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

RESEARCH

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ABSTRACT

New information and communication technologies (ICTs) have fundamentally changed work and working conditions. Digitalisation holds great potential, but studies also show that increased work-related stress accompanies this transformation. Nevertheless, few validated self-report instruments measuring stressors and resources from digitalisation are available. Thus, this study aimed 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 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.

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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 in work tasks and work conditions have been accompanied by an increase in work-related stress and emotional exhaustion in the last decade (Cianferoni, 2023; Federal Statistical Office FSO, 2024; 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.

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?

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.

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 PSYNDEXplus, PsycINFO, Scopus, and Google Scholar for the search, adhering to the recommendations of 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

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
			First exclusion after step III	
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
			Second exclusion after step IV	
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
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
			Third exclusion after step IX	

Table 1 Validation procedure and steps of analysis.

99 articles and scientific reports regarding stress in the context of digitalisation. After screening the literature, a total of nine central topics 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 origins, 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. 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 (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).

ANTECEDENTS OF TECHNOSTRESS

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).

STEP II: SCALE SELECTION, REVISION OF DEFINITIONS, AND ITEM ADAPTATION

The identified literature included scales for the measurement of the constructs. All authors 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.

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 reconceptualise 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

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)
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)

Table 2 Identified constructs.

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 questionnaire (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 psychologists then participated in the preliminary study to ensure content validity as well as comprehensibility of the scales. Most of the feedback

concerned the intelligibility of the items (e.g. unclear words such as "end user") or their content (e.g. the original items of *involvement facilitation* did not capture 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.

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

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. [a]
	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. [a]
	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.
	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.

(Contd.)

CONSTRUCT	ITEM CODE	ITEMS
ICT Control	Control_day1	I have no control over how I use ICTs at work. [a]
	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.

Table 3 Revised items of the new questionnaire.

Note. [a]Reverse coded after feedback in a preliminary study.

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 working 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 (see 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).

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 ω along with Cronbach›s alpha α. Where ω could

