

**Measuring Work Demands and Resources of Digitalisation:  
The ICT Resources and Stressors Scale**

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### Abstract

The last decades have been characterised by new information and communication technologies (ICTs) and the associated digital transformation of work and working conditions. The digitalisation holds a lot of potential, for example through the automation of simple or monotonous tasks and the reduction of work requirements. On the other hand, stress monitoring studies indicate that this process has been accompanied by an increase in work-related stress. Nevertheless, validated self-report instruments measuring stressors and resources from digitalisation are still only scarcely available. Thus, this study aimed to identify specific ICT-related resources and stressors and to develop a questionnaire that is broadly applicable to employees in different sectors and professions. First, we identified existing ICT-specific constructs and revised their definitions to ensure content validity. Experts then rated the comprehensibility and content validity of these scales. Subsequently, 375 individuals participated in an online survey to conduct an item analysis and to evaluate reliability and validity. The resulting questionnaire comprises the three resources *involvement facilitation*, *ICT control*, and *ICT resources and upgrades*, as well as the stressor *telepressure*. The four scales comprise a total of 16 items, which performed well in our item analysis and showed good reliabilities. Subsequent analyses using structural equation modelling revealed that the indicators appropriately capture the constructs at the scale level. Furthermore, they predict health and organisational outcomes beyond the influence of established general resources and stressors, thus demonstrating incremental validity. The new ICT Resources and Stressors Scale is recommended for use in organisational settings or stress monitoring studies.

**Keywords:** Digitalisation, ICT resources, ICT stressors, technostress, scale development, job demands-resources theory

## Introduction

*‘Believe me, if it can be digitized, it will be’* said Carly Fiorina, former CEO of Hewlett-Packard in 2000. The last two decades impressively demonstrated that this is indeed the case. Driven by new information and communication technologies (ICTs) with an increasing number of uses and applications, digitalisation has changed our world and fundamentally transformed the work environment. Consider how the ubiquity of computing devices has changed the way we consume news, and buy things, and how online messenger services or videoconference software allow us to collaborate remotely and in real-time with our colleagues who are in different locations. The Covid-19 pandemic has further accelerated digital transformation, for example by increasing working from home models (i.e. telework, Zürcher et al., 2021) and the use of digital solutions to replace physical meetings (Döhring et al., 2021; Nagel, 2020). This wave of digital transformation holds a lot of potential, for example through the automation of simple or monotonous tasks and the reduction of work requirements (Demerouti, 2022; Sarmah, 2019), or the opportunity to learn new technologies and thus new skills (Collin et al., 2021), but may also lead to an increase in the pace of work and the perceived workload (Kubicek et al., 2015; Mauno et al., 2019). As Parker and Grote (2022) suggest, proactive work design choices play a crucial role in employee resources as well as individual and organisational outcomes during technology implementation. Meanwhile, many changes of work tasks and work conditions have been accompanied by an increase in work-related stress and emotional exhaustion in the last decade (Cianferoni, 2023; Galliker et al., 2022; Galliker et al., 2024; Igic et al., 2017; Krieger & Arial, 2020; Krieger et al., 2017; Leclerc et al., 2022; Techniker Krankenkasse, 2021; Tritschler et al., 2022). In recent years, stress monitoring studies started to include the use of ICTs in their scope. However, research on ICT influence on stress experience and well-being is still scarce, as the assessment of resources and stressors is primarily based on instruments that measure well-

established constructs in stress research, but which do not focus on ICTs (e.g. ISTA, Irmer et al., 2019; Semmer et al., 1999; SALSA, Udris & Rimann, 1999; BASA II, Richter & Schatte, 2011; COPSOQ, Burr et al., 2019; Kristensen et al., 2005; etc.). These instruments mostly capture resources and demands on a general level such as job control, time pressure, uncertainty regarding work tasks (e.g. Semmer et al., 1995), or social stressors due to superiors or colleagues (e.g. Frese & Zapf, 1987). The fact that new types of stressors or resources resulting from ICTs are not yet part of a systematic stress assessment, is also due to the lack of established operationalisations. In particular, and to the best of our knowledge, no questionnaire to date comprehensively captures and measures both, specific resources and stressors related to digitalisation. Considering the significant influence of ICTs on our lives, organisations must recognise their impact on the well-being of their employees. Only then appropriate actions can be initiated to increase resources and minimise stressors.

### **The Need for a New Scale**

In our opinion, incorporating a comprehensive questionnaire to assess stressors and resources resulting from digitalisation is crucial for organisational success. Such a scale could serve as an essential tool for identifying potential risks to employee well-being stemming from the rapid changes associated with digital transformation. By systematically measuring ICT-related stressors and their effects on outcomes such as workload (e.g. Zinke et al., 2023), work intensification (Mauno et al., 2019), or technological uncertainty (e.g. Pfaffinger et al., 2020), organisations can pinpoint specific areas needing attention and intervention. This could help mitigate the risks of burnout and turnover associated with digital transformation. High levels of stress resulting from rapid changes and uncertainty can lead to employee disengagement, decreased morale, and ultimately, turnover. By proactively identifying stressors and providing targeted support, organisations can create a supportive work

environment that promotes employee well-being and reduces the likelihood of burnout and turnover, preserving institutional knowledge and fostering organisational citizenship among employees. Moreover, a scale that also measures ICT-related resources would further allow organisations to understand which resources are crucial for their employees to use ICTs successfully. This enables companies to ensure that their employees have the necessary tools and support systems to effectively master digital challenges.

In addition to the practical applications within organisations, a questionnaire assessing resources and stressors in the context of digitalisation is also invaluable for research purposes. By collecting data on ICT-related stressors and resources, researchers gain insights into the digital workplace's complexities. This data informs strategies to mitigate negative impacts and promote positive outcomes. Thus, such a questionnaire may contribute not only to understanding future challenges but also to developing interventions for individuals, organisations, and society.

Measuring ICT-related resources and stressors is thus imperative for organisations to gain insights into the specific challenges their workforce faces and tailor interventions to enhance the positive aspects of ICT use while mitigating potential negative consequences. Our study aims to contribute to the expanding body of literature by identifying a comprehensive range of existing ICT-related resources and stressors and developing a self-report questionnaire for their assessment in organisational settings, thereby offering practical insights for fostering a healthy and productive work environment.

### **Theoretical Considerations**

We conducted our study based on established theories of stress research. Zapf and Semmer (2004) define stress as a perceived imbalance between demands (i.e. stressors) and a person's ability (i.e. resources) to respond to them. This imbalance is perceived as unpleasant and reduces well-being. Chronic work-related stress can lead to illness. The present study uses the job demands-resources model (Bakker & Demerouti, 2007; Demerouti et al., 2001) as a framework to explain how stress occurs and applies it to the context of ICTs. Central to the model is the assumption that resources and demands are triggers for two different and independent processes. On the one hand, work demands deplete personal physical and psychological resources and thus impair health. On the other hand, work resources fulfil psychological needs and thus primarily influence attitudes towards work. It is further assumed that there are interactions between resources and work demands, in that the positive effects of resources have a mitigating effect on the negative influences of work stressors.

### **The current research**

This paper reports the development and validation of the ICT resources and stressors scale. The instrument was designed as a short self-report questionnaire that can be broadly applied in the population of employees regardless of their field of work or their occupation. We followed the questionnaire development process as suggested by MacKenzie et al. (2011) and answered the following research questions:

1. Is there existing research on constructs concerning resources and stressors resulting from digitalisation and are scales available for measuring them?
2. Do these scales satisfy content validity?

3. Do these scales and their items meet the requisites concerning response characteristics, reliability, construct validity, criterion validity, and incremental validity?

Table 1 below shows the steps of the validation procedure. To answer research questions one and two, we first conducted an extensive literature search and identified existing validated scales and items from international studies (step I). We revised the definitions of the constructs and optimised the items if necessary. Then, we ensured the content validity as well as comprehensibility of the scales in a preliminary study, subject matter experts were surveyed for this purpose (step II).

To answer research question 3, we carried out several analyses (steps III-IX). To this end, we conducted an online validation study in which a total of 375 German-speaking employees in Switzerland took part. Based on this data, we first conducted an item analysis (step III). To establish construct validity we then analysed the measurement models with confirmatory factor analyses (CFA) (step IV) and performed a known-group comparison (step V), as suggested by MacKenzie et al. (2011). In steps VI to IX, we assessed criterion and incremental validity using structural equation modelling (SEM). To measure criterion validity, we examined whether ICT stressors and resources influence health outcomes (i.e. exhaustion, well-being, and general health) and attitude towards work (i.e. job satisfaction, intentions to quit, and affective commitment). These variables have been previously used as outcome variables (e.g. Igic et al., 2014; Igic et al., 2017). In line with the job demands-resources model (Bakker & Demerouti, 2007) we then examined whether the ICT resources moderated the relationships between ICT stressors and the outcome variables. Next, we examined if the relationships persisted when relevant control variables (i.e. age and attitudes towards digital change) were taken into account. Age is associated with a more positive attitude towards work, fewer stressors, more resources, and less emotional exhaustion. Older

workers are also more satisfied and less likely to quit their jobs (Kooij et al., 2010; Ng & Feldman, 2010). A negative attitude towards technological change is related to more perceived difficulty in using ICTs (Nov & Ye, 2008) and could thus lead to increased perceived stressors related to ICTs. In the final step, we tested whether our ICT Resources and Stressors scale explained additional variance in health and job outcomes when established resources and stressors are considered. For this, we selected the resources *job control*, *task completeness*, and *participation*, as well as the stressors *qualitative overload*, *social stressors from work colleagues*, and *problems with the organisation of work tasks (POWT)*, which have shown robust relationships with the outcome variables (e.g. Igic et al., 2014; Igic et al., 2017). Table 1 summarises all steps of the validation procedure.

**Table 1**

Validation procedure and steps of analysis

Step	Research Question	Type of analysis / procedure	Description	Level of analysis
I	1	Identification	Identification of relevant constructs and scales	Constructs, scales
II	2	Content validity	Revision of definitions and adaptation of items. Preliminary study with subject experts.	Constructs, scales, items
III	3	Item analysis	Analysis of response frequencies, variances, item difficulty, item discrepancy indices, and reliabilities.	Single items, scales
IV	3	Analysis of measurement models	Verification of model goodness-of-fit, average variances extracted (AVE) and loadings of indicators using confirmatory factor analysis.	Single items, scales
V	3	Known-group comparison	Verification if scales can measure mean differences in known groups and show measurement invariance.	Entire questionnaire
VI	3	Analysis of criterion validity	Verification of predictive power of ICT resources and stressors regarding health and work attitudes.	Single scales
VII	3	Analysis of interaction effects	Examination of moderation effects by ICT resources on the relationship between ICT stressors and health, or work attitudes.	Single scales



Step	Research Question	Type of analysis / procedure	Description	Level of analysis
VIII	3	Impact of control variables	Verification if relationships between variables were preserved when relevant control variables were taken into account.	Single scales
IX	3	Incremental validity	Verification if ICT resources and stressors could explain additional variance above more general resources and demands.	Entire questionnaire

### Step I: Identification of relevant constructs and scales

To obtain an overview of the state of research, we conducted a literature search using the keywords *digital stress*, *digital resources*, *digital demands*, and *digitalisation & stress* in both, German and English. We used the databases PSYINDEXplus, PsycINFO, Scopus, and Google Scholar for the search, adhering to the standards of consulting at least two separate databases as recommended by Siddaway et al. (2019). In addition to the keyword search, German and English peer-reviewed journals were consulted to search for specific articles on these topics. To get a comprehensive overview of the existing literature we also examined grey literature, searching for relevant reports on institutional websites (e.g. the *Bundesanstalt für Arbeitsschutz und Arbeitsmedizin*). This led to the identification of a total of 99 articles and scientific reports regarding stress in the context of digitalisation. After screening the literature, a total of nine research areas were identified (see Appendix A for an overview). To be further considered we selected constructs (1) where scales for their measurement were available, (2) that were novel (i.e. not covered by commonly used instruments), and (3) were widely applicable (i.e. not limited to certain professions). This resulted in a final selection of eleven constructs from four different subject areas, which are subsequently described.

#### ICT demands and resources

Day et al. (2010) developed a framework for ICT demands and resources based on the job demands-resources model (Bakker & Demerouti, 2007; Demerouti et al., 2001), the

transactional stress model (Lazarus, 1966; Lazarus & Folkman, 1984) and the conservation of resources theory (Hobfoll, 1989). ICT demands were defined as ‘any ICT factor or process at work involving some type of storing, transmitting, or processing technology (e.g., computer programs) or device (e.g., computer, cell phone) that have the potential to be perceived as stressful by workers’ (Day et al., 2010, p. 324). ICT demands include *response expectations*, *availability*, *poor communication*, *lack of control*, *ICT hassles*, *employee monitoring*, *learning expectations*, and *workload*. ICT resources include *personal assistance* and *ICT resources/upgrades* and were defined as “any ICT factor or process at work [...] that assist employees with the completion of their work, reduce the burden of job demands, or that promote personal growth and development.” (Day et al., 2010, p. 324). According to Day et al. (2012), ICT demands and resources are associated with job demands such as overload, ambiguity, and job control as well as with health outcomes like experience of stress, strain, exhaustion, and cynicism.

