INTERNATIONAL JOURNAL OF OCCUPATIONAL AND ENVIRONMENTAL HEALTH, 2017
VOL. 23, NO. 2, 160–171
https://doi.org/10.1080/10773525.2018.1436015

Taylor & Francis
Taylor & Francis Group

Use of information communication technology and stress, burnout, and mental health in older, middle-aged, and younger workers – results from a systematic review

Gabriele Berg-Beckhoff, Grace Nielsen and Eva Ladekjær Larsen

Unit for Health Promotion Research, University of Southern Denmark, Esbjerg, Denmark

ABSTRACT

The aim of this systematic review is to summarise quantitative studies in occupational settings observing the association between Information communication technology (ICT) and stress, and burnout, considering age as an effect modifier. A systematic review using PRISMA guidelines was conducted through the following bibliographic databases: PubMed, Web of Science, Psycinfo, and the Cochrane Library. Inclusion criteria were occupational settings and content relevant to our research question. Risk of bias was assessed using the Newcastle–Ottawa scale. Two interventional, 4 cohorts, and 29 cross-sectional studies were found. ICT use in occupational settings was associated with stress seen in cross-sectional studies, but not in interventional studies. There was a concordant association with ICT and burnout in different study designs. Overall, there were no linear trends between age and technostress. We suggest that the observed associations were mostly present in the middle-aged working population and that these associations need to be supported in further studies.

ARTICLE HISTORY
Received 17 October 2016
Accepted 30 January 2018

KEYWORDS
Information communication technology (ICT); stress; technostress; burnout; mental health; work environment

Introduction

Modern work life

The growth of technology has affected our work over the past three decades and influences the way we communicate, interact, learn, and work. Information and communication technology (ICT) is defined as technology that provides access to information through telecommunications, such as the Internet, wireless networks, cell phones, and other communication media [1]. Although ICT improves productivity and communication possibilities at workplaces, it creates adaptation demands not only on the person and the tasks performed, but also in the physical and organisational context [2]. Work is no longer bound to a certain time or place, and this is expected to have negative consequences on workers' health. For example, intensive use of ICT requires more work time and work speed [3], enhances multi-tasking, and causes disturbances to working routines and overexposure to information [4], which may cause anxiety and frustration that potentially leads to burnout over time [5].

Psychosocial reactions to ICT use can be divided into three interdependent categories: (a) cognitive: beliefs about and perceptions of technology; (b) affective: emotional responses; and (c) behavioural: the use of or withdrawal from the technology [5]. These three components potentially reduce the psychosocial consequences caused by ICT. The psychosocial consequences may result in anxiety disorders, frustration, job dissatisfaction, and low job performance, and may develop into burnout and mental health problems over longer periods of time [5,6]. In a preliminary literature search, we found studies on psychosocial consequences related to ICT use addressing stress, burnout, anxiety and mental health problems. Although these mentioned psychosocial consequences differ in terms of characteristics and classifications, we have decided to pursue and include the terms in this study to be able to establish links between ICT use and mental health problems exemplified by different mental health disorders. *Stress and ICT use.*

Psychosocial consequences emerging from the use of ICT are often described as technostress, defined as one's discomposure, fear, tenseness, and anxiety when learning and using computer technology directly or indirectly, ultimately resulting in psychological and emotional problems [7,8]. To further conceptualise creators of technostress, Tarafdar et al. [9] developed a theoretical framework consisting of five components:

- *Techno-overload* describes how ICT forces users to work faster and longer.
- *Techno-invasion* describes the invasive effect of ICT in terms of creating situations where users

CONTACT Gabriele Berg-Beckhoff gbergbeckhoff@health.sdu.dk

The supplemental data for this article can be accessed at https://doi.org/10.1080/10773525.2018.1436015

potentially can be reached anytime, thus enhancing the feeling for employees to be constantly connected.
- *Techno-complexity* describes situations where the complexity associated with ICT makes users feel inadequate in relation to their skills, and forces them to spend time and effort to learn various aspects of ICT.
- *Techno-insecurity* is associated with situations in which the users feel threatened about possible job loss as a result of a new ICT or better ICT-trained staff replacing them.
- *Techno-uncertainty* refers to contexts where continuous changes and upgrades in ICT unsettle users and creates uncertainty, which results in their having to constantly educate themselves.

Additionally, technostress inhibitors are considered such as technical support, literacy facilitators, and strengthening the engagement of employees to work with new technologies [10]. The concept of technostress is not yet fully explained [11]. ICT use forces employees to accomplish more tasks in less time, results in the elimination of manual jobs, and affects relationships with colleagues, leading to stress. Nevertheless, the benefits of ICT, including speed, replicability, responsiveness, and accuracy, which result in an efficacy in information storage, processing, and retrieval, need to be considered as well. Use of ICT changes our occupational environment with greater impact than expected [10].

