in time and performance pressures. In addition, the introduction of new technologies can itself increase work intensity. Hence, techno-*overload* has been considered a stressor (Ragu-Nathan et al. 2008), and according to our EFA, this stressor is the single component of the second-order factor. In line with role stress and technostress theory, we refer to the second-order factor as *technology-related overload* or *overload* for short.

Technology-related task obstruction. Digital technologies in the workplace are supposed to be tools supporting the execution of tasks. The better the characteristics of a technology are matched to the requirements of the respective task and a specific user group, the more likely it is to provide support (Goodhue and Thompson 1995). However, unreliable, failing technology (e.g., a system breakdown) keeps employees from doing their work tasks. Technologies that interrupt the user (based on individual settings) in a way that interferes with task completion (e.g., notifications that are not relevant to the current task) are also considered barriers to task completion. If a worker's work equipment lacks the necessary digital technologies, the work equipment provided is insufficient to perform the given tasks. In all three cases, *unreliability, interruptions,* and *nonavailability of digital technologies*, which correspond to the three stressors grouped in this second-order factor, we see a lack of task-technology fit that leads to task obstructions. Therefore, we term the second-order factor *technology-related task obstruction* or *obstruction* for short.

Technology-related ineffectiveness. Among humans' basic psychological needs is competence, that is, the perception that one can apply one's skills and influence the environment in desirable ways (Ryan and Deci 2008, Weinstein and Ryan 2011). In a work context, this perception relates to effectiveness in completing work tasks and achieving goals. The frustration of basic psychological needs can lead to stress (van den Broeck et al. 2008, Weinstein and Ryan 2011, Fernet and Austin 2014). Hence, feeling ineffective in getting things done properly can be a hindrance stressor. Three stressors are jointly oriented in this direction, as the EFA and the stressors definitions suggest. *Role ambiguity* is a stressor in role stress theory. It refers to the vagueness of job expectations, characterized by insufficient information about job tasks, workplace procedures, and outcomes of job performance (Kahn et al. 1964, Kahn and Quinn 1970, Rizzo et al. 1970), for example, whether to expend resources to perform the original work tasks or to acquire new skills related to technologies (Ayyagari et al. 2011). This ambiguity hinders feeling effective at work. Regarding *complexity,* employees feeling inadequately skilled may spend time developing digital skills rather than engaging in their tasks (Tarafdar et al. 2007), contributing to the feeling of diminished job accomplishment. *Lacking a sense of achievement* due to the inability to recognize and grasp work results when working with digital technologies also contributes to feeling ineffective. Thus, we refer to the second-order factor as *technology-related ineffectiveness* or *ineffectiveness* for short. This ineffectiveness is a perception by the individual worker and not necessarily an "objective" ineffectiveness. The same holds true for the other stressors.

Both obstruction and ineffectiveness are related to the work task to be performed. By juxtaposing both constructs, it becomes clear that obstruction is directly related to the use or nonuse of digital technologies. Ineffectiveness is indirectly influenced by the presence of digital technologies through users' perceptions and reactions.

Technology-related surveillance. People value autonomy (Ryan and Deci 2008). Assaults to privacy by technology-related surveillance limit the perception of autonomy (Kupfer 1987), impairing job control. According to the job demands-control model, a high workload is thought to result from high job demands, workers' low levels of control over their work activities, and interaction between the two job characteristics (Karasek and Theorell 1990). Low-control jobs are associated with hindrance stress (Häusser et al. 2010, Rosen and Wischniewski 2019). Close monitoring by others is detrimental to the sense of control over one's work. Thus, technology-related increased (perceived) performance monitoring is likely to be stressful. Irrespective of work performance, invasion of privacy is a stressor (Ayyagari et al. 2011). A common theme between performance monitoring and invasion of privacy is that surveillance results in a loss of (perceived) control and autonomy, which triggers stress. A further aspect is that humans are inherently social creatures who place great importance on their place within their social groups. They have the basic psychological need for relatedness (Ryan and Deci 2008). Hence, the anticipation or experience of negative social evaluations by coworkers or supervisors due to surveillance is a major source of acute stress (Dickerson et al. 2008). This stressor is so potent and reliable that it is widely used in the Trier social stress test to induce stress in psychological studies (Allen et al. 2017). Hence, we call the second-order factor that summarizes *invasion of privacy* and *performance monitoring technology-related surveillance* or *surveillance* for short.

Technology-related rumination. Rumination involves continuously dwelling on negative thoughts about oneself, emotions, personal issues, and upsetting events (Watkins 2008). The stressors *invasion, insecurity,* and *uncertainty* all relate to dwelling on negative thoughts about the consequences of not being constantly available or being unable to understand digital work. The accessibility of employees in the context of mobile work, which is only possible to the extent enabled by digital technologies, is increasingly blurring the boundaries between work and private life and between work and nonwork time, making it difficult to disengage from work during nonwork hours and negatively impacting the recovery process (Meijman and Mulder 1998, Sonnentag and Fritz 2015). We see insufficient detachment from work as a key link between *invasion, insecurity,* and *uncertainty*. *Invasion* reduces detachment from work, and *uncertainty* and *insecurity* make disengagement difficult, negatively affecting perceived self-efficacy and fostering rumination. Rumination has repeatedly been found to mediate the association between stressful stimuli and negative psychological responses (Watkins and Roberts 2020). Hence, based on the empirical results and consistent with psychological theory on stress and rumination, we refer to the second-order factor as *technology-related rumination* or *rumination* for short.