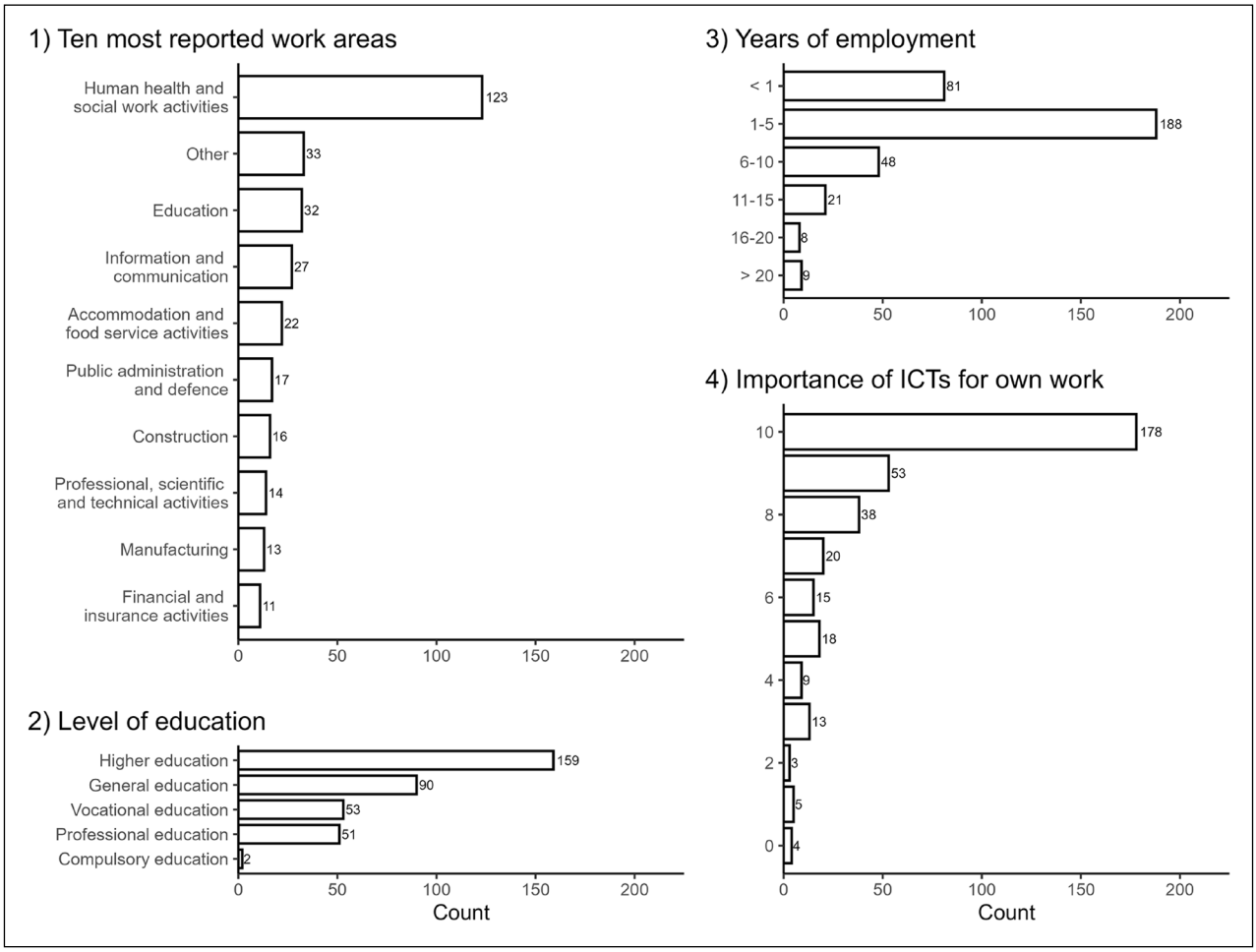

Figure 1 Overview of sample characteristics.

Note. To enhance readability, plot 1 shows the ten most reported work areas (n = 308). One respondent did not provide information on education or years of employment (n = 355). The total number of respondents for importance of ICTs is 356. 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).

not be calculated (i.e. intentions to quit), the correlation with Spearman-Brown correction ρ is reported in addition to Cronbach›s α (see Eisinga et al., 2013).

CONTROL AND SPLIT VARIABLES

We assessed the participants' age and attitudes towards digital change 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 α = .82, ω = .82.

Importance of ICTs for one's 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*'.

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 α = .79, ω = .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 α = .80 and the corrected correlation of the two items was ρ = .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 α = .87, ω = .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 α = .83, ω = .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 α = .88, ω = .88.

General health was measured with a single-item scale (adapted from Igic et al., 2014) ('*How would you describe your health in general?*').

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 α = .79, ω = .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 α = .67, ω = .68 for POWT, and α = .91, ω = .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 α = .80, ω = .80.

Procedure

The online survey consisted of four parts: an introduction explaining the study's purpose, the demographic and control variables, our ICT Resources and Stressors scale, and 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' (Lüdecke, 2023) was used for the item analysis, and 'lavaan' (Rosseel, 2012) and 'semTools' (Jorgensen et al., 2022) for the structural equation modelling. 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 known-group 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 electronic 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.

ITEM	M	SD	MED	MIN	MAX	ITEM DIFFICULTY	DISCRIMINATION INDEX	α WHEN DELETED	SKEW	KURTOSIS
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
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

(Contd.)

ITEM	M	SD	MED	MIN	MAX	ITEM DIFFICULTY	DISCRIMINATION INDEX	α WHEN DELETED	SKEW	KURTOSIS
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

Table 4 Descriptive item statistics.

Note. n = 356. Item difficulties and reliabilities without item (α 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 λ^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 the squared loadings of each item.

All AVEs met the recommendation of MacKenzie et al. (2011) except literacy facilitation. However, several single items 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.

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: χ^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 work with those of individuals with low ICT importance values.

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)	.0.114 [.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

Table 5 Fit indices of measurement models.

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.

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		

Table 6 Squared loadings of individual items.

Note. n = 356.

[a]λ^2 = squared loadings.

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

Table 7 Bivariate correlations of the latent variables in the overall model.

Note. n = 356.

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

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). 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.

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 (χ^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

MODEL	χ^2	RMSEA	CFI	TLI	SRMR	AIC	BIC
Configural MI[a]	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[b]	55.419 (*df* = 5, *p* < .847)	.01	–.021	–.022	.031	40	22

Table 8 Fit indices of the different measurement invariance models regarding ICT importance.

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

[a]MI = Measurement invariance.

[b]Difference between the same means model and model of scalar invariance.