### **Technostress**

Stress resulting from technological change has long been a research topic in the field of information systems. Brod (1984) introduced the term *technostress*, which describes a stress response resulting from the maladaptive use of ICTs. Based on the transactional stress model (Lazarus, 1966; Lazarus & Folkman, 1984), Tarafdar et al. (2007) and Ragu-Nathan et al. (2008) developed the technostress inventory. They identified technostress creators (i.e. stressors) that can lead to stress experiences as well as technostress inhibitors (i.e. resources) that reduce these effects (see Tarafdar et al., 2007). The technostress creators include *techno-overload* (a sensation that ICTs force their users to work more and faster), *techno-invasion* (all-time accessibility through ICTs), *techno-complexity* (feeling of inadequacy resulting from ICT use), *techno-insecurity* (job-insecurity because of ICTs), and *techno-uncertainty* (arising from continuing changes in ICTs). The technostress inhibitors include *literacy*

*facilitation* (organisational support for learning new ICTs), *technical support provision*, and *involvement facilitation* (inclusion of employees in technological change and encouraging interaction). Since its conceptualisation, technostress has been extensively investigated and expanded, and there is empirical evidence of its predictive value (see for example Ayyagari et al., 2011; D'Arcy et al., 2014; Galluch et al., 2015; Kaltenegger et al., 2023; Maier, 2014; Maier et al., 2015; Nimrod, 2018; Riedl, 2012; Riedl et al., 2012; Salanova et al., 2013; Sarabadani et al., 2018; Tarafdar et al., 2011). Technostress has been associated with job satisfaction, organisational commitment, turnover intentions, role overload, role conflict, reduced productivity, and increased role stress as well as with health outcomes such as exhaustion, burnout, and strain. Expanding upon the technostress framework, Ayyagari et al. (2011) identified characteristics of ICTs that function as antecedents of technostress creators, using the person-environment fit model (Edwards & Cooper, 1988) as a theoretical basis. A key characteristic is the *usability* of ICTs. When used voluntarily, usability is associated with the acceptance and use of ICTs (Weil & Rosen, 1997). In the work context, where the use of ICTs is not voluntary per se, employees have to use the available technologies despite a possible low perceived usability. This can lead to an increase in perceived workload and health problems such as musculoskeletal pain (Åborg & Billing, 2003). Ayyagari et al. (2011) consider *usefulness* an important aspect of ICT usability (next to *complexity* and *reliability*). Technologies that are considered useful reduce feelings of workload, leading to employees accomplishing work tasks faster and being more productive (Ayyagari et al., 2011).

### **Telepressure**

*Workplace telepressure* is defined as “the combination of a strong urge to be responsive to people at work through message-based ICTs with a preoccupation with quick response times.” (Barber & Santuzzi, 2015, p. 172). Workplace telepressure can negate the

benefits of asynchronous communication (e.g. flexible response times) if employees start to view it as a synchronous form of communication that requires an immediate response. This can lead to prioritising responding to messages and neglecting recovery times. Telepressure involves internalising existing norms of expectation in the workplace and is associated with workaholism, absenteeism, poorer sleep quality, work overload, emotional exhaustion, less detachment from work, lower satisfaction with one's work-life balance (Barber & Santuzzi, 2015; Barber et al., 2019; Grawitch et al., 2018; Santuzzi & Barber, 2018) and its effects on a range of biological parameters is currently being researched (Semaan et al., 2023).

To summarise, the research on ICT demands and resources, technostress and telepressure contains important promising constructs that received empirical evidence on their predictive value and can make an additional incremental contribution to predicting occupational health and well-being, and attitudes towards work like job satisfaction, affective commitment, and turnover intentions beyond existing established instruments that measure task-related stressors and resources (e.g. ISTA, Irmer et al., 2019; Semmer et al., 1999; SALSA, Udris & Rimann, 1999; BASA II, Richter & Schatte, 2011).

## **Step II: Scale selection, revision of definitions, and item adaptation**

The identified literature included scales for the measurement of the constructs. We contacted the authors, who all gave their consent for adapting their scales in the present study. Constructs, that did not meet the requirements in regards to being novel or widely applicable (e.g. techno-overload, techno-insecurity, response expectations, ICT hassles, etc.) or had considerable overlap with constructs from a different origin (e.g. technical support provision, Ragu-Nathan et al., 2008 with personal assistance, Day et al., 2012 or techno-complexity, Ragu-Nathan et al., 2008 with complexity, Ayyagari et al., 2011) were excluded from further adaptation. This resulted in eleven constructs measured by a total of 43 items:

techno-complexity, techno-uncertainty, literacy facilitation, and involvement facilitation (Ragu-Nathan et al., 2008; Tarafdar et al., 2007); usefulness (Ayyagari et al., 2011); poor communication, employee monitoring, lack of control, ICT resources & upgrades and personal assistance (Day et al., 2012); and telepressure (Barber & Santuzzi, 2015). Table 2 shows the identified constructs.

**Table 2***Identified constructs*

Construct (nr. of items)	Description	Origin of items
Techno-complexity (4)	Techno-complexity occurs when users experience their own skills as insufficient due to the complexity of ICTs and they are required to invest time and effort in learning and understanding them (Tarafdar et al., 2007)	Technostress creators (Ragu-Nathan et al., 2008)
Techno-uncertainty (4)	Techno-uncertainty arises when ICTs change constantly. As a result, users feel forced to keep up to date and learn new technologies (Tarafdar et al., 2007).	Technostress creators (Ragu-Nathan et al., 2008)
Literacy facilitation (4)	Organisations can reduce stress from ICTs by promoting the sharing of ICT knowledge within the organisation. It reduces stress by helping users understand ICTs and their impact, and by enabling them to cope with the demands of learning new ICTs (Ragu-Nathan et al., 2008).	Technostress inhibitors (Ragu-Nathan et al., 2008)
Involvement facilitation (3)	By involving employees in the process of technological change, i.e. by informing users about the reasons and expected effects of new technologies as well as motivating them to use new ICTs, organisations can reduce the negative impacts of the implementation process (Ragu-Nathan et al., 2008).	Technostress inhibitors (Ragu-Nathan et al., 2008)
Usefulness (4)	An ICT is useful when it improves work performance. Technologies that are considered useful reduce feelings of workload, leading to employees accomplishing work tasks faster and being more productive (Ayyagari et al., 2011).	Antecedents of technostress (Ayyagari et al., 2011)
Poor communication (3)	ICT-mediated communication offers great potential for errors because very few verbal or non-verbal signals are present (Rainey, 2000). Poor communication skills can lead to frustration and higher levels of strain in employees (Day et al., 2010).	ICT demands (Day et al., 2012)
Employee monitoring (4)	Monitoring employees' work performance, communication (emails or phone calls) or internet use during work using ICTs, may be perceived as an invasion of privacy. This can lead to higher feelings of stress, anxiety, depression, health complaints, anger, and exhaustion (Amick & Smith, 1992; Day et al., 2012; Lund, 1992; Schleifer & Shell, 1992).	ICT demands (Day et al., 2012)
Lack of control (3)	Lack of control describes the degree of influence employees have over the ICTs they use. Individuals with less control over ICTs are more anxious, and experience more frustration and more stress (Day et al., 2010; Day et al., 2012; Hair et al., 2007; O'Driscoll et al., 2010).	ICT demands (Day et al., 2012)
ICT resources & upgrades (4)	ICT resources & upgrades means providing current technology, necessary updates and training in the introduction of new ICTs. This can increase employees' self-efficacy and confidence in using new ICTs, which in turn can reduce stress (Beas & Salanova, 2006; Day et al., 2012).	ICT resources (Day et al., 2012)

Construct (nr. of items)	Description	Origin of items
Personal assistance (4)	Personal assistance reduces stress following operational problems with ICTs and can be provided by an organisation in the form of an IT support department. Technical IT support can increase employee engagement with ICTs (O'Driscoll et al., 2010). Competent support further leads to faster resolution of problems, which in turn results in fewer work interruptions (Ragu-Nathan et al., 2008) and thus has a positive impact on stress levels.	ICT resources (Day et al., 2012)
Telepressure (6)	Workplace telepressure manifests itself by constantly thinking about a received ICT-based message, accompanied by the urge to respond immediately (Barber & Santuzzi, 2015). Telepressure is associated with workaholism, absenteeism, poorer sleep quality, work overload, emotional exhaustion, less detachment from work, and lower satisfaction with one's work-life balance (Barber & Santuzzi, 2015; Barber et al., 2019; Grawitch et al., 2018; Santuzzi & Barber, 2018).	Telepressure (Barber & Santuzzi, 2015)

### Defining the Item Pool

As mentioned above, several scales were created over a decade ago and did not meet the specified requirements in Podsakoff et al. (2016) to have clear conceptualisations and definitions, and consequently needed to be adapted for contemporary use. Furthermore, following an interview study, Fischer et al. (2019) recommended revising and updating the technostress inventory. In addition, Nastjuk et al. (2023) describe in their meta-analysis how technostress creators have varying relationships with different outcome variables. Moreover, they are commonly aggregated in a second-order construct. In accordance with the job-demands-resources framework, we re-conceptualise each technostress creator as an individual stressor. Therefore, to ensure construct and content validity, we revised the definitions of all identified constructs using the guidelines in Podsakoff et al. (2016) and MacKenzie et al. (2011) specifying the conceptual domain and theme for each. This led to the reconceptualisation of ICT control as a resource instead of as a stressor that was defined solely through the absence of specific characteristics, and in accordance to previous research (e.g. Karasek, 1979; Semmer et al., 1995). Furthermore, we created new items in some

instances, to guarantee that all facets of the constructs are captured, and adapted item wordings to be consistent within the scale (e.g. regarding the use of the term information and communication technology). During this step, all items were translated into German and then retranslated by a native English speaker with a background in occupational and organisational psychology. Discrepancies were discussed and corrected where necessary. Eight people then participated in the preliminary study. All had a background in psychology and were recruited within the personal network of the authors. The objective was to ensure content validity as well as comprehensibility of the scales. Participants could give feedback for each construct as well as general feedback for the entire questionnaire. Most of the comments concerned the intelligibility of the items (e.g. unclear words such as “end user”) or their content (e.g. the items on *involvement facilitation* are asked from the perspective of the company and not from the perspective of the employees). Where modifications were possible without changing the meaning, the items were adapted accordingly. An overview of the revised items is shown in table 3. On the reader’s request, we can provide a full detail of the steps undertaken during this phase.



**Table 3***Revised items of the new questionnaire*

Construct	Item code	Items
Techno-complexity	TechCom_rag1	I do not know enough about the ICTs I use, to handle my job satisfactorily.
	TechCom_rag2	I can easily understand and use new ICTs. <sup>a</sup>
	TechCom_rag3	I do not find enough time to improve my ICT skills.
	TechCom_rag4	I often find new ICTs too complex for me to understand and use.
Techno-uncertainty	TechUnc_rag1	There are always new developments in the ICTs we use in our organisation.
	TechUnc_rag2	There are constant changes in computer software in our organisation.
	TechUnc_rag3	There are constant changes in computer hardware in our organisation.
	TechUnc_new1	I feel insecure due to the constant changes in ICTs in our organisation.
	TechUnc_new2	I wished the ICTs in our organisation were not constantly changing.
	TechUnc_new3	I am overwhelmed by having to learn new ICTs all the time.
Literacy facilitation	LiteFac_rag1	Our organisation emphasises teamwork in dealing with new ICT-related issues.
	LiteFac_rag2	Our organisation provides end-user training before the introduction of new ICTs.
	LiteFac_rag3	Our organisation fosters a good relationship between the IT department and end users.
	LiteFac_rag4	Our organisation provides clear documentation to end users on using new ICTs.
Involvement facilitation	InvoFac_rag1	We as end users are consulted before introducing new ICTs.
	InvoFac_rag2	We as end users are involved in the technological change and implementation of ICTs.
	InvoFac_New1	Our organisation communicates in a transparent way about the reasons for introducing new ICTs.
	InvoFac_New2	Our organisation communicates in a transparent way about the hoped-for effects of the introduction of new ICTs.
Usefulness	Usefuln_ayy1	The ICTs I use at work enable me to accomplish my tasks more quickly.
	Usefuln_ayy2	The ICTs I use at work improve the quality of my work.
	Usefuln_ayy3	The ICTs I use at work make it harder for me to do my job. <sup>a</sup>
	Usefuln_ayy4	The ICTs I use at work enhance my effectiveness.
Poor communication	PoorCom_day1	People often misinterpret my ICT-based text messages.
	PoorCom_day2	I often receive rude ICT based text messages from my colleagues or clients.