The composition of the second-order factors is empirically driven. It follows from the results of the EFA. The first-order stressors are distinct constructs that align with different second-order factors depending on the respondents' data. Beyond empirics, the grouping is also theoretically plausible. The groups of first-order factors that cluster together in second-order factors share common characteristics, as the previous reasoning shows.

At the risk of oversimplifying the second-order concepts, we summarize very briefly: People experience intense digital stress when they have the impression that, because of digital technologies, they have a lot of work to do (overload), are being impeded in their tasks (obstruction), are not making any real progress (ineffectiveness), are monitored and evaluated from the outside (surveillance), and are not able to switch off from work (rumination). Table 3 summarizes the five second-order DHSs more formally.

5.4.2. Third-Order Model. At the next level, the question again arises of whether the five second-order stressors are independent or interrelated. The popular model from Ragu-Nathan et al. (2008) elegantly provides a single technostressor construct (in their model, a second-order reflective construct). To test whether it is possible to summarize the five second-order stressors into a third-order construct, we applied confirmatory factor analysis (CFA) on the 12 first-order stressors, the 5 second-order stressors, and a single third-order construct. Inspecting the CFA loadings shows that

Table 3. Second-Order Digital Hindrance Stressors

Second-order stressor	Definition	Related first-order stressors
Technology-related overload	Perceived hindrance in the form of feeling overwhelmed by a heavy workload due to digital technologies.	*Overload* Related constructs: techno-overload (e.g., Tarafdar et al. 2007), work/information/email/social overload (e.g., Soucek and Moser 2010, Ayyagari et al. 2011, Brown et al. 2014, Chen and Wei 2019), telepressure, response expectations, workload (e.g., Day et al. 2012)
Technology-related task obstruction	Perceived hindrance in that the digital technologies are seen as inappropriate for the task at hand and impeding work.	*Unreliability, interruptions, nonavailability* Related constructs: hassles (e.g., Day et al. 2012), discrepant IT event (Ortiz de Guinea 2016), software/hardware problems (Körner et al. 2019), (perceived) interruption overload (Tams et al. 2020, Yu et al. 2023)
Technology-related ineffectiveness	Perceived hindrance from the impression of not performing well at work due to digital technologies and further digital skills development.	*Role ambiguity, lacking a sense of achievement, complexity* Related constructs: suitability for task (Körner et al. 2019), incompatibility (Vaziri et al. 2020), techno-complexity (e.g., Tarafdar et al. 2007), usability (Körner et al. 2019)
Technology-related surveillance	Perceived hindrance in the form of technology-mediated scrutiny by coworkers or supervisors may be recognized as leading to negative social evaluations and reduced autonomy.	*Invasion of privacy, performance monitoring* Related constructs: monitoring (e.g., Day et al. 2012), electronic performance monitoring (e.g., Ravid et al. 2023)
Technology-related rumination	Perceived hindrance in the form of dwelling on repetitive negative thoughts around the consequences of not being available or not understanding but being forced to use digital technologies constantly.	*Insecurity, uncertainty, invasion* Related constructs: techno-insecurity (e.g., Tarafdar et al. 2007), job insecurity (Ayyagari et al. 2011), techno-uncertainty (e.g., Tarafdar et al. 2007), learning expectations (e.g., Day et al. 2012), frequent changes (Körner et al. 2019), techno-invasion (e.g., Tarafdar et al. 2007), work-home conflict (e.g., Ayyagari et al. 2011), or availability/availability expectations/extended availability (Day et al. 2012, Grawitch et al. 2018, Cho et al. 2020)