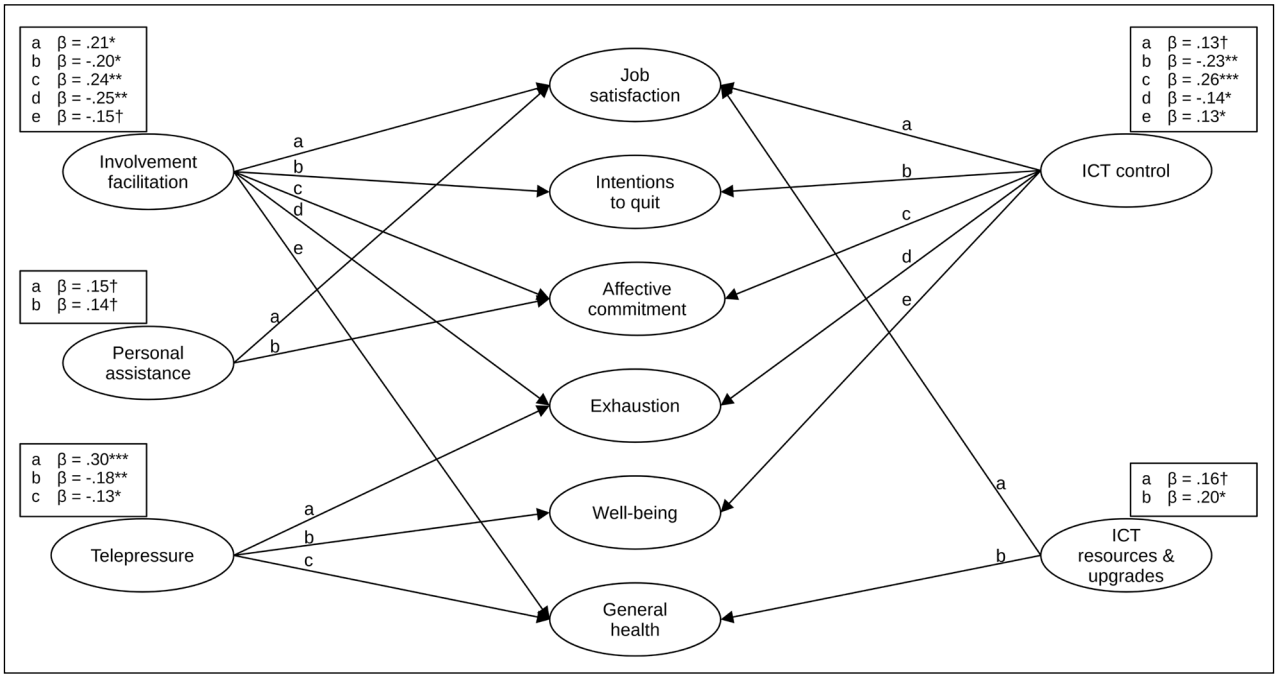

Figure 2 Prediction of health outcomes and attitudes towards work.

Note. Only significant paths are shown.

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

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.

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.

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

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***	.10ɪ	.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*	−.11ɪ	.11ɪ	−.40***	.47***

Table 9 Bivariate correlations between predictors and outcome variables.

Note. ɪ $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$.