Construct	Item code	Items
	PoorCom_day3	I often misinterpret the tone of incoming ICT-based text messages.
Monitoring	EmpMoni_day1	My organisation uses ICTs to monitor my work.
	EmpMoni_day2	My organisation monitors my internet usage.
	EmpMoni_day3	My organisation monitors my emails.
	EmpMoni_day4	My organisation monitors my phone calls.
	EmpMoni_new1	I experience the monitoring of my work as an invasion of my privacy.
	EmpMoni_new2	I do not mind my organisation monitoring my work activities.
	EmpMoni_new3	I do not want my organisation monitoring my work activities.
ICT Control	Control_day1	I have no control over how I use ICTs at work. <sup>a</sup>
	Control_day2	I choose the types of ICTs I use in my work myself.
	Control_day3	ICTs allow me the flexibility to do my work when I want.
	Control_day4	ICTs allow me the flexibility to do my work where I want.
Personal assistance	PersAs_day1	Technical support is available at work when I need it.
	PersAs_day2	Our technical support staff are helpful.
	PersAs_day3	My organisation's technical support staff respond promptly to all my requests.
	PersAs_day4	Our technical support teaches me how to solve problems in case they happen again.
ICT resources & upgrades	ICTResU_day1	My organisation implements appropriate software as it becomes available.
	ICTResU_day2	My organisation uses the latest technology.
	ICTResU_day3	I receive the upgrades I need.
	ICTResU_day4	New ICT systems in my organisation are implemented on a timely basis.
Telepressure	Telepr_barsan1	It's hard for me to focus on other things when I receive a message from someone.
	Telepr_barsan2	I can concentrate better on other tasks once I've responded to my messages.
	Telepr_barsan3	I can't stop thinking about a message until I've responded.
	Telepr_barsan4	I feel a strong need to respond to others immediately.
	Telepr_barsan5	I have an overwhelming feeling to respond right at that moment when I receive a request from someone.
	Telepr_barsan6	It's difficult for me to resist responding to a message right away.

*Note.* <sup>a</sup> reverse coded after feedback in a preliminary study.

### **Steps III to IX: Item analysis and scale validation**

Next, we conducted an online survey for the validation of our ICT Resources and Stressors Scale. The study was reviewed and approved by the Ethics Committee of the Faculty of Human Sciences, University of Bern, Switzerland. Based on the data collected, we further validated the questionnaire and verified whether the scales and their items meet the requirements in terms of response behaviour, reliability, construct validity, criterion validity, and incremental validity.

## **Methods**

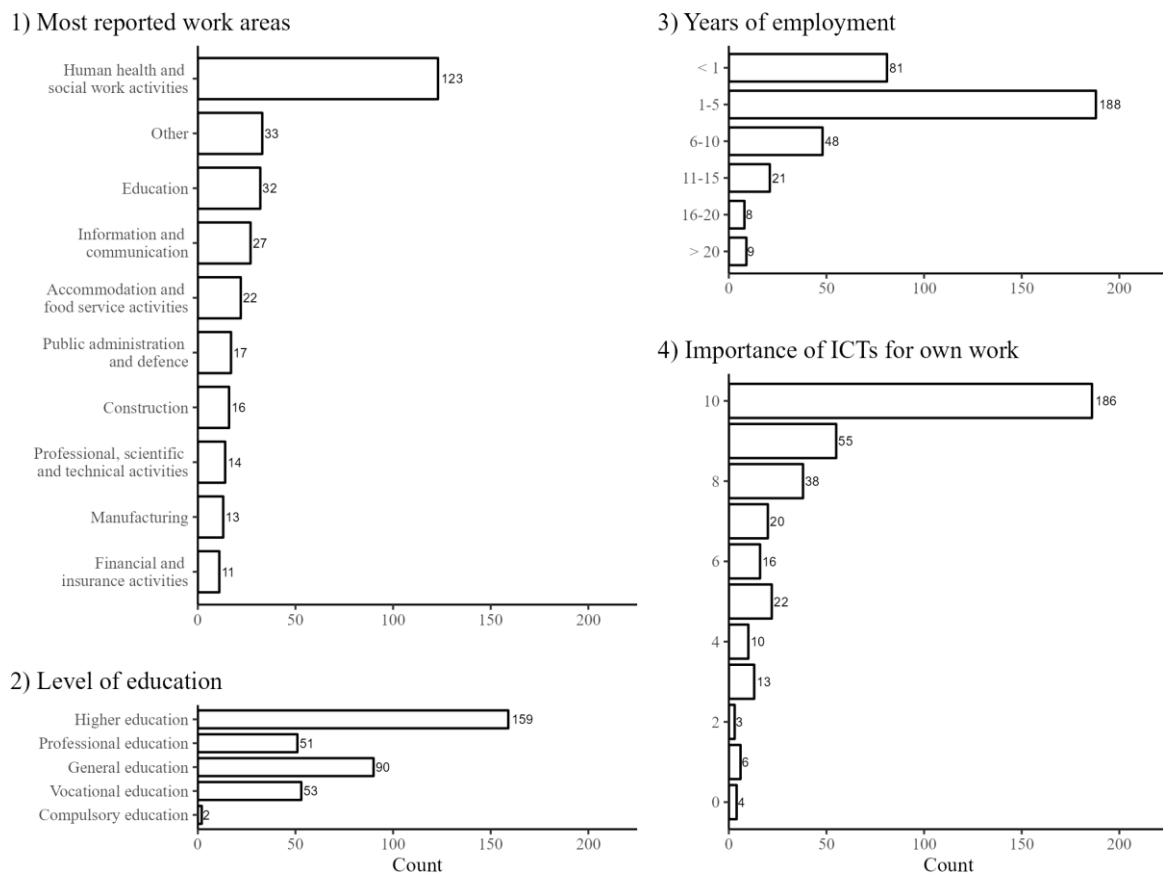
### ***Sample***

From November 2020 to February 2021, a total of 375 German-speaking employees in Switzerland (269 female, 103 male, 1 other, 2 no information) between 18 and 73 years ( $M = 34.1$ ,  $SD = 11.5$ ) completed the online survey. Participants in retirement age were included, if they indicated that they were still working. Among the participants were 38 employees of a foundation operating in the Swiss health sector. In addition, participants were recruited via the personal environment of the author ( $n = 105$ ) and social media ( $n = 149$ ). These participants had the opportunity to take part in a lottery for a CHF 50.00 gift certificate at the end of the survey. Furthermore, 83 participants were students from the University of Bern and received a course credit in exchange for their participation. Two individuals were excluded because they did not meet the requirement of employment of at least 20% or 8 work hours per week. Moreover, 17 participants were excluded for not completing the online survey carefully (details reported in section data analysis). Thus, the sample for validation contained the data of 356 participants. See figure 1 for an overview of the sample's characteristics regarding most reported work areas, education level, years of employment, and importance of ICTs for their work. The participants' education level was high, with 45% reporting a degree from a higher education institution (university, institute of technology, or

university of applied sciences). In total, over 200 different job titles were reported (e.g. project managers, commercial employees, psychologists, chefs, CEO). The median employment level was 80% (min. 20%, max. 160%). 76% of all participants had been employed at their current job for five years or less. 30% reported having supervisory responsibilities and 4% stated to be self-employed. The median importance of ICTs for one's job was 9.5 on a scale of 0 to 10 ( $M = 8.3$ ,  $SD = 2.4$ ).

**Figure 1**

*Overview of sample characteristics*



*Note.*  $n = 355$  for plots 1 – 3. One person did not provide demographic information. The work areas were derived from the general classification of economic activities, and the education levels from the educational degrees and certificates by the Federal Statistical Office (FSO, 2008, 2020).

### **Measures**

Established scales were used for measuring control and outcome constructs. If possible, we used measures that were already available in German. English measures were translated and retranslated by a native speaker. The new and revised ICT resources and stressors were assessed using the revised items. A detailed overview of the scales we used is included in Appendix B. Being recommended by Hayes and Coutts (2020), we reported McDonald's omega  $\omega$  along with Cronbach's alpha  $\alpha$ . Where  $\omega$  could not be calculated (i.e. scales with only two items such as openness, intention to quit, and conscientiousness), the correlation with Spearman-Brown correction  $\rho$  is reported in addition to Cronbach's  $\alpha$  (see Eisinga et al., 2013).

Participants indicated their gender, age, highest level of education, job title, area of work, employment level (in %), and years of employment at the current job, as well as whether they have supervisory responsibilities or are self-employed. Age and attitudes towards digital change were added as control variables. The latter was measured with the subscale technology acceptance by Neyer et al. (2012) using a five-point Likert scale (example item: '*I am very curious about new technical developments.*'). The reliability of the scale was  $\alpha = .82$ ,  $\omega = .82$ . **Importance of ICTs for one's own work** was included as a split variable for the known-group-comparison and was measured with the question '*How important are ICTs for the execution of your work?*'. The participants reported their assessment using a slider from 0 = '*ICTs are unnecessary for my job*' to 10 '*My job cannot be carried out without ICTs*'.

The following scales were included as outcome variables. **Job satisfaction** was assessed with the single-item scale general job satisfaction ('*How satisfied are you when you look at your work situation in general?*') and the job satisfaction scale (example item: '*If certain things don't change soon at my job, I'll look for a new job.*') by Semmer et al. (1990).

The four items were combined into one scale. The reliability was  $\alpha = .79$ ,  $\omega = .80$ . **Intentions to quit** were assessed with two items from Baillod (1992), adapted from Bluedorn (1982) (example item: *'How likely is it that you will still be working at your current company in six months?'*). The reliability was  $\alpha = .80$  and the corrected correlation of the two items was  $\rho = .81$ . **Affective commitment** was assessed with four items by Allen and Meyer (1990) (example item: *'I enjoy talking to others about my organisation.'*). The reliability was  $\alpha = .87$ ,  $\omega = .87$ . **Exhaustion** was assessed with eight items of the Oldenburg burnout inventory by Demerouti et al. (2001) (example item: *'After work, I now often need longer recovery times than before to get fit again.'*). The reliability was  $\alpha = .83$ ,  $\omega = .84$ . **Well-being** was measured using the five items of the WHO-5 (Topp et al., 2015; WHO Regional Office for Europe, 1998) (example item: *'In the last two weeks, I have been happy and in a good mood'*). The reliability was  $\alpha = .88$ ,  $\omega = .88$ . **General health** was measured with a single-item scale (adapted from Igic et al., 2014) (*'How would you describe your health in general?'*).

The subsequent scales measure established general resources and stressors and were included for assessing incremental validity. **Qualitative overload** and **task completeness** were measured with three, resp. one item from Udris and Rimann (1999) (example item *'You have to do things for which you are actually not trained and prepared enough.'*, *'In my work, you can produce or carry out a thing or a job from A to Z.'*). The reliability of qualitative overload was  $\alpha = .79$ ,  $\omega = .79$ . **Problems with the organisation of work tasks (POWT)**, **participation**, and **job control** were assessed with four, one and six items using the corresponding subscales from the instrument for stress-oriented task analysis ISTA (Irmer et al., 2019; Semmer et al., 1995) (example items: *'Which of the two workplaces (A or B) is more similar to your workplace? A has to spend a lot of time getting information, material or tools to continue working. B always has the necessary information, material or tools*

*available.*’, *‘In decisions affecting my situation as an employee, I have no influence at all*’, *‘Can you decide for yourself the way in which you do your work?’*). The reliabilities were  $\alpha = .67$ ,  $\omega = .68$  for POWT, and  $\alpha = .91$ ,  $\omega = .92$  for job control. **Social stressors** in relation to work colleagues were assessed with five items by Frese and Zapf (1987) (example item: *‘One often has arguments with some work colleagues.’*). The reliability was  $\alpha = .80$ ,  $\omega = .80$ .

### ***Procedure***

The online survey consisted of four main parts. After the landing page explaining the purpose of the study, the first set of questions followed, which included the demographic and control questions. The second part consisted of the items on ICT resources and stressors. The third part included the scales used for the multigroup comparison. In the fourth block, we assessed the outcome variables. Within the four sections, each scale was presented on a single page, with their sequence and the order of the items within the scales being randomised. At the end of sections two, three, and four, we added a question to assess whether the participants had read the questions attentively (e.g. *‘To confirm that you read the answers carefully, please choose the option ‘I completely agree’*).