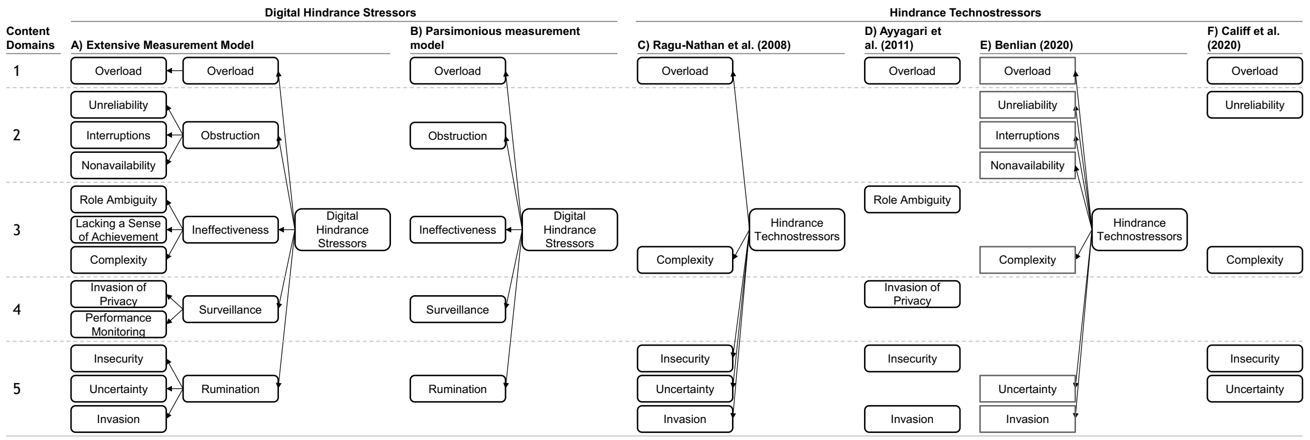
loadings on all levels of the model are substantial and significant. The standardized loadings for the second-order factors on the third-order factor are 0.86 for *overload*, 0.97 for *obstruction*, 0.94 for *ineffectiveness*, 0.73 for *surveillance*, and 0.88 for *rumination*. More importantly, we evaluated the CFA model fit according to standard fit measures, specifically Root Mean Square Error of Approximation (RMSEA) and Standardized Root Mean Square Residual (SRMR) as global measures, Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), and Normed Fit Index (NFI) as incremental measures, and Adjusted Goodness-of-Fit Index (AGFI) to assess model parsimony (Hu and Bentler 1999, Gefen et al. 2000, Lei and Wu 2007). We do not report χ^2 or χ^2/df, as these are not considered meaningful for samples of our size. All conventional targets are met (see the Online Appendix). Thus, we conclude that a model with a third-order superordinate DHS construct is neatly aggregated and statistically reasonable given the data in the developmental sample.

5.5. Identification of the Parsimonious Measurement Model (Phase E)

Parsimony is generally considered a beneficial characteristic of theoretical models (Popper 2005). The DHS model developed thus far is more comprehensive but also more complex than any prior model of HTS. This complexity might be an acceptable side effect for achieving a unified picture for some usage scenarios. However, a parsimonious model is beneficial when stressors are not the core construct and/or the survey-based assessment of stressors requires a brief questionnaire. Hence, we developed such a model.

The general idea was to (1) retain content validity by keeping the full breadth of the conceptual domain of DHSs, (2) retain the summary in a single superordinate construct, (3) reduce the number of measurement items, and (4) avoid single-item measures. To this end, we first selected one item from each first-order DHS. Using the third-order CFA model from before, for each stressor, we inspected the item loadings and content. We identified the highest loading item per stressor and all items with loadings of at most 0.1 lower than this highest loading. From this set, we decided which item to retain based on matching with the conceptual definition of the stressor. This resulted in a multi-item scale for four of the five second-order DHSs. For *overload*, this procedure delivered a single-item scale. Hence, we added a second item for *overload*. This led us to a parsimonious measurement model with 13 items measuring the five second-order DHSs and, indirectly, a superordinate DHS construct. The items are provided in the

Figure 3. Comparison of the Four Models of Hindrance Technostress



Online Appendix. The developmental sample shows an adequate model fit in terms of loadings, Cronbach's α, and the average variance extracted (AVE) except for *obstruction* and *rumination,* where the AVE is slightly lower than 0.5 (see the Online Appendix).

5.6. Model Validation (Phase F)

The validation uses longitudinal data (validation sample, n_6 = 1,560 workers) to validate the new DHS model with its two alternative measurement models (Figure 3, Models A and B). As an immediate negative psychological response, we focus on emotional exhaustion. Emotional exhaustion is a form of strain (Ayyagari et al. 2011, Brown et al. 2014) and a burnout dimension (Maslach and Jackson 1986). Prior research repeatedly hypothesized and demonstrated that stressors increase emotional exhaustion (Brown et al. 2014, Zinke et al. 2024). The Online Appendix summarizes the simple nomological net, the measurement items, the scale properties, and the tests, indicating that common-method bias does not present a major threat to our data—especially since there was an approximate one-year delay between our first DHS query and our assessment of emotional exhaustion as a psychological response.

We performed covariance-based structural equation modeling (CB-SEM) of both models on the validation sample. The Online Appendix reports details on the fit indices and path estimates. Both models fit the data reasonably well, and the path from DHS to emotional exhaustion is positive, substantial, and significantly different from zero for both models, as hypothesized. The reflective higher-order structures work well: For the extensive measurement model, the smallest loading of a first-order DHS on a second-order DHS is 0.66, and the smallest loading of a second-order DHS on the third-order DHS is 0.75. For the parsimonious measurement model, the smallest loading of a first-order factor on the second-order factor is 0.66. The share of variance explained (R^2) in emotional exhaustion is 0.26 for the extensive measurement model and 0.27 for the parsimonious measurement model. The magnitude of this effect appears to be fair, given the time delay of about one year between the first assessment of DHS and the psychological response. Somewhat surprisingly, the parsimony of the measurement model does not reduce the explanatory power of the DHS model.