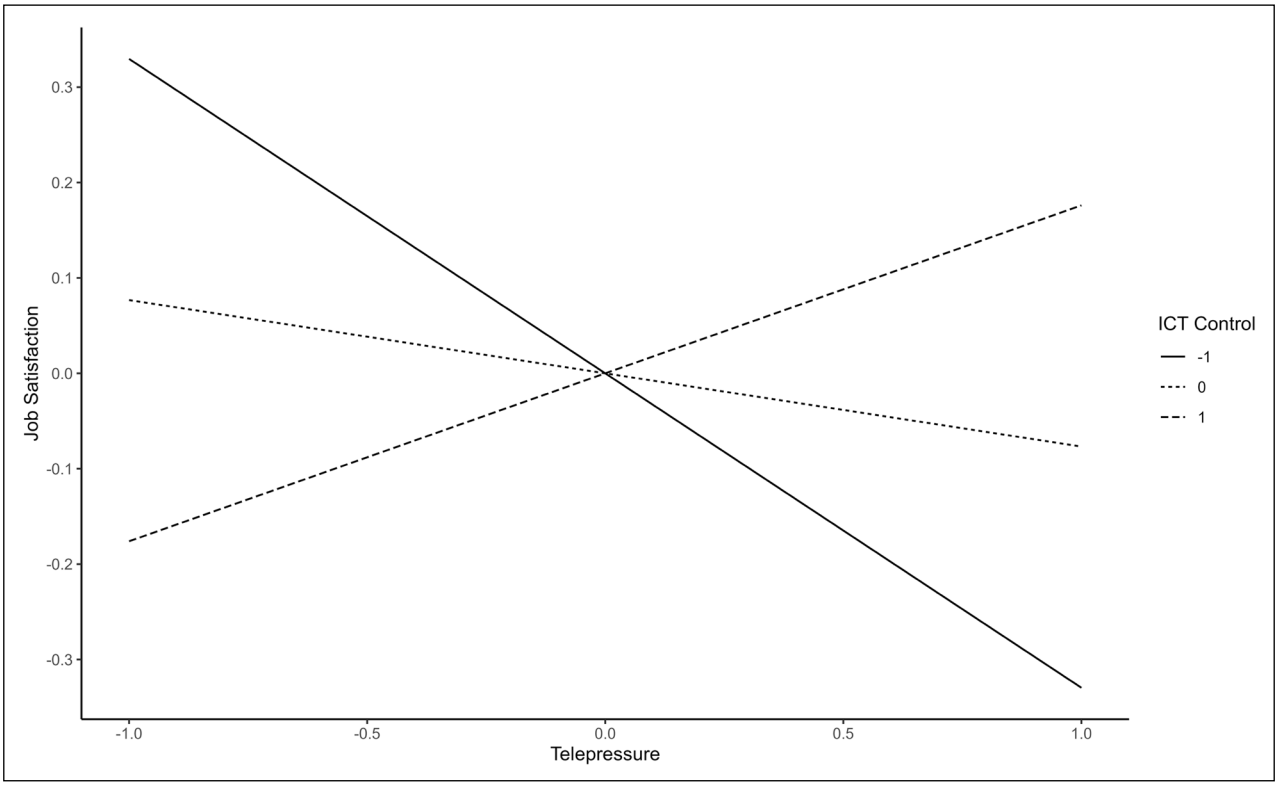

Figure 3 Relationship between telepressure and job satisfaction at different levels of ICT control.

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).

(χ^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.

Incremental validity (Step IX)

To determine whether the new scales explained additional variance in the outcome variables, the resources job control, task completeness, and

VARIABLES	JOB SATISFACTION				INTENTION TO QUIT				AFFECTIVE COMMITMENT			
	MODEL A		MODEL B		MODEL A		MODEL B		MODEL A		MODEL B	
	β	*p*	*β*	*p*	*β*	*p*	*β*	*p*	*β*	*p*	*β*	*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	
	β	*p*	*β*	*p*	*β*	*p*	*β*	*p*	*β*	*p*	*β*	*p*
InvoFac	–.25	.003**	–.22	.008**	.13	.141	.10	.237	–.15	.067†	–.15	.061†
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

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

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

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

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 χ^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 χ^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).

INTEGRATION OF RESULTS AND FINAL QUESTIONNAIRE

Following the item analysis (step III), 23 items measuring six constructs remained. The analysis of the measurement models showed that the overall model has a good fit and is significantly better than the alternative models. Literacy facilitation, however, did not meet the evaluation criteria recommended by MacKenzie et al. (2011) and was therefore excluded after step IV. The remaining scales showed scalar measurement invariance concerning gender and the importance of ICTs for one's work. Furthermore, we established preliminary evidence for significant differences in the empirical mean values between groups with high and low importance of ICTs. However, whereas the decrease in CFI was above the threshold for accepting 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 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.

	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	.1†	−.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***

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

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

VARIABLES	ORIGINAL MODEL	INCL. ICT RESOURCES AND STRESSORS			ONLY TELEPRESSURE			ONLY ICT RESOURCES		
	R^2	R^2	ΔR^2	Δ in %	R^2	ΔR^2	Δ in %	R^2	ΔR^2	Δ 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%

Table 12 Difference in explained variance in outcome variables.

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.

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 after step IX. Table 13 provides an overview of the results. The final ICT Resources and Stressors Scale contains four constructs measured by 16 items and is included in Appendix C.

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 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

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	α = .85, ω = .85	acceptable	yes	no	in part	yes	no	yes	yes
ICT control	α = .77, ω = .82	acceptable	yes	no	in part	yes	for Job satisfaction	in part	yes
ICT resources & upgrades	α = .86, ω = .86	acceptable	yes	no	in part	no	no	yes	yes
Telepressure	α = .90, ω = .90	acceptable	yes	no	yes	no	-	yes	yes

Table 13 Overview of results for the final questionnaire.

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

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. We aimed 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.

CONCLUSION

Following the standards of MacKenzie et al. (2011), we first identified key constructs in the existing literature on resources and stressors from digitalisation. We then refined the definitions and developed an instrument to comprehensively capture these constructs. The result of our validation study is a 16-item questionnaire covering four constructs with good psychometric properties. Our findings align with the job demands-resources model (Bakker & Demerouti, 2007) and extend it to ICT-specific stressors and resources. Our questionnaire enables organisations to systematically assess and address ICT-related stressors and resources and to improve occupational health management. Thus, our instrument not only helps to understand the complexity of the digital workplace but also to formulate appropriate strategies to mitigate negative effects and promote positive outcomes when introducing new ICTs.

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. 10). We reported all experimental conditions and variables (p. 8–10). We report all data exclusion criteria and whether these were determined before or during the data analysis (p. 10). We report all outlier criteria and whether these were determined before or during data analysis (p. 10).

ADDITIONAL FILES

The additional files for this article can be found as follows:

- **Appendix A.** Identified literature. DOI: https://doi.org/10.5334/spo.59.s1
- **Appendix B.** Overview of validation scales. DOI: https://doi.org/10.5334/spo.59.s2
- **Appendix C.** Final questionnaire. DOI: https://doi.org/10.5334/spo.59.s3

COMPETING INTERESTS

The authors have no competing interests to declare.

AUTHOR CONTRIBUTIONS

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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