### ***Data analysis and dealing with common method variance***

All analyses were conducted with the statistical software R (R Core Team, 2023) and R Studio (Posit team, 2024). The package ‘sjPlot’ (Lüdtke, 2023) was used for the item analysis, and ‘lavaan’ (Rosseel, 2012) and ‘semTools’ (Jorgensen et al., 2022) for the structural equation modelling (the data and code used in this study are included in the electronic supplements). We used a confirmatory instead of an exploratory approach to test the internal structure of the scales as suggested by Fokkema and Greiff (2017) and Ziegler (2014) and performed CFAs on the construct level. We considered a sample size of more than 300 to be sufficient, following the recommendations of Fabrigar et al. (1999) as well as

Mundfrom et al. (2005). To test whether the structural equation models have sufficient power, we conducted tests of not-close fit as recommended by MacCallum et al. (1996). The sample size was sufficient for the assessment of construct validity of the overall measurement model of the ICT resources and stressors and for assessing criterion validity. To minimize possible effects due to careless responses, we excluded the data from participants, who did not correctly answer the attention question in the corresponding step. 356 people answered the first question correctly, 353 people answered the first and second questions correctly and 325 people answered all three questions correctly. No further outlier criteria were defined, apart from this exclusion all cases were considered for carrying out our analyses. Thus, the item analysis comprised the data of 356 individuals, the confirmatory factor analysis and the multigroup comparison were conducted with the data of 353 participants, and for the evaluation of criterion validity we used the data of 325 individuals. Because of the nature of the data collection, common method variance might have been an issue (Podsakoff et al., 2003; Podsakoff et al., 2012). We minimised bias due to item characteristics by revising the definitions and the scales and adjusting unclear wording or ambiguities. Possible effects of the context within the survey were controlled for by randomising both, the order of the scales and the items within the scales.

## **Results**

### ***Item analysis (Step III)***

We examined the response distributions and the overall reliabilities for each scale and evaluated, for each individual item, the item difficulties, the discrimination indices, and the change in reliability in case of item elimination. Table 4 shows the descriptive statistics for each item (the response distributions for each scale individually can be found in the electronical supplements). The scale reliabilities were sufficient to high: Cronbach's alpha



ranged between .69 (poor communication) and .90 (telepressure), McDonald's omega ranged between .70 and .90. The item analysis showed promising results for the scales literacy facilitation, involvement facilitation, and telepressure as well as for the scales ICT control, personal assistance, and ICT resources & upgrades, although they each had one insufficient item (Control\_day1, PersAs\_day2 and ICTResU\_day3). In contrast, the scales techno-complexity, techno-uncertainty, poor communication, employee monitoring, and usefulness did not reach satisfactory values on a scale level, suggesting their items were not able to capture the constructs effectively. These scales were therefore excluded from further consideration.

**Table 4***Descriptive item statistics*

Item	<i>M</i>	<i>SD</i>	<i>Med</i>	<i>Min</i>	<i>Max</i>	<i>Item diffi- culty</i>	<i>Discrimi- nation index</i>	<i>α when deleted</i>	<i>Skew</i>	<i>Kurtosis</i>
TechCom_rag1	1.87	0.98	2	1	5	.37	.61	.67	1.10	0.62
TechCom_rag2	2.19	0.87	2	1	5	.44	.46	.75	0.93	0.98
TechCom_rag3	2.74	1.09	3	1	5	.55	.54	.72	0.08	-0.92
TechCom_rag4	2.04	0.90	2	1	5	.41	.64	.66	0.84	0.35
TechUnc_rag1	2.91	1.03	3	1	5	.58	.71	.72	0.06	-0.68
TechUnc_rag2	2.82	1.10	3	1	5	.56	.68	.75	0.19	-0.84
TechUnc_rag3	2.33	1.00	2	1	5	.47	.64	.79	0.58	-0.23
TechUnc_new1	1.73	0.87	2	1	5	.35	.73	.79	1.24	1.19
TechUnc_new2	2.08	1.13	2	1	5	.42	.73	.79	0.86	-0.24
TechUnc_new3	1.74	0.97	1	1	5	.35	.72	.79	1.28	0.98
LiteFac_rag1	3.18	1.09	3	1	5	.64	.58	.74	-0.33	-0.59
LiteFac_rag2	3.02	1.23	3	1	5	.60	.60	.73	-0.12	-0.94
LiteFac_rag3	3.21	1.17	3	1	5	.64	.61	.73	-0.28	-0.78
LiteFac_rag4	3.16	1.20	3	1	5	.63	.58	.74	-0.29	-0.82
InvoFac_rag1	2.86	1.23	3	1	5	.57	.68	.81	0.03	-1.08
InvoFac_rag2	2.88	1.11	3	1	5	.58	.62	.83	-0.05	-0.86
InvoFac_New1	3.29	1.19	4	1	5	.66	.73	.78	-0.43	-0.73
InvoFac_New2	3.30	1.11	3	1	5	.66	.70	.80	-0.37	-0.65
PoorCom_day1	1.73	0.75	2	1	5	.35	.54	.55	0.92	0.86
PoorCom_day2	1.44	0.76	1	1	5	.29	.43	.68	2.01	4.45
PoorCom_day3	1.84	0.82	2	1	5	.37	.54	.54	0.79	0.25
EmpMoni_day1	1.80	0.90	2	1	4	.45	.60	.84	0.72	-0.64
EmpMoni_day2	1.74	0.95	1	1	4	.43	.74	.78	1.08	0.05
EmpMoni_day3	1.57	0.84	1	1	4	.39	.76	.77	1.42	1.15
EmpMoni_day4	1.41	0.73	1	1	4	.35	.64	.82	1.86	2.94
EmpMoni_new1	1.98	1.07	2	1	4	.50	.41	.76	0.64	-0.94
EmpMoni_new2	2.79	1.02	3	1	4	.70	.59	.55	-0.23	-1.18
EmpMoni_new3	2.80	1.06	3	1	4	.70	.60	.53	-0.37	-1.11
Control_day1	3.45	1.18	4	1	5	.69	.29	.77	-0.31	-0.91
Control_day2	2.58	1.23	2	1	5	.52	.48	.68	0.33	-0.92
Control_day3	3.21	1.41	3	1	5	.64	.68	.55	-0.27	-1.24
Control_day4	3.43	1.46	4	1	5	.69	.62	.59	-0.47	-1.17
PersAs_day1	3.77	1.06	4	1	5	.75	.67	.79	-0.72	-0.08
PersAs_day2	4.03	0.98	4	1	5	.81	.73	.77	-0.96	0.64
PersAs_day3	3.63	1.07	4	1	5	.73	.73	.77	-0.56	-0.37
PersAs_day4	3.24	1.14	3	1	5	.65	.56	.84	-0.25	-0.74
ICTResU_day1	3.12	1.13	3	1	5	.62	.75	.83	-0.14	-0.78

Item	<i>M</i>	<i>SD</i>	<i>Med</i>	<i>Min</i>	<i>Max</i>	<i>Item diffi- culty</i>	<i>Discrimi- nation index</i>	<i><math>\alpha</math> when deleted</i>	<i>Skew</i>	<i>Kurtosis</i>
ICTResU_day2	3.08	1.15	3	1	5	.62	.74	.83	-0.10	-0.92
ICTResU_day3	3.70	1.04	4	1	5	.74	.65	.86	-0.62	-0.15
ICTResU_day4	3.16	1.06	3	1	5	.63	.77	.82	-0.12	-0.71
Telepr_barsan1	2.63	1.20	2	1	5	.53	.73	.88	0.31	-0.92
Telepr_barsan2	3.31	1.20	3.5	1	5	.66	.69	.89	-0.36	-0.81
Telepr_barsan3	2.39	1.10	2	1	5	.48	.73	.88	0.42	-0.64
Telepr_barsan4	3.02	1.24	3	1	5	.60	.72	.88	-0.19	-1.07
Telepr_barsan5	2.55	1.27	2	1	5	.51	.70	.89	0.27	-1.14
Telepr_barsan6	2.78	1.22	3	1	5	.56	.81	.87	0.20	-0.99
Usefuln_ayy1	3.94	0.98	4	1	5	.79	.71	.69	-0.94	0.59
Usefuln_ayy2	3.75	0.95	4	1	5	.75	.64	.73	-0.72	0.37
Usefuln_ayy3	4.18	0.89	4	1	5	.84	.35	.86	-1.24	1.72
Usefuln_ayy4	3.90	0.95	4	1	5	.78	.76	.67	-0.85	0.61

*Note.*  $n = 356$ . Item difficulties and reliabilities without item ( $\alpha$  when deleted) refer to the corresponding scale, not to the entire questionnaire.

#### ***Evaluation of the measurement models (Step IV)***

To verify the factor structure of the original validation studies we conducted a confirmatory factor analysis using MacKenzie et al.'s (2011) recommendations as evaluation criteria: i.e. the Goodness of Fit of the measurement models, the average variance extracted (AVE) to test the indicators as a whole (Fornell & Larcker, 1981) and the loadings of the individual indicators. The latent construct should explain more than half of the variance in the indicators (i.e.  $AVE > .50$ ) and no individual indicator should have a squared factor loading  $\lambda^2$  below .50. The CFAs confirmed that all measurement models could be estimated, and all indicators had significant loadings on the latent factors. Table 5 shows the fit indices of the scales and table 6 for squared loadings of each item.

**Table 5***Fit indices of measurement models*

Scale	$\chi^2$	RMSEA	CFI	TLI	SRMR	AIC	BIC	AVE
Literacy facilitation	7.903 ( $df = 2; p < .05$ )	.107 [.037, .189]	.979	.937	.029	4'126	4'157	.48
Involvement facilitation	29.521 ( $df = 2; p < .001$ )	.219 [.153, .292]	.945	.835	.052	3'879	3'910	.58
ICT control	-	-	-	-	-			.59
Personal assistance	-	-	-	-	-			.54
ICT resources & upgrades	-	-	-	-	-			.68
Telepressure	41.326 ( $df = 9; p < .001$ )	.113 [.079, .149]	.966	.944	.035	5'703	5'750	.60
Overall model	340.136 ( $df = 215; p < .001$ )	.040 [.033, .048]	.965	.959	.038	22'236	22'472	.58
Alternative A	1178.783 ( $df = 229; p < .001$ )	.0114 [.108, .121]	.730	.702	.084	23'147	23'329	.40
Alternative B	857.084 ( $df = 227; p < .001$ )	.093 [.087, .100]	.821	.800	.066	22'791	22'981	.47

*Note.*  $n = 356$ . ICT control, personal assistance and ICT resources & upgrades had each three indicators and were exactly identified. Therefore, no fit indices could be estimated for these models.

**Table 6***Squared loadings of individual items*

Items	$\lambda^{2,a}$	Items	$\lambda^{2,a}$
LiteFac_rag3	.51	PersAs_day1	.60
LiteFac_rag2	.49	PersAs_day4	.41
LiteFac_rag1	.46	ICTResU_day1	.69
LiteFac_rag4	.46	ICTResU_day4	.68
InvoFac_New1	.74	ICTResU_day2	.67
InvoFac_New2	.68	Telepr_barsan6	.75
InvoFac_rag1	.49	Telepr_barsan1	.61
InvoFac_rag2	.41	Telepr_barsan3	.60
Control_day3	.92	Telepr_barsan4	.59
Control_day4	.65	Telepr_barsan5	.55
Control_day2	.20	Telepr_barsan2	.53
PersAs_day3	.61		

*Note.*  $n = 356$ .

<sup>a</sup>  $\lambda^2$  = squared loadings

All AVEs met the recommendation of MacKenzie et al. (2011) except literacy facilitation. However, there were several single items who did not reach a squared loading of .50 (i.e. LiteFac\_rag1, LiteFac\_rag2, LiteFac\_rag4, InvoFac\_rag1, InvoFac\_rag2, Control\_day2, and PersAs\_day4). Furthermore, not all global model fit indices reached acceptable levels for involvement facilitation and telepressure (specifically RMSEA and for the former also TLI, cf. Hu and Bentler, (1999). However, according to the test of not-close fit (MacCallum et al., 1996), the statistical power to find a suitable RMSEA value was only .11 for literacy facilitation and involvement facilitation and .34 for telepressure. Inspection of standardised residuals of the covariance matrix and modification indices greater than 5.00 (value recommended by Eid et al., 2017) for literacy facilitation, involvement facilitation, and telepressure (available in the electronic supplements) suggested that individual indicators within those constructs were not correlated with each other solely because of the latent factor (Brown, 2006). Examining the different measurement models together showed a good model fit (see table 6 above). All resources were significantly correlated, with literacy facilitation showing strong correlations with involvement facilitation, personal assistance, and ICT resources & upgrades. In addition, ICT control showed a weak relationship with telepressure. The bivariate correlations are shown in table 7.

**Table 7**

*Bivariate correlations of the latent variables in the overall model*

Variables	1	2	3	4	5
1 Literacy facilitation					
2 Involvement facilitation	.76***				
3 ICT control	.30***	.21***			
4 Personal assistance	.75***	.48***	.30***		
5 ICT resources & upgrades	.60***	.55***	.27***	.46***	
6 Telepressure	.08	.07	.16**	.03	.09

*Note.*  $n = 356$ .