6. Model Benchmarking (Phase G)

In the last step of our dominant quantitative part, we turned to an analysis using two additional samples to offer a final perspective on the absolute adequacy and relative strengths of the different models. We have six competing models (Figure 3): (A) the new DHS model with its extensive measurement model, (B) the same theoretical DHS model with a parsimonious measurement model, and (C–F) four benchmark models. We see Ragu-Nathan et al. (2008) as the current de facto standard model of HTS as a required benchmark. Furthermore, we considered the HTS models in all other papers reviewed in Section 5.1 as potential further benchmark models. For selecting models, we used four criteria: Their breadth of covering the conceptual domain, their role as either a timely or classical model of HTS, their reception in the academic literature in terms of citations, and the coherence of the portfolio of benchmark models. This led to the selection of the models by Ayyagari et al. (2011), Benlian (2020), and Califf et al. (2020) as benchmark models. The Online Appendix describes the selection in detail. Figure 3 depicts latent constructs as rounded and the manifest items in the model by Benlian (2020) as squared boxes.

Ayyagari et al. (2011) and Califf et al. (2020) do not have an aggregate technostressor construct.

Comparing these models necessitates an assessment of their statistical properties and content validity to cover the breadth of the phenomenon. We first focus on the statistics. The content perspective can be found in the discussion section. Regarding statistics, we focus on increasing the robustness of our results by introducing two new data sets and increasing the heterogeneity of participants and sampling procedures in the overall set of our empirical studies. We first considered the models' fit with the data for each data set. Then, we analyzed the estimated effects of the different hindrance stressor models on negative psychological responses and outcomes.

6.1. Nomological Net

We included all direct consequences of stressors from our benchmark models and followed their hypothesized interrelations (Figure 4). Stressors are hypothesized to increase strain (Ragu-Nathan et al. 2008, Ayyagari et al. 2011), negative affect (Benlian 2020), and distress (Califf et al. 2020).[5] Unlike in the model validation (Section 5.6), we did not consider emotional exhaustion as psychological response here, as none of the benchmark models considered it. We related each single stressor to the psychological responses for stressor models A, B, C, and E with a single superordinate stressor. For stressor models D and F—each having five HTSs on the same level—we related each of these HTSs to each of the psychological responses.

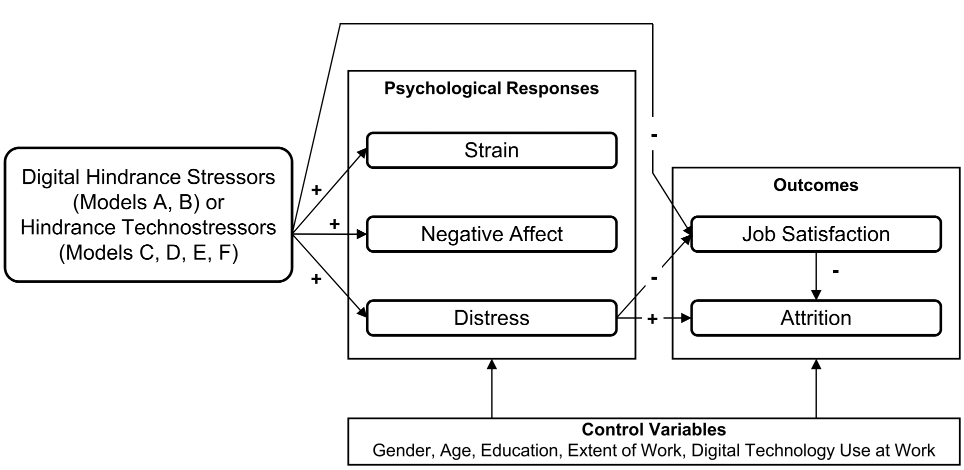
Further, we added the indirect outcomes of stressors from the model by Califf et al. (2020). Distress is hypothesized to reduce job satisfaction; attrition is hypothesized to be negatively affected by job satisfaction and positively affected by distress (Califf et al. 2020). Using this nomological net for benchmarking the different stressor models implies that each HTS model is not only related to the psychological responses and outcomes that it related to in its original paper. Instead, each stressor model is combined with multiple dependent variables from all the original papers. We believe that is fair because a useful stressor model should not only, for example, explain variance in job satisfaction but also in negative affect. The control variables are listed in Figure 4 and discussed in the Online Appendix.

The hypotheses are all standard, and any result that does not support them would be very surprising. The point is not to test the hypotheses but to understand the explanatory power of different DHS and HTS models. In this regard, the key metric of concern is the adjusted variance explained (adjusted R^2) in the psychological responses and outcomes.