†  $p < .10$ , \*  $p < .05$ , \*\*  $p < .01$ , \*\*\*  $p < .001$

Because of the strong relationships between the resources, and the previous conceptualisation as a higher order factor (Nastjuk et al., 2023), we tested whether a different number of latent resources resulted in a better measurement model, we estimated two alternative models (with one, resp. two latent resources factors). Both had a poorer model fit (see table 5), low AVEs, fewer individual indicators with sufficient squared loadings, and more significant standardised residuals, demonstrating support for the original model.

To sum up, the confirmatory factor analysis showed that the individual measurement models had acceptable levels of AVE, except literacy facilitation. Neither the individual indicators nor the scale as a whole demonstrated strong results and was therefore excluded from further analysis. The fit of the overall model after exclusion was:  $\chi^2 = 232.657$ ,  $df = 142$ ,  $p < .001$ ;  $CFI = .969$ ;  $TLI = .962$ ;  $RMSEA = .045$ , 90%-CI [.034; .055];  $SRMR = .038$ ;  $AVE = .60$ . Not all of the individual indicators of the other scales met the recommended levels. Excluding these items, however, would have meant not adequately capturing all facets of the respective constructs (MacKenzie et al., 2011). Following their recommendation, no further items were excluded.

### ***Measurement invariance and known-group comparison (Step V)***

MacKenzie et al. (2011) recommend performing known-group-comparisons for further assessment of construct validity. Therefore we compared the mean values of the ICT Resources and Stressors scales from individuals with high ICT importance for their own work with those of individuals with low ICT importance values. Scalar measurement invariance is necessary for group comparisons to be appropriate (Schmitt & Kuljanin, 2008) which we were able to show regarding the importance of ICTs as well as gender (see Steenkamp & Baumgartner, 1998 for more details about the process of establishing measurement invariance). When comparing the model of equal means with the model of

scalar measurement invariance, the fit indices decreased (see table 8), but the difference between the models was not significant ( $p = .847$ ) according to the test of small differences in fit (MacCallum et al., 2006). In contrast, the CFI differed by more than .01, which was above the threshold for acceptance of the stricter model reported by Cheung and Rensvold (2002). Furthermore, examination of the estimated mean values, indicated that they were higher in the “ICTs as requirement” group. Analysis of the structural models showed, that the estimated intercept of involvement facilitation was 0.24 ( $p = .079$ ), ICT control 1.21 ( $p < .001$ ), personal assistance 0.30 ( $p = .052$ ), ICT resources & upgrades 0.40 ( $p = .003$ ) and telepressure 0.30 ( $p = .050$ ) higher than the intercepts in the low to medium ICTs importance group. These differences were in line with expectations and provided preliminary evidence that the scales were able to capture the differences in the groups. However, according to the test of small differences in fit, the equal means model could not be said to be explicitly worse.

**Table 8**

*Fit indices of the different measurement invariance models regarding ICT importance*

Model	$\chi^2$	RMSEA	CFI	TLI	SRMR	AIC	BIC
Configural MI <sup>a</sup>	375.151 ( $df = 284; p < .001$ )	.052 [.036, .065]	.959	.951	.056	13'857	14'336
Metric MI	389.889 ( $df = 298; p < .001$ )	.050 [.035, .064]	.959	.953	.058	13'841	14'271
Scalar MI	423.799 ( $df = 312; p < .001$ )	.054 [.040, .066]	.951	.947	.060	13'843	14'223
Same means	479.218 ( $df = 317; p < .001$ )	.064 [.052, .075]	.930	.925	.091	13'883	14'245
Difference <sup>b</sup>	55.419 ( $df = 5, p < .847$ )	.01	-.021	-.022	.031	40	22

Note.  $n_1 = 87, n_2 = 178$ .

<sup>a</sup> MI = Measurement invariance

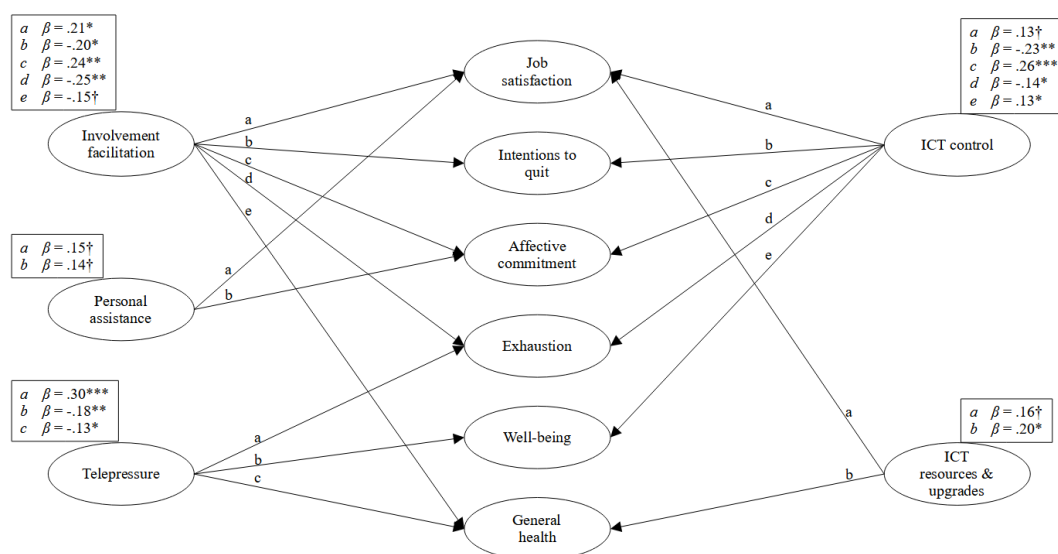
<sup>b</sup> Difference between the same means model and model of scalar invariance

### *Predicting health and attitudes towards work (Step VI)*

To test criterion validity, we examined whether ICT resources and stressors predicted health and work-related outcomes using structural equation modelling. The fit of the measurement model was acceptable ( $\chi^2 = 1371.63$ ,  $df = 806$ ,  $p < .001$ ;  $CFI = .914$ ;  $TLI = .904$ ;  $RMSEA = .048$ , 90%-CI [.044; .053];  $SRMR = .059$ ). Figure 2 shows the significant paths of the structural equation model, and bivariate correlations of the latent variables are shown in table 9. Telepressure was a significant predictor of exhaustion, well-being, and general health. In contrast it did not predict any of the work-related variables, demonstrating its deteriorating effects were primarily on health outcomes. The ICT resources were primarily associated with work-related outcomes: involvement facilitation predicted job satisfaction, intentions to quit, and affective commitment as well as exhaustion and general health. ICT control was predictive of all work-related outcomes as well as exhaustion and well-being. Personal assistance only predicted job satisfaction and affective commitment, while ICT resources & upgrades predicted job satisfaction and general health.

**Figure 2**

*Prediction of health outcomes and attitudes towards work*



*Note.* Only significant paths are shown.

$^\dagger p < .10$ ,  $^* p < .05$ ,  $^{**} p < .01$ ,  $^{***} p < .001$



**Table 9***Bivariate correlations between predictors and outcome variables*

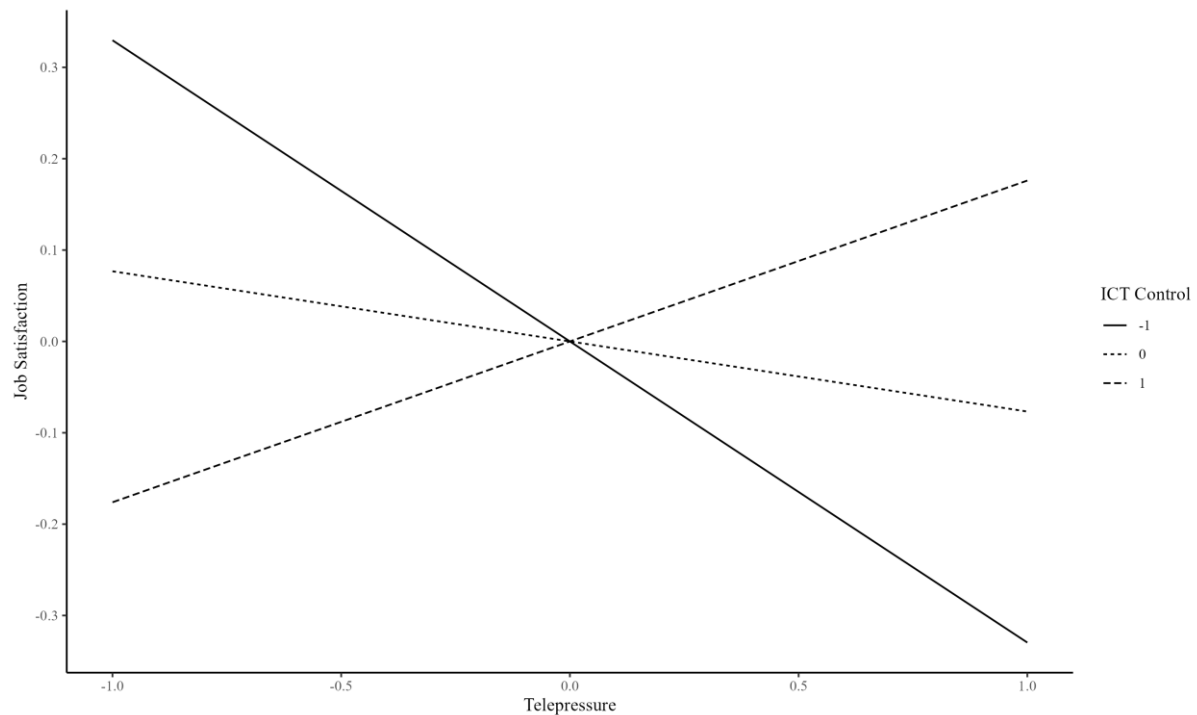
Variables	1	2	3	4	5	6	7	8	9	10
1 InvoFac										
2 Control	.18**									
3 ICTResU	.56***	.25***								
4 PersAs	.48***	.27***	.47***							
5 Telepre	.05	.16*	.08	.02						
6 JobSat	.38***	.23**	.36***	.35***	-.05					
7 IntQuit	-.30***	-.30***	-.22**	-.28***	-.03	-.77***				
8 AffComm	.36***	.35***	.28***	.33***	.10†	.81***	-.88***			
9 Exhaustion	-.32***	-.17*	-.26***	-.22**	.26***	-.49***	.31***	-.27***		
10 Wellbeing	.19**	.15*	.15*	.17*	-.15*	.50***	-.36***	.40***	-.64***	
11 GenHealth	-.01	.01	.14*	.09	-.12*	.17*	-.11†	.11†	-.40***	.47***

Note. †  $p < .10$ , \*  $p < .05$ , \*\*  $p < .01$ , \*\*\*  $p < .001$

### ***Interaction effects of ICT resources (Step VII)***

In accordance with the job demands – resources model (Demerouti et al., 2001), we expected the ICT resources to moderate the relationship between ICT stressors and the outcome variables. We tested the interaction effects of ICT resources using the double-mean-centering strategy (Crowson, 2020; Lin et al., 2010). There was a significant interaction between ICT control and telepressure in association with job satisfaction ( $\beta = .17$ ,  $p = .024$ ). The model fit was very good:  $\chi^2 = 370.713$ ,  $df = 365$ ,  $p = .407$ ;  $CFI = .999$ ;  $TLI = .999$ ;  $RMSEA = .008$ , 90%-CI [.000; .024];  $SRMR = .039$ . Simple slope analysis showed that the interaction was significant when ICT control was low ( $-1 SD$ ,  $p = .018$ ), but not significant at average ( $M$ ,  $p = .178$ ) or high ( $+1 SD$ ,  $p = .109$ ) levels of ICT control (see figure 3), suggesting that low ICT control reinforces the negative relationship between telepressure and job satisfaction. No significant interactions were found for the remaining ICT resources.

**Figure 3**

*Relationship between telepressure and job satisfaction at different levels of ICT control*

*Note.* Job satisfaction at different levels of ICT control: one standard deviation below the mean (solid line), at the mean (dotted line) and one standard deviation above the mean (dashed line).

***Controlling for confounding variables (Step VIII)***

In the next step, age and personal attitude towards digital change were included in the model as control variables ( $\chi^2 = 1683.42$ ,  $df = 1004$ ,  $p < .001$ ;  $CFI = .907$ ;  $TLI = .895$ ;  $RMSEA = .047$ , 90%-CI [.043; .051];  $SRMR = .058$ ). The relationships between the outcome variables and involvement facilitation, ICT resources & upgrades, and telepressure remained significant (see table 10). For ICT control, the relationships with affective commitment and intentions to quit remained significant, but this was not the case with job satisfaction, exhaustion, and well-being. For personal assistance, the marginal relationships between job satisfaction and affective commitment disappeared completely. Personal assistance had no

predictive value on the outcome variables when age and attitudes towards digital change were taken into account.