6.2. Measurement and Data

We used the original measurement scales used in the benchmark and our DHS measurement models for all stressors, psychological responses, and outcomes. We recruited two sets of participants in July 2023. For the panel benchmark sample, we recruited and paid 750 participants from the U.S. workforce (minimum age of 18) via the online panel provider Prolific and paid them 2.75 USD for participation. For the organizational benchmark sample, we recruited 112 employees of a German knowledge work organization (minimum age of 18). Here, participants were recruited via e-mails from executives of the organization. Participants were not paid for participation. The response rate was about 35%. For both surveys, participation was anonymous. We analyzed only data from participants who completed the survey and passed an attention check. The Online Appendix details the final scale properties and the tests that show that common-method bias is not a severe threat to our data. Because of the labor structure of this organization, the organization benchmark

Figure 4. Nomological Net Used for Model Benchmarking



sample consists of comparatively young participants (95% are between 18 and 34 years old).

6.3. Model Fit and Path Estimates

For the panel benchmark sample, we considered the full nomological net (Figure 4). For the organizational benchmark sample, we considered only stressors and strain (Ragu-Nathan et al. 2008, Ayyagari et al. 2011) due to the comparatively low sample size and issues with the psychometric properties of some scales of the dependent variables (notably, no issues with the stressor scales). We performed CB-SEM on all six models using both benchmarking samples (i.e., plugging in Models A–F from Figure 3 in the nomological net). For the panel benchmark sample, each model met some targets and slightly missed other targets for key model fit measures. For the organizational benchmark sample, the fit measures were inferior to the panel benchmark sample, with most targets not being met. A key reason might lie in the comparatively low sample size. Hence, the structural model results from the organizational benchmark sample should be interpreted cautiously. Overall, this analysis of model fit did not allow us to rule out any stressor model as inappropriate while retaining other models. Turning to the structural model, most path coefficients had the hypothesized sign and were significantly different from zero. Details are presented in the Online Appendix.

6.4. Explanatory Power

We analyzed the adjusted share of variance explained (adjusted R^2) in the psychological responses and outcomes as the measure of explanatory power. Considering the panel benchmark sample, the variance explained in the psychological responses is substantial (Table 4). The DHS model with either measurement model and the model by Ragu-Nathan et al. (2008) performed particularly well. Among the outcomes, the effect of stressors on attrition is fully mediated by distress and job satisfaction (Califf et al. 2020). Hence, it is not surprising that the different models explained little difference in the variance.

For the organizational benchmark sample, the variance explained in terms of strain is also provided in Table 4 (to the right of the dashes). The DHS model performed best on the organizational benchmark sample, especially with the parsimonious measurement model.

In sum, the data from the two benchmarking samples suggest that the DHS model with either measurement model performed very well. There was little difference in the variance explained by DHS with respect to the two measurement models. Any difference observed tended to favor the parsimonious measurement model. None of the benchmark models substantially outperformed either of the variants of the new digital hindrance stressor model on any variable or data set. On the contrary, the new digital hindrance stressor models introduced here outperformed (numerically and in an ad-hoc interpretation of the differences in adjusted R^2; no test for statistical significance) each of the benchmark models on at least one comparison regarding the direct psychological responses to stressors.

7. Discussion

Our findings provide a unified perspective on the established but fragmented research on hindrance technostressors. We reviewed the literature on technostress, digital stress, and occupational stress and performed qualitative and quantitative empirical research. The purpose of our quantitative dominant mixed-methods study was developmental. The qualitative inferences from the prestudy combined with the structured literature search are as follows. (1) There is a large set of existing hindrance technostressor models in the

Table 4. Explanatory Power (Adjusted R^2) of the Competing Models Embedded in the Nomological Net and Estimated on the Panel Benchmark Sample ($n_7 = 750$)/Organizational Benchmark Sample ($n_8 = 112$)

	Digital hindrance stressors		Hindrance technostressors			
Dependent variables	Extensive measurement model	Parsimonious measurement model	Ragu-Nathan et al. (2008)	Ayyagari et al. (2011)	Benlian (2020)	Califf et al. (2020)
Psychological responses						
Strain	**0.43/0.36**	**0.44/0.39**	**0.43**/0.32	0.36/0.29	0.29/0.16	0.38/0.23
Negative affect	**0.37**	**0.39**	**0.41**	0.31	0.25	0.32
Distress	**0.56**	**0.59**	**0.58**	0.42	0.29	0.52
Outcomes						
Job satisfaction	**0.19**	**0.20**	**0.19**	**0.21**	0.14	0.17
Attrition	**0.67**	**0.67**	**0.67**	**0.67**	**0.66**	**0.67**

Notes. Values for the organizational benchmark sample for strain behind the slashes. All other values are from the panel benchmark sample. Bold font indicates that the adjusted R^2 value makes up at least 90% of the highest adjusted R^2 for the respective dependent variable (i.e., the maximum value in each line). For strain, it relates to the maximum value for each of the two presented data sets.

literature. (2) Taken together, these models account for 12 HTSs. (3) Despite some models' age, none of the individual HTSs is obsolete in contemporary work practice. (4) The set of 12 HTSs appears to be a complete set of the most important contemporary HTSs, as neither the literature nor engaging 15 experts and 46 workers in qualitative discussions suggested further stressors. Of course, this is no guarantee that future studies (in different/new work settings) will not find further digital hindrance stressors. (5) No previous study has come close to examining the full breadth of hindrance technostressors.