**Table 10***Comparison of regression weights between models with and without control variables*

Variables	Job satisfaction				Intention to quit				Affective commitment			
	Model A		Model B		Model A		Model B		Model A		Model B	
	$\beta$	$p$	$\beta$	$p$	$\beta$	$p$	$\beta$	$p$	$\beta$	$p$	$\beta$	$p$
InvoFac	.21	.031*	.20	.036*	-.20	.017*	-.18	.022*	.24	.004**	.21	.007**
Control	.13	.072†	.12	.114	-.23	.001**	-.18	.013*	.26	.000***	.19	.006**
ICTResU	.16	.062†	.18	.031*	.01	.914	-.05	.547	.02	.819	.09	.265
PersAs	.15	.097†	.12	.159	-.12	.152	-.08	.350	.14	.092†	.09	.232
Telepre	-.09	.141	-.08	.212	.02	.763	.00	.990	.04	.452	.06	.292
Age	-	-	.11	.057†	-	-	-.26	.000***	-	-	.28	.000***
DigOpen	-	-	-.05	.500	-	-	.00	.997	-	-	.06	.373

	Exhaustion				Well-being				General health			
	Model A		Model B		Model A		Model B		Model A		Model B	
	$\beta$	$p$	$\beta$	$p$	$\beta$	$p$	$\beta$	$p$	$\beta$	$p$	$\beta$	$p$
InvoFac	-.25	.003**	-.22	.008**	.13	.141	.10	.237	-.15	.067†	-.15	.06†
Control	-.14	.034*	-.11	.116	.13	.049*	.06	.422	-.02	.806	.00	.960
ICTResU	-.10	.219	-.09	.291	.04	.670	.06	.475	.20	.016*	.19	.028*
PersAs	-.02	.862	-.04	.634	.06	.490	.06	.520	.07	.383	.09	.281
Telepre	.30	.000***	.33	.000***	-.18	.002**	-.19	.001**	-.13	.033*	-.15	.022*
Age	-	-	.11	.084†	-	-	.10	.114	-	-	-.11	.072†
DigOpen	-	-	-.18	.009**	-	-	.17	.017*	-	-	.03	.664

Note.  $n = 324$  (one missing indication of age). Model A = original structural model, model B = with control variables.

†  $p < .10$ , \*  $p < .05$ , \*\*  $p < .01$ , \*\*\*  $p < .001$

***Incremental validity (Step IX)***

To determine whether the new scales explained additional variance in the outcome variables, the resources job control, task completeness, and participation as well as the demands qualitative overload, social stressors, and problems with the organisation of work tasks (POWT), were added to the model. The overall model was then compared with the model without the new ICT resources and stressors using SEM as suggested by Wang and Eastwick (2020) and Westfall and Yarkoni (2016). The bivariate correlations are shown in table 11. The model fits were  $\chi^2 = 1806.82$ ,  $df = 1040$ ,  $p < .001$ ;  $CFI = .888$ ;  $TLI = .873$ ;  $RMSEA = .050$ , 90% CI [.046; .054];  $SRMR = .064$  for the model without ICT resources and stressors and  $\chi^2 = 3117.04$ ,  $df = 2043$ ,  $p < .001$ ;  $CFI = .894$ ;  $TLI = .882$ ;  $RMSEA = .042$ , 90% CI [.039; .045];  $SRMR = .045$  for the model with ICT resources and stressors. The inclusion of the new scales increased the explained variance of all outcome variables. Looking at the additional explained variance revealed that telepressure mainly affected health related variables and the ICT resources had an effect primarily on attitudes towards work (see table 12).

**Table 11***Bivariate correlations of ICT resources and stressors, outcome variables, and general resources and stressors*

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 InvoFac																		
2 ICTControl	.19**																	
3 ICTResU	.56***	.26***																
4 PersAs	.48***	.28***	.47***															
5 Telepre	.05	.16*	.08	.02														
6 JobSat	.38***	.23**	.37***	.35***	-.05													
7 IntQuit	-.29***	-.3***	-.22**	-.28***	-.03	-.76***												
8 AffComm	.36***	.36***	.28***	.33***	.10†	.81***	-.87***											
9 Exhaustion	-.32***	-.17*	-.26***	-.21**	.26***	-.49***	.31**	-.27**										
10 Wellbeing	.20**	.16*	.15*	.18*	-.15*	.50***	-.36***	.40***	-.64***									
11 GenHealth	-.01	.01	.14*	.09	-.13*	.16*	-.10	.11	-.40***	.48***								
12 Age	.03	.19**	-.07	.14*	-.05	.14*	-.31***	.34***	.03	.16*	-.10†							
13 DigOpen	.16*	.36***	.11	.08	.14*	.06	-.15*	.23**	-.20**	.20**	-.01	.16*						
14 JobCtrl	.20**	.68***	.18**	.27***	.10	.31***	-.37***	.38***	-.25***	.16*	.12*	.28***	.20**					
15 TaskComp	.09	.15*	.09	.08	-.08	.3***	-.22**	.24***	-.11†	.22***	.05	.12*	.01	.2**				
16 Particip	.41***	.32***	.16**	.24***	-.05	.47***	-.44***	.47***	-.24***	.20**	.09	.15**	.14†	.43***	.21***			
17 QualOverl	-.10	.09	.02	-.05	.17*	-.03	-.09	.07	.42***	-.26***	-.11†	-.16*	-.07	.07	-.07	-.05		
18 SocStres	-.27**	-.31***	-.25**	-.26**	.10	-.62***	.52***	-.53***	.47***	-.37***	-.15†	-.16**	-.11	-.38***	-.25**	-.40***	.15†	
19 POWT	-.46***	-.21**	-.56***	-.48***	.03	-.49***	.34***	-.33***	.48***	-.37***	-.28***	-.04	-.17*	-.23**	-.20**	-.37***	.29**	.40***

*Note.*  $n = 324$  (one missing indication of age).†  $p < .10$ , \*  $p < .05$ , \*\*  $p < .01$ , \*\*\*  $p < .001$

**Table 12***Difference in explained variance in outcome variables*

Variables	Original model	Incl. ICT resources and stressors			Only telepressure			Only ICT resources		
	$R^2$	$R^2$	$\Delta R^2$	$\Delta in \%$	$R^2$	$\Delta R^2$	$\Delta in \%$	$R^2$	$\Delta R^2$	$\Delta in \%$
GenHealth	.117	.164	.047	40.5%	.130	.014	11.6%	.154	.037	32.0%
Exhaustion	.461	.517	.056	12.1%	.506	.045	9.7%	.469	.007	1.6%
AffComm	.472	.505	.034	7.2%	.487	.015	3.3%	.493	.022	4.6%
Wellbeing	.254	.265	.011	4.3%	.264	.010	4.1%	.254	.000	0.0%
JobSat	.515	.531	.016	3.1%	.516	.001	0.2%	.531	.016	3.0%
IntQuit	.441	.452	.010	2.4%	.444	.003	0.8%	.449	.008	1.8%

*Note.* The original model contained the outcome variables general health, exhaustion, affective commitment, well-being, job satisfaction, intention to quit, the control variables age, attitude towards digital change and the predictors job control, completeness of work tasks, participation, qualitative overload, social stressors and problems with the organisation of work tasks.

**Integration of results and final questionnaire**

Table 13 provides an overview of the results. The items that remained after the item analysis had good descriptive statistics. The analysis of the measurement models showed that the overall model has a good fit and is a significantly better solution than the alternative models. Literacy facilitation, however, did not meet the evaluation criteria recommended by MacKenzie et al. (2011) and was therefore excluded. The remaining scales showed scalar measurement invariance concerning gender and the importance of ICTs for one's work. Furthermore, we could establish preliminary evidence for significant differences in the empirical mean values between groups with high and low importance of ICTs for their work. However, whereas the decrease in CFI was above the threshold for acceptance of the stricter model, the test of small differences in fit (MacCallum et al., 2006) did not support this. Regarding criterion validity, the scales involvement facilitation, ICT control, ICT resources & upgrades, and telepressure were able to predict health (i.e. exhaustion, well-being, and general health) and/or work-related outcomes (i.e. job satisfaction, affective commitment, and intentions to quit). The scales explained additional variance in health and work-related outcomes and thus demonstrated incremental variance. Our analyses confirmed that telepressure mainly increased explained variance in health outcomes while the ICT resources primarily increased explained variance in attitudes towards work.

Overall, the scales involvement facilitation, ICT control, ICT resources & upgrades, as well as telepressure, showed robust results in the different steps of the validation process, particularly regarding criterion validity. Personal assistance, however, could not predict health or work-related outcomes after controlling for age and personal attitude towards digital change, and when general constructs were taken into account. Thus, we excluded it from the final questionnaire. The final ICT Resources and Stressors Scale contains four constructs measured by 16 items and is included in Appendix C.



**Table 13***Overview of results for the final questionnaire*

Scale	Reliability	Construct validity			Criterion validity				
		Measurement models	Measurement invariance	Mean differences in ICT importance	Prediction of health outcomes	Prediction of work attitudes	Moderation	Robustness (control variables)	Incremental validity
Involvement facilitation	$\alpha = .85$ , $\omega = .85$	acceptable			in part	yes	no	yes	
ICT control	$\alpha = .77$ , $\omega = .82$	acceptable			in part	yes	on Job satisfaction	in part	
Personal assistance	$\alpha = .77$ , $\omega = .77$	acceptable	yes	no	no	in part	no	no	yes
ICT resources & upgrades	$\alpha = .86$ , $\omega = .86$	acceptable			in part	no	no	yes	
Telepressure	$\alpha = .90$ , $\omega = .90$	acceptable			yes	no	-	yes	

*Note.* Measurement invariance, mean differences in ICT importance and incremental validity were analysed regarding the entire questionnaire, not individual scales.

### **Overall Discussion**

The main purpose of this study was to develop a comprehensive questionnaire to capture resources and stressors of digitalisation. The scale validation process followed the recommendations of MacKenzie et al. (2011). First, we identified key constructs from existing literature and revised their definitions to guarantee clear conceptualisations. We created new items to capture the constructs in their entirety and adapted existing ones if necessary. Next, we conducted a preliminary study inviting experts to review the scales and to give feedback, to augment the intelligibility of the items and ensure content validity of the scales. Then we conducted an online survey with 375 participants, among which were employees of a foundation operating in the Swiss health sector, which resulted in the final questionnaire comprising 16 items and four constructs measuring the resources involvement facilitation, ICT control, and ICT resources & upgrades, as well as the stressor telepressure. The results demonstrate that the scales meet the recommendations regarding item characteristics (e.g. skew, kurtosis, item difficulty, and item discrimination) and are reliable. Overall, the scales show construct and criterion validity and possess scalar measurement invariance regarding gender and the importance of ICTs for one's work. The known-group comparison provided evidence for differences between groups with high and low importance of ICTs for their work. The ICT resources were significant predictors of attitudes towards work and, in part, health outcomes.

In contrast, telepressure exclusively predicted health outcomes. These results are consistent with the assumptions of the job demands-resources model, according to which stressors influence well-being and resources motivational and work-related aspects (Bakker & Demerouti, 2007; Demerouti et al., 2001). The relationships with the outcome variables were robust and remained after controlling for age and attitude towards digital change.

Furthermore, the ICT resources and stressors were found to explain additional variance in attitudes towards work and health, demonstrating incremental validity.

### **Practical and theoretical implications**

The results suggest that the scales are a reliable way to measure key resources and stressors in the context of digitalisation. The scales are internally consistent and can be used separately or together to identify possible areas of action and to expand occupational health management. The validation among employees of the foundation, which used the obtained results to identify potential for internal digital transformation processes, further demonstrates the practical value of the scales.

The present questionnaire can be used in various contexts. For example, the scales telepressure and ICT control could be administered to reduce stress from ICT based telepressure and ICT control could be administered to reduce stress from ICT based messaging, which is a key form of communication for cooperation and task completion in organisations. With the increase in hybrid or working-from-home work-models, it has even become more important (Greer & Payne, 2014). However, employees often feel overwhelmed by the constant influx of such messages (e.g. e-mails), which leads to lower productivity and an increased experience of workload (Sonnentag et al., 2018).

Administering the questionnaire, the organisation is able to assess the extent of telepressure experienced by employees and identify strategies to mitigate its negative effects, such as introducing messaging management policies, providing training on effective communication practices, or exploring alternative communication channels. Our findings suggest that the negative effects of telepressure are higher when ICT control is low. Thus, measuring ICT control could be used to address work design decisions when seeking strategies to mitigate telepressure or implementing new processes.