The quantitative inferences include: (1) The 12 DHSs have discriminant validity. (2) They are related to five second-order superordinate DHSs, which can be summarized in an overarching superordinate DHS construct. (3) The DHS model has an extensive and a parsimonious measurement model. (4) The DHS model—especially with its parsimonious measurement model—performs no worse and in some cases better than prior models in terms of explanatory power for the psychological response to hindrance stressors and outcomes. The meta-inference is a new model of digital hindrance stressors.

7.1. Contributions and Implications for Research

The contribution made by this paper is fourfold. (1) It tests whether the classical models of hindrance technostressors are still up-to-date and suggests an evolution toward the concept of *digital hindrance stressors*. (2) It contributes a *unified, hierarchical model of digital hindrance stressors at work* that captures the full breadth of the conceptual domain of technology-related hindrance stressors at work. This DHS model goes substantially beyond any single prior hindrance technostressor model and marginally beyond the combination of prior models, representing a combination that has not been studied before. (3) It provides both an *extensive and a short-scale measurement model* for the unified model of digital hindrance stressors. (4) It guides researchers and practitioners on when to use which model of hindrance technostressors or digital hindrance stressors (as elucidated later).

Our study was motivated by two issues concerning the state of research on occupational hindrance technostressors: (1) unclear evidence regarding the up-to-dateness of the extant models and (2) the lack of a model covering the breadth of the conceptual domain. Our contributions resolve both issues: We provide a theoretically and empirically backed unified model of DHSs and offer extensive qualitative and quantitative empirical evidence showing that the stressors in this model are relevant to contemporary digital work.

7.1.1. Up-to-Dateness and Digital Stressors. Following a general call by Compeau et al. (2022) emphasizing the need for caution when applying constructs (like technostressors) that were developed in now-outdated contexts, our research was motivated by the fundamental digital transformation of work in recent decades. Similar skepticism about the appropriateness of classical HTS models can be found in Benlian (2020) and Fischer et al. (2021). Our findings indicate, somewhat surprisingly, that none of the hindrance technostressors traditionally studied is out of date. Despite changes in the socio-technical environment at work over decades, they are still relevant. Furthermore, our qualitative study aimed at surfacing additional stressors suggested only one addition not yet considered in technostress literature: lacking a sense of achievement. This result resembles the work by Califf et al. (2020), who interviewed nurses to identify technostressors. The resulting hindrance technostressors could be linked to existing constructs. Similarly, Benlian (2020) conducted a qualitative study to develop a measurement scale for technology-driven hindrance stressors. The eight items on the scale can be linked to existing constructs.

In the overall view of these results, we find that each of the individual lowest-level HTS considered in the literature is up to date in the sense of being relevant in contemporary work settings. However, none of the existing hindrance technostressor models from the literature is up to date in the sense of adequately covering the phenomenon of technology-related hindrance stressors in contemporary work settings.

7.1.2. Unified Model of Digital Hindrance Stressors. We identified 12 stressors and, based on theoretical and empirical evidence, derived and validated a unified model of DHSs. This model builds on prior technostress research and is substantially more complete than any prior account of hindrance technostressors. Furthermore, we grouped stressors treated with different terminology in different studies based on their conceptual and empirical relationships. We grouped them into five second-order DHSs: technology-related overload, technology-related task obstruction, technology-related ineffectiveness, technology-related surveillance, and technology-related rumination. Overload most directly relates to prior technostress research (Ragu-Nathan et al. 2008, Ayyagari et al. 2011). The other second-order DHSs are an empirically informed and theoretically backed abstraction of multiple known stressors. We believe that our identification and characterization of these constructs allow for further theorizing of digital stressors and digital stress on a more abstract level than previously possible. We also acknowledge the argument of Nastjuk et al. (2023) in favor of research on disaggregated stressors, and our model allows individual stressors to be positioned within a holistic perspective on digital hindrance stressors. Nevertheless, we maintain that a single superordinate digital hindrance stressor construct is an important contribution because it is theoretically appropriate, more parsimonious, more generalizable, and less complex than a disaggregated model.

7.1.3. Extensive and Parsimonious Measurement Models. The DHS model has two measurement models. The extensive measurement model has multi-item scales for each first-order DHS. Although most of these scales were adapted from prior technostress research, three were newly developed. These multi-item scales allow for the high-quality measurement of each DHS. However, because responding to a set of 51 items overall is burdensome for survey respondents, we developed a parsimonious measurement model with 13 items covering the breadth of the conceptual domain of DHS and measuring each second-order DHS with two to three items. Because both measurement models have been validated, possess satisfactory psychometric properties, and work for DHSs, both models will be useful for future research.

7.1.4. Model Comparison. We empirically benchmarked the DHS model with its two measurement models against the current standard model from Ragu-Nathan et al. (2008) and the hindrance technostressor models of Ayyagari et al. (2011), Benlian (2020), and Califf et al. (2020). Table 5 summarizes the models for DHS and HTS along key dimensions. Theoretically, the DHS model outperforms the HTS models in providing better coverage of the phenomenon of technology-related hindrance stress at work. Practically, the parsimony of the measurement model is important. Here, our DHS model with parsimonious measurement excels, along with the models of Benlian and Ayyagari et al. Empirically, all six models are about equal in model fit.

Although there are empirical model differences, one might be tempted to disregard the new DHS model for lack of substantial empirical superiority. However, this would be a mistake, as properly theorizing stressors related to digital work is critically important. Explanation and prediction are different functions of IS theories, and all models included here are theories for explaining and predicting (Gregor 2006). The DHS model excels at explaining, as it more broadly covers the theoretical domain. Although it is only slightly better than the other models at predicting, prediction is only one of two important functions.

To understand the importance of covering the breadth of the conceptual domain, it is crucial to differentiate between the first-order reflective construct indicators and those of the second-order superordinate constructs (Polites et al. 2012). In the case of first-order reflective constructs, indicators are deemed interchangeable, allowing for estimating the construct even if not all indicators are available (Petter et al. 2007). "In contrast, when modeling superordinate constructs, it is

Table 5. Comparison of Different Models of Digital Hindrance Stressors and Hindrance Technostressors

	Digital hindrance stressors		Hindrance technostressors			
Criteria	Extensive measurement model	Parsimonious measurement model	Ragu-Nathan et al. (2008)	Ayyagari et al. (2011)	Benlian (2020)	Califf et al. (2020)
Coverage of the conceptual domain (number of stressors)	High (12)	High (12/5)	Low (5)	Low (5)	Medium (7)	Low (5)
Parsimony of measure (number of items)	Low (51)	High (13)	Medium (22)	High (17)	High (9)	Medium (22)
Model fit	Good	Good	Good	Good	Good	Good
Performance regarding psychological responses (adjusted R^2 range)	High (0.36–0.56)	High (0.39–0.59)	High (0.29–0.59)	Medium (0.29–0.42)	Low (0.16–0.29)	Medium (0.23–0.52)
Performance regarding job satisfaction (adjusted R^2)	High (0.19)	High (0.20)	High (0.19)	High (0.21)	Medium (0.14)	Medium (0.17)

Notes. Gross categorizations based on ad hoc thresholds. Details for different responses and outcomes on different samples are in Section 6. Benlian (2020) and Califf et al. (2020) also consider challenge technostress. This is out of scope in the present paper. We do not discuss attrition as an outcome, as stressors only indirectly affect it. For the DHS model with parsimonious measurement model, we write "12/5" as the number of stressors to indicate that the model covers the breadth of all 12 stressors theoretically and in its measurement model but aggregates them to 5 DHSs.

not safe to assume that the dimensions are interchangeable or that a second-order construct may be estimated in the absence of a dimension" (Polites et al. 2012, p. 27). Doing so would imply that each dimension equally represents the overarching construct and manifests it to the same extent (Edwards 2001). However, the residual variances can differ among the dimensions of the higher-order constructs (Edwards 2001). Hence, "it is important to conceptualize and measure all dimensions of a superordinate construct" (Polites et al. 2012, p. 28). Each dimension offers a distinct facet of the theoretical concept and uniquely relates to the overall construct. Therefore, although it is reasonable to expect the dimensions to be correlated, it would be incorrect to assume they are interchangeable (Rindskopf and Rose 1988).

7.1.5. Future Model Use. Each model of hindrance technostressors and digital hindrance stressors should be used for different research purposes (Table 6). The DHS model is appropriate for researchers seeking to explain the phenomenon of technology-related hindrance stress in its full richness. Theories can describe a phenomenon of interest and relationships among constructs or explain how and why things happen (Gregor 2006). With these goals in mind, the DHS model provides researchers with a unified and timely model to approach the phenomenon—for example, when researchers wish to analyze specific antecedents, outcomes, inhibitors, or coping strategies related to DHSs or to explore the hierarchical structure further.

In contrast, rather than seeking to describe and explain a phenomenon holistically, some researchers may be interested in using the stressor construct as a predictor, moderator, or control variable. With prediction, the focus is on testable propositions, and well-developed justificatory causal explanations may not be needed (Gregor 2006). In this case, it is vital to have a construct with high predictive power that can explain much of the variance of the dependent variables but is not unnecessarily complex or difficult to measure. For such cases, we specifically recommend the parsimonious-measurement DHS model.

The long-standing models from Ragu-Nathan et al. (2008), Ayyagari et al. (2011), and others should be used when researchers aim to replicate findings from prior literature or when high comparability with prior studies is important. The models of Benlian (2020) and Califf et al. (2020) are uniquely suited for research combining hindrance and challenge technostressors and researching both the bright and dark sides of stress. However, because these two models treat challenge and hindrance stressors as clearly distinctive, our DHS model could eventually be plugged into their challenge/hindrance distinction.