In another specific scenario, the questionnaire could be applied to improve the efficiency and productivity of the organisation before the transition to new strategic software.

Measuring involvement facilitation and ICT resources and upgrades is a suitable tool for organisations that aim to assess how their employees perceive support in terms of technological change in line with work design recommendations (Parker & Grote, 2022). The scale ICT resources and upgrades can help to assess the needs for more appropriate ICTs and ensure that the new resources are sufficient, and effectively address previous technological shortcomings. This guarantees that employees have the necessary tools to perform their tasks efficiently. In addition, employee involvement in change management is crucial. With the involvement facilitation scale, organisations can ensure a smooth introduction and minimise resistance from employees who rely on using the new software to complete their work tasks.

The present study provides new insights into the measurement of work-related resources and stressors in the context of digitalisation that are not captured by existing instruments. We expanded upon the work of Tarafdar et al. (2007), Ragu-Nathan et al. (2008), Ayyagari et al. (2011), Day et al. (2012), and Barber and Santuzzi (2015), reviewing the original definitions, adapting, or creating new items to capture the constructs in their entirety, and thus optimising the measurement of involvement facilitation, ICT control, ICT resources & upgrades, and telepressure. In doing so we addressed the criticism of Fischer et al. (2019) concerning the conceptualisation of technostress. We claim that our scales are a valuable supplement to other measurement instruments concerning technological stressors or resources, such as Fischer et al.'s (2021) revised and updated digital stressors scale. Our questionnaire not only enables the measurement of stressors but also of resources at the same time. The development process recommended by MacKenzie et al. (2011) and Podsakoff et al. (2016) ensures the quality of the scales. The study extends the job demands-resources model (Bakker & Demerouti, 2007; Demerouti et al., 2001) to ICT-specific stressors and resources.

### **Limitations and future research**

The study has some limitations that need to be considered. First, the ICT resources and stressors examined in this study should not be considered exhaustive. In the literature review, we aimed to find constructs that can be captured by existing scales and are relevant in the work context. Thus, stressors and resources resulting from private ICT use were not considered. Our aim was to search for scales that are widely applicable in the general population of employees. Therefore, occupation-specific resources and stressors were not included. In a specific case, it may therefore make sense to adapt the questionnaire to the specific circumstances.

Furthermore, as Fischer et al. (2019) and Marsh et al. (2022) note, work-related digital stressors and resources change over time, and it is essential that measurement instruments are regularly updated. Second, all variables were measured cross-sectionally and via self-report, which raises the issue of common method variance (Podsakoff et al., 2003). However, by using questions to assess the participants' attention, simplifying the online survey, and randomising the order of scales and items, we increased the data quality and minimised biases due to inattentive completion. Third, sampling effects may have influenced the relationships between the variables (Kelava & Moosbrugger, 2012). Women, individual work areas as well as professions in which ICTs are a prerequisite were overrepresented, and the education level of the participants was relatively high. This reduces external validity. Fourth, the practical value of the questionnaire has been demonstrated by applying it to the employees of a healthcare organisation. However, this step should be repeated in a future study with different organisations. In addition, the results obtained should be cross-validated on a new sample to further validate the questionnaire in the field (Hinkin, 1998; MacKenzie et al., 2011). Completing the process of scale development, scale norms should then be created for benchmarking, by administering the questionnaire to a representative sample of

the workforce. Additionally, the new questionnaire should be translated into other languages.

This requires that the scales are revalidated for use in different language regions and that measurement invariance regarding questionnaire language is established.

### **Data Accessibility Statement**

The data and the supplementary materials are openly available in the Open Science Framework at <https://doi.org/10.17605/OSF.IO/6FTDB>

### **Transparency Statement**

We reported how we determined the sample size and the stopping criterion (p. 23). We reported all experimental conditions and variables (p. 20-23). We report all data exclusion criteria and whether these were determined before or during the data analysis (p. 23). We report all outlier criteria and whether these were determined before or during data analysis (p 23).

### **Competing Interests**

The authors have no competing interests to declare.

### **Author Contribution**

Jari Cianci: Conceptualisation (equal), data curation (lead), formal analysis (lead), investigation (lead), methodology (lead), project administration (lead), software (lead), visualisation (lead), writing – original draft preparation (lead). David Weibel: Conceptualisation (equal), formal analysis (supporting), investigation (supporting), methodology (supporting), project administration (supporting), resources (lead), supervision (equal), validation (equal), writing – original draft preparation (supporting) , writing – review & editing (equal). Achim Elfering: Conceptualisation (equal), investigation (supporting), methodology (supporting), supervision (equal), validation (equal), writing – original draft preparation (supporting), writing – review & editing (equal).

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## Appendix A

## Identified research areas

Research area	Country	Demands	Resources	Main article	Reasons for inclusion or exclusion	Main theory frameworks
DYNAMIK: Psychosocial Work Stressors in Modern Working Environments	Germany	Workload: - time pressure - interruption of work - multi-tasking - flexibility requirements Boundary permeability: - extensive overtime - insufficient breaks (-) - work-family balance - work during leisure time Participation: - in decision making - influence on work content - influence on work methods Leader support: - conflict with leader (-) - support by leader - recognition of work performance Usability: - technical problems (-) - usability		Diebig, M., Dragano, N., Körner, U., Lunau, T., Wulf, I. C., & Angerer, P. (2020). Development and Validation of a Questionnaire to Measure Psychosocial Work Stressors in Modern Working Environments. <i>Journal of Occupational and Environmental Medicine</i> , 62(3), 185–193. <a href="https://doi.org/10.1097/JOM.0000000000001779">https://doi.org/10.1097/JOM.0000000000001779</a>	Excluded. The demands were not considered novel	- Psychosocial risk assessment (Rick & Briner, 2000) - Stressor Strain Framework (z.B. Bliese, Edwards & Sonnentag, 2017) - Effort Reward Imbalance Model (Siegrist, 1996) - Job Demand Control Model (Karasek, 1979)
ICT Demands	Sweden	- Load: too many calls and emails to be available on work-related issues both during work hours and leisure time - Urgency: immediate answers to emails and telephone calls that require a lot of work - Interruption: constantly being interrupted by the telephone and email - Tech Failure: computers and other equipment that fail to work properly		Stadin, M., Nordin, M., Broström, A., Magnusson Hanson, L. L., Westerlund, H., & Fransson, E. I. (2016). Information and communication technology demands at work: The association with job strain, effort-reward imbalance and self-rated health in different socio-economic strata. <i>International Archives of Occupational and Environmental Health</i> , 89(7), 1049–1058. <a href="https://doi.org/10.1007/s00420-016-1140-8">https://doi.org/10.1007/s00420-016-1140-8</a>	Excluded. There was considerable overlap with other research areas. Some demands were also no considered novel	- Johansson-Hidén, B., Wästlund, E., & Wallin, S. (2003). Reflecting on ICT and Stress-Conceptual Connections and a Suggested Application.

Research area	Country	Demands	Resources	Main article	Reasons for inclusion or exclusion	Main theory frameworks
ICT Demands & Supports	Canada	<ul style="list-style-type: none"> <li>- Availability</li> <li>- Communication</li> <li>- ICT control</li> <li>- ICT hassles</li> <li>- Employee monitoring</li> <li>- Learning</li> <li>- Response expectations</li> <li>- Workload</li> </ul>	<ul style="list-style-type: none"> <li>- Personal assistance</li> <li>- ICT resources / Upgrades</li> </ul>	Day, A., Paquet, S., Scott, N., & Hambley, L. (2012). Perceived information and communication technology (ICT) demands on employee outcomes: The moderating effect of organizational ICT support. <i>Journal of Occupational Health Psychology</i> , 17(4), 473–491. <a href="https://doi.org/10.1037/a0029837">https://doi.org/10.1037/a0029837</a>	Included. There were novel constructs and the research was one of a few, that considered resources as well as demands.	<ul style="list-style-type: none"> <li>- Job Demands Resources Model (Demerouti, Bakker, Nachreiner &amp; Schaufeli, 2001)</li> <li>- Conservation of Resources (Hobfoll, 1989)</li> </ul>
Information overload	Germany	Information overload through digital media		Drössler, S., Steputat, A., Schubert, M., Günther, N., Staudte, R., Kofahl, M., Hegewald, J., & Seidler, A. (2018). Informationsüberflutung durch digitale Medien am Arbeitsplatz. <i>Zentralblatt Für Arbeitsmedizin, Arbeitsschutz Und Ergonomie</i> , 68(2), 77–88. <a href="https://doi.org/10.1007/s40664-018-0267-8">https://doi.org/10.1007/s40664-018-0267-8</a>	Excluded. No scale for measuring the construct was available. There was also considerable overlap with other research areas.	<ul style="list-style-type: none"> <li>- Informationsüberflutung am Arbeitsplatz (Preising, 2004)</li> </ul>
Intensification of Job Demands	Austria	<ul style="list-style-type: none"> <li>- Work intensification</li> <li>- Intensified job-related planning and decision making demands</li> <li>- Intensified career-related planning and decision-making demands</li> <li>- Intensified knowledge-related learning demands</li> <li>- Intensified skill-related learning demands</li> </ul>		Kubicek, B., Paškvan, M., & Korunka, C. (2015). Development and validation of an instrument for assessing job demands arising from accelerated change: The intensification of job demands scale (IDS). <i>European Journal of Work and Organizational Psychology</i> , 24(6), 898–913. <a href="https://doi.org/10.1080/1359432X.2014.979160">https://doi.org/10.1080/1359432X.2014.979160</a>	Excluded. Intensification of work is more related to broader change in work than specifically to digitalisation.	<ul style="list-style-type: none"> <li>- Theory of Social acceleration (Rosa, 2003).</li> <li>- Intensification of Job Demands (Korunka &amp; Kubicek, 2013)</li> </ul>
Characteristics of Work 4.0	Germany	<ul style="list-style-type: none"> <li>- Digitalisation</li> <li>- Flexibilisation</li> <li>- Dissolution of boundaries</li> </ul>	<ul style="list-style-type: none"> <li>- Participation</li> <li>- Relevance</li> </ul>	Poethke, U., Klasmeier, K. N., Diebig, M., Hartmann, N., & Rowold, J. (2019). Entwicklung eines Fragebogens zur Erfassung zentraler Merkmale der Arbeit 4.0. <i>Zeitschrift Für Arbeits- Und Organisationspsychologie A&amp;O</i> , 63(3), 129–151. <a href="https://doi.org/10.1026/0932-4089/a000298">https://doi.org/10.1026/0932-4089/a000298</a>	Excluded. The demands were not considered novel	<ul style="list-style-type: none"> <li>- Entgrenzung Arbeit &amp; Privatleben (Korunka &amp; Kubicek, 2017)</li> <li>- Job Diagnostic Survey (Hackman &amp; Oldham, 1976)</li> <li>- Work Design Questionnaire (Morgeson &amp; Humphrey, 2006)</li> <li>- COPSOQ (Kristensen, Hannerz, Høgh &amp; Borg, 2005)</li> </ul>

Research area	Country	Demands	Resources	Main article	Reasons for inclusion or exclusion	Main theory frameworks
Predictors of technostress	USA	Usability features - Usefulness - Complexity - Reliability Dynamic features - Pace of change Intrusive features - Presenteeism (reachability of user) - Anonymity		Ayyagari, R., Grover, V., & Purvis, R. (2011). Technostress: Technological Antecedents and Implications. <i>MIS Quarterly</i> , 35(4), 831–858. <a href="https://doi.org/10.2307/41409963">https://doi.org/10.2307/41409963</a>	The subscale usefulness was included.	- Person Environment Fit Model (Edwards & Cooper, 1988) - Technostress (Ragu-Nathan et al., 2008)
Technostress	USA	Techonstress creators - Techno-overload - Techno-invasion - Techno-complexity - Techno-insecurity - Techno-uncertainty	Technostress inhibitors - Literacy facilitation - Technical support provision - Involvement facilitation	Ragu-Nathan, T. S., Tarafdar, M., Ragu-Nathan, B. S., & Tu, Q. (2008). The Consequences of Technostress for End Users in Organizations: Conceptual Development and Empirical Validation. <i>Information Systems Research</i> , 19(4), 417–433. <a href="https://doi.org/10.1287/isre.1070.0165">https://doi.org/10.1287/isre.1070.0165</a>	Included. There were novel constructs and the research was one of a few, that considered resources as well as demands.	- Technostress (Brod, 1984, Arnetz & Wiholm 1997) - Transactional stress model (Lazarus & Folkman, 1984)
Telepressure	USA	Telepressure	-	Barber, L. K., & Santuzzi, A. M. (2015). Please respond ASAP: Workplace telepressure and employee recovery. <i>Journal of Occupational Health Psychology</i> , 20(2), 172–189. <a href="https://doi.org/10.1037/a0038278">https://doi.org/10.1037/a0038278</a>	Included. The constructs is novel and relevant for the current research.	- Job Demands Resources Model (Demerouti, et al., 2001) - ICT Demands & Supports (Day et al., 2012) - Work-Nonwork-Boundaries (Olson-Buchanan & Boswell, 2006)

## Appendix B

*Overview of validation scales*

Measure	Reason for inclusion	Nr of items	Response scale	Response format	Reliability	Origin
Attitude towards digital change	control variable	4	5-point Likert scale	1 = not at all true 5 = completely true	$\alpha = .82$ , $\omega = .82$ .	Neyer, F. J., Felber, J., & Gebhardt, C. (2012)
Job satisfaction	outcome variable	4	7-point Likert scale;	1 = extremely dissatisfied; 7 = extremely satisfied	$\alpha = .79$ , $\omega = .80$	Semmer, N., Baillod, J., & Ruch, L. (1990)
Intentions to quit	outcome variable	2	5-point Likert scale	1 = very unlikely; 5 = very likely	$\alpha = .80$ , $\rho = .81$	Baillod, J. (1992)
Affective commitment	outcome variable	4	7-point Likert scale	1 = not true at all; 7 = almost fully true	$\alpha = .87$ , $\omega = .87$	Allen, N. J., & Meyer, J. P. (1990)
Exhaustion	outcome variable	8	5-point Likert scale	1 = not exhausted at all; 5 = very exhausted	$\alpha = .83$ , $\omega = .84$	Demerouti, E., Bakker, A. B., Nachreiner, F., & Schaufeli, W. B. (2001)
Well-being	outcome variable	5	5-point Likert scale	1 = at no time 5 = all of the time	$\alpha = .88$ , $\omega = .88$	WHO Regional Office for Europe. (1998)
General health	outcome variable	1	5-point Likert scale	1 = very bad; 5 = very good	-	Igic, I., Keller, A., Brunner, B., Wieser, S., Elfering, A., & Semmer, N. (2014)
Qualitative overload	assessing incremental validity	3	5-point Likert scale	1 = almost never / not at all true; 5 = almost always / fully true	$\alpha = .79$ , $\omega = .79$	Udris, I., & Rimann, M. (1999)
Task completeness	assessing incremental validity	1	5-point Likert scale	1 = almost never / not at all true; 5 = almost always / fully true	-	Udris, I., & Rimann, M. (1999)
Problems with the organisation of work tasks (POWT)	assessing incremental validity	4	5-point Likert scale	1 = exactly like A; 5 = Exactly like B	$\alpha = .67$ , $\omega = .68$	Semmer, N., Zapf, D., & Dunckel, H. (1999); Irmer, J. P., Kern, M., Schermelleh-Engel, K., Semmer, N. K., & Zapf, D. (2019)
Participation	assessing incremental validity	1	5-point Likert scale	1 = I have no possibility whatsoever to influence the decision; 5 = I have considerable influence on the decision	-	Semmer, N., Zapf, D., & Dunckel, H. (1999); Irmer, J. P., Kern, M., Schermelleh-Engel, K., Semmer, N. K., & Zapf, D. (2019)
Job control	assessing incremental validity	6	5-point Likert scale	1 = very little/ not at all; 5 = very much / always	$\alpha = .91$ , $\omega = .92$	Semmer, N., Zapf, D., & Dunckel, H. (1999); Irmer, J. P., Kern, M., Schermelleh-Engel, K., Semmer, N. K., & Zapf, D. (2019)
Social stressors	assessing incremental validity	5	5-point Likert scale	1 = strongly disagree; 5 = strongly agree	$\alpha = .80$ , $\omega = .80$	Frese, M., & Zapf, D. (1987)

## Appendix C

### Final questionnaire English

#### *Involvement facilitation*

By involving employees, the organisation facilitates the use of information and communication technologies. It consults employees before the introduction and involves them in the implementation process by reporting transparently on the reasons for the new introduction and the hoped-for effects. The organisation thus facilitates and promotes the use of new ICTs.

#### **Items**

Please rate the following statements on the involvement of end users\* of ICTs in the introduction of new technologies in your organisation.

\* End users are the individuals who ultimately use the ICTs (e.g., by using the email program, or the accounting software, etc.).

- 1) We as end users are consulted before introducing new ICTs.
- 2) We as end users are involved in the technological change and implementation of ICTs.
- 3) Our organisation communicates in a transparent way about the reasons for introducing new ICTs
- 4) Our organisation communicates in a transparent way about the hoped-for effects of the introduction of new ICTs.

Response scale: 1 Totally disagree; 2 rather disagree; 3 partly agree; 4 rather agree; 5 totally agree

***ICT resources & upgrades***

By providing new technical work resources in a timely manner and keeping them up to date, the organisation can minimise ICT-based issues. As an ICT-specific organisational resource, it minimises effects of ICT stressors that are problem-based and related to the use of information and communication technologies. This can increase employees' self-efficacy and confidence in using new ICTs, which in turn can reduce strain.

**Items**

Please rate the following statements about ICT resources in your organisation.

- 1) My organisation implements appropriate software as it becomes available.
- 2) My organisation uses the latest technology.
- 3) New ICT systems in my organisation are implemented on a timely basis.

Response scale: 1 Totally disagree; 2 rather disagree; 3 partly agree; 4 rather agree; 5 totally agree

***ICT control***

ICT control describes the influence people have over and receive from information and communication technologies at work. ICT control has a positive effect on stress experience, as people choose the ICTs themselves to carry out their work tasks. ICTs also enable people to work flexibly in relation to time and location.

**Items**

Please rate the following statements about your means of control of ICTs at work.

- 1) I choose the types of ICTs I use in my work myself.
- 2) ICTs allow me the flexibility to do my work when I want.
- 3) ICTs allow me the flexibility to do my work where I want

Response scale: 1 Totally disagree; 2 rather disagree; 3 partly agree; 4 rather agree; 5 totally agree

***Telepressure***

Workplace telepressure manifests itself by constantly thinking about an ICT-based message received (e.g. email, Whatsapp, etc.), accompanied by the urge to respond immediately. With telepressure, the advantages of asynchronous communication via ICT messages (e.g. flexible time to respond) can be cancelled out when employees start to see it as a synchronous form of communication that requires a direct response. Workplace telepressure is associated with work overload, emotional exhaustion, less detachment from work and a lower satisfaction with one's work-life balance.

**Items**

Please rate the following statements about your response behaviour to ICT messages\* at your work.

\*work-related ICT messages are for instance e-mails, Microsoft Teams messages, Slack messages or Whatsapp messages, etc..

- 1) It's hard for me to focus on other things when I receive a message from someone.
- 2) I can concentrate better on other tasks once I've responded to my messages.
- 3) I can't stop thinking about a message until I've responded.
- 4) I feel a strong need to respond to others immediately.
- 5) I have an overwhelming feeling to respond right at that moment when I receive a request from someone.
- 6) It's difficult for me to resist responding to a message right away.

Response scale: 1 Totally disagree; 2 rather disagree; 3 partly agree; 4 rather agree; 5 totally agree



**Final questionnaire German*****Einbindung der Mitarbeitenden***

Durch das Einbinden der Mitarbeitenden erleichtert die Organisation die Nutzung von Informations- und Kommunikationstechnologien. Sie konsultiert Mitarbeitende vor der Einführung und bezieht sie in den Implementationsprozess ein, indem sie transparent über die Gründe der Neueinführung und die erhofften Auswirkungen berichtet. Die Organisation erleichtert und fördert so den Umgang mit neuen ICTs.

**Items**

Bitte beurteilen Sie folgende Aussagen zur Einbindung der Endnutzer:innen\* von ICTs in die Einführung neuer Technologien in Ihrer Organisation.

\*Endnutzer:innen sind die Personen, welche die ICTs am Ende anwenden (z.B. durch Nutzung des E-Mail-Programms, oder der Buchhaltungssoftware, etc.)

- 1) Wir als Endnutzer:innen werden vor der Einführung neuer ICTs konsultiert.
- 2) Wir als Endnutzer:innen werden in den technologischen Wandel und die Implementierung von ICTs ein-bezogen.
- 3) Unsere Organisation kommuniziert transparent über die Gründe der Neueinführung von ICTs.
- 4) Unsere Organisation kommuniziert transparent über die erhofften Auswirkungen der Neueinführung von ICTs.

Antwortskala: 1 Stimme überhaupt nicht zu; 2 Stimme eher nicht zu; 3 Teils teils; 4 Stimme eher zu; 5 Stimme voll und ganz zu

***ICT Ressourcen & Upgrades***

Indem die Organisation neue technische Arbeitsmittel zeitgerecht zur Verfügung stellt und diese auf dem neuesten Stand hält, können ICT basierte Probleme minimiert werden. Als ICT-spezifische organisationale Ressource minimiert sie Effekte von ICT Belastungen, die problembasiert sind und mit der Nutzung von Informations- und Kommunikationstechnologien zusammenhängen. Dadurch kann die Selbstwirksamkeit und Zuversicht der Angestellten bei der Nutzung neuer ICTs erhöht werden, was wiederum die Beanspruchung vermindern kann.

**Items**

Bitte beurteilen Sie folgende Aussagen zu den ICT Ressourcen in Ihrer Organisation.

- 1) Meine Organisation implementiert geeignete Software, sobald sie verfügbar wird.
- 2) Meine Organisation benutzt die aktuellste Technologie.
- 3) In meiner Organisation werden neue ICT Systeme rechtzeitig implementiert.

Antwortskala: 1 Stimme überhaupt nicht zu; 2 Stimme eher nicht zu; 3 Teils teils; 4 Stimme eher zu; 5 Stimme voll und ganz zu

***ICT Kontrollmöglichkeiten***

ICT Kontrollmöglichkeit beschreibt den Einfluss den Personen über die Informations- und Kommunikationstechnologien bei der Arbeit haben und sie durch diese erhalten. Kontrolle wirkt sich positiv auf das Stressempfinden aus, indem Personen die ICTs zur Abwicklung ihrer Arbeitsaufgaben selbst auswählen. Die ICTs ermöglichen es weiter, ihre Arbeit zeitlich flexibel und ortsunabhängig auszuüben.

**Items**

Bitte beurteilen Sie folgende Aussagen zu Ihren Kontrollmöglichkeiten von ICTs bei der Arbeit.

- 1) Ich wähle die Arten der ICTs, die ich in meiner Arbeit verwende, selbst aus.
- 2) ICTs erlauben mir die Flexibilität meine Arbeit auszuführen, wann ich will.
- 3) ICTs erlauben mir die Flexibilität meine Arbeit auszuführen, wo ich will.

Antwortskala: 1 Stimme überhaupt nicht zu; 2 Stimme eher nicht zu; 3 Teils teils; 4 Stimme eher zu; 5 Stimme voll und ganz zu

***Telepressure***

Telepressure am Arbeitsplatz äussert sich durch ständiges Denken an eine erhaltene ICT basierte Nachricht (z.B. E-Mail, Whatsapp, etc.), begleitet vom Drang unmittelbar darauf antworten zu müssen. Bei Telepressure können die Vorteile der asynchronen Kommunikation über ICT Nachrichten (z.B. zeitlich flexibel zu antworten) aufgehoben werden, wenn die Mitarbeitenden anfangen, sie wie eine synchrone Form der Kommunikation zu sehen, die eine direkte Antwort benötigt. Telepressure am Arbeitsplatz ist assoziiert mit Arbeitsüberlastung, emotionaler Erschöpfung, weniger Abgrenzung von der Arbeit und eine tiefere Zufriedenheit mit der eigenen Work-Life-Balance.

**Items**

Bitte beurteilen Sie folgende Aussagen zu Ihrem Antwortverhalten auf ICT-Nachrichten\* bei Ihrer Arbeit.

\*arbeitsrelevante ICT Nachrichten sind z.B. E-Mails, Microsoft Teams Nachrichten, Slack Nachrichten oder Whatsapp Nachrichten, etc.

- 1) Es fällt mir schwer mich auf andere Dinge zu konzentrieren, wenn ich eine Nachricht von jemandem erhalte.
- 2) Ich kann mich besser auf andere Aufgaben konzentrieren, nachdem ich meine Nachrichten beantwortet habe.
- 3) Ich kann nicht aufhören an eine Nachricht zu denken, bis ich sie beantwortet habe.
- 4) Ich verspüre ein starkes Bedürfnis anderen sofort zu antworten.
- 5) Ich verspüre ein überwältigendes Gefühl, genau in dem Moment zu antworten, in dem ich eine Anfrage von jemandem erhalte.
- 6) Es fällt mir schwer, zu widerstehen unmittelbar auf eine Nachricht zu antworten.

Antwortskala: 1 Stimme überhaupt nicht zu; 2 Stimme eher nicht zu; 3 Teils teils; 4 Stimme eher zu; 5 Stimme voll und ganz zu