7.1.6. Future Model Updates. When should the digital hindrance stressor model be updated? It should be updated when there are severe conceptual or empirical limitations (Compeau et al. 2022, step 1). Conceptual limitations might arise from technological development, diffusion, and associated organizational and societal changes. Empirical limitations might, for example, show a lack of fit of the model to new datasets or a potential future decline of explanatory power. There is always the possibility that updates are necessary, but we do not expect the time to be soon. The different waves of data acquisition reported in this paper span from April 2018 to July 2023: more than five years with a rise of artificial intelligence at work and in the media and a pandemic that temporarily disrupted the organization of work and seems to have long-term effects on, for example, hybrid and remote work. Thus, the model development included somewhat different contexts, and there appeared to be no major effects on the digital hindrance stressors. The intensity of digital stress might change over time and has substantial variation between persons and digital work contexts. However, the conceptualization of digital hindrance stressors appears to be remarkably stable. Hence, we would be surprised if a major update would be required in the next 10 years.

Table 6. Primary Reasons for Using the Different Models

	Digital hindrance stressor, extensive measurement model	Digital hindrance stressor, parsimonious measurement model	Established technostressor models
For researchers	Describing and explaining	Predicting	Comparability with prior studies. For recent models, integration with challenge technostressors.
For practitioners	Identification of inhibitors and coping strategies specifically for digital hindrance stressors	Analysis of digital hindrance stressors as one of multiple aspects of a psychological risk assessment	Comparability with prior risk assessments. For recent models, integration with challenge technostressors to inform work design.

Research on hindrance technostress at work has decades of history. Compared with that, research on technostress in the private domain and challenge technostress is relatively recent. Once the body of knowledge in these realms matured, it might be time for an integrated model of digital stressors.

7.2. Limitations

As with any work, this study has limitations that should be considered. First, we limited our analysis to technology-related hindrance stressors in the work context, covering an important phenomenon in practice and the bulk of prior technostress literature. However, we omitted the relevant but less mature research streams on challenge technostress and private contexts. We believe that further research in these emerging streams is needed and could eventually lead to an even broader unified view of technology-related stress.

Second, we engaged with 61 individuals in the qualitative phase of our research, with 39 researchers for card-sorting, and collected survey responses from 5,867 workers in various industries and occupations in the quantitative phases. Any sampling and survey procedure has limitations (Lowry et al. 2016). Thus, we have some diversity in our procedures to balance issues related to, for example, biased sampling or respondents' incentives. The quantitative data were obtained from respondents via two panel providers in different countries (Germany and the United States), in different languages (German and English), and within an organization. The data were obtained in multiple waves between 2018 and 2023. Panel participants were paid; participants in the organization were not paid specifically for the survey. Although we believe that the study's data represent a strength, there are always limitations associated with sampling. The qualitative prestudy could have involved more heterogeneous experts and employees. In the quantitative studies, the samples are diverse in terms of age, gender, and educational background but have limited cultural diversity and only limited differences in terms of the national regulatory framework in which their work is embedded. There is no reason to believe that our sample is representative of the global workforce.

Finally, we provided little information about the methodology due to length restrictions. Details are provided in the Online Appendix. Upon publication of the manuscript, the quantitative data and statistical analysis scripts will be made publicly available to allow other researchers to replicate our findings and leverage our data.

8. Conclusion

Digitalization has dramatically transformed modern society. However, tremendous benefits come with a dark side, including hindrance stress related to digital technologies at work and the subsequent negative psychological responses and outcomes. Our research contributes to understanding hindrance technostressors by unifying a fragmented stream of research. It lays a foundation for further research regarding the antecedents, appraisal, coping, and outcomes of digital hindrance stressors and for designing social, technical, and socio-technical systems seeking to limit excessive stress and its negative consequences.

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Endnotes

[1] The models by Tarafdar et al. (2007) and Ragu-Nathan et al. (2008) are identical with respect to the technostressors. In the following, we use Ragu-Nathan et al. (2008) to refer to that model.

[2] "Technostress is composed of five dimensions" might be perceived as misleading depending on how one uses the word dimensions. When one considers stress as a process (which is consistent with Califf et al.'s conceptualization), stress can reasonably be seen as involving more dimensions. We think this formulation is meant to express that classically five hindrance technostressors are considered.

[3] Califf et al. (2020) also considered challenge stressors. We focus on hindrance stressors here.

[4] Benlian (2020) also considered challenge stressors. We focus here on hindrance stressors. A further motivation for Benlian's new measurement scale was the need for a parsimonious scale for daily surveys.

[5] Califf et al. (2020) use the term *negative psychological response*. To avoid confusion with the overarching category *psychological responses* we use the term *distress*, as Califf et al. build their construct on the K10 Psychological Distress Scale.

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