Burnout and ICT use

Job burnout is a negative occupational outcome that develops due to prolonged chronic stressors during the job [12,13]. Therefore, burnout is important in the current discussion as ICT use might create chronic stress overload. Maslach et al. divided burnout into three dimensions: emotional exhaustion (the feeling of being "empty"), depersonalisation (negative cynical attitude towards the work or the recipients), and finally reduced professional efficacy (negative evaluation of achievement at work) [12,14]. Technostress creators are likely to influence job outcomes and thereby burnout through negative or positive evaluations, depending on whether the ICT user evaluates the ICT use as a threat or as an opportunity [13].

Anxiety and ICT use

Computer anxiety is explained as a negative emotional feeling while using a computer [15]. It is characterised by the following behavioural and cognitive symptoms: (1) Excessive caution with computers, (2) avoidance of computers, (3) negative remarks about computers, and (4) attempts to reduce the time using computers [16]. Computer anxiety is tightly connected to computer self-efficacy and computer expertise [16]. With regard to implementing recommendations for ICT use in occupational settings, it is necessary to consider computer anxiety, as it may counteract with the efficacy of teaching/learning if otherwise not considered.

Mental health and ICT use

Mental health describes emotional, psychological, and social well-being. It affects stress-coping strategies and it is related to how people relate to others, and makes choices [17]. A systematic review of studies on Internet use and mental health in the overall population suggests a positive correlation between Internet use and improved well-being in later life. The authors indicated that most studies did not find significant results, and the results were inconclusive [18]. Additionally, the studies had not investigated ICT used at work, but rather technology used for personal purposes in leisure times. Further research is missing to clarify underlying theories on how ICT use might affect mental health.

ICT and age

While it is well illustrated that there are psychosocial consequences related to ICT, it is less certain whether age influences these consequences. A study has concluded that there are age differences related to the ability to adapt to new technologies, although the results are not consistent [5,19]. Other studies have found that older adults perceive ICT as more difficult to use [20,21], while Ragu-Nathan et al. [10] concluded that technostress was less prevalent in older workers, which is likely to be related to their generally improved stress management skills compared to younger age groups.

According to O'Driscoll et al. 2010 [5], it is a popular belief that younger generations experience less ICT-related anxiety. This belief is illustrated among work leaders who perceive older workers to be lacking enthusiasm towards ICT, and additionally they are found to be less productive and only "passing time" until retirement [22,23].

Research in understanding employment participation by older workers is highly prioritised in international research [24]. Demographic development, i.e. increasing life expectancies and lower birth rates, has a huge impact on welfare societies and there is a need to develop initiatives that sustain economic growth and social development. Such initiatives are for example delaying retirement and making sure that workplaces meet the needs of older workers. A recent review identified that there is a need for greater research investigating the increased use of ICT in work settings and its impact on retirement [24]. Due to the inconsistency of the given results regarding the relationship between ICT and age, and knowing that mental health is a huge predictor of early retirement [25], we respond to this call

by investigating the age-dependent effect in the associations between ICT and mental health/stress, burnout, and mental health problems.

To evaluate whether older workers experience more stress, burnout, anxiety, and mental health problems than younger ones, we have conducted a systematic review of the scientific literature available on the associations between ICT use, stress, burnout, anxiety, and mental health and the specific effect modification of age. The results will help provide an evidence-based foundation for the development of future interventions to prevent common mental disorders caused by the use of ICT and to enhance work participation of older workers.

Methods

A systematic review was conducted using the guidelines from the *Preferred Reporting Items for Systematic Reviews and Meta-Analyses* (PRISMA) statement [26].

A two-stage search strategy was applied. In the first stage, bibliographic databases (PubMed, Web of Science, Psycinfo, and the Cochrane Library) were systematically searched by screening titles, abstracts, and topics, and applying keywords depending on the database. Search terms included *information communication technology, computer, work, occupation, mental health, stress, technostress, burnout, depression,* and *anxiety.* Various observational quantitative human studies addressing ICT use, stress, depression, and mental health in working populations (at work or at home office) were eligible for inclusion in the review. Studies were excluded if they focused on not working populations, were not written in English, and where the report was inadequate to thoroughly evaluate the methods and results. In addition, we chose to limit the review to more recent publications, including only studies published from the year 2000 until January 2016. Secondly, a snowballing technique was used, where references of references were pursued in order to further detect reports of studies not found in the database search. Studies were initially identified by title and abstract, and later included after full text evaluation. The latest search was conducted in January 2016.

The risk of bias in the studies included was assessed by the Newcastle-Ottawa scale [27,28]. The risk of bias in cohort studies and interventional studies in relation to selection, comparability, and assessment of the exposure/outcome was assessed by nine items, using a star allocation scheme. Stars were allocated if a study was deemed to have a low risk of bias within each item according to the coding manual. For cross-sectional studies, the number of questions was diminished to five items, as questions about follow-up were deleted. A study was categorised as having a low risk of bias if a total of 8–9 stars (cohort and interventional study version) or 5 stars (cross-sectional version) were allocated. A medium risk of bias was categorised if 6–7 stars and 3–4 stars were allocated, respectively; a high risk of bias was given if the study was given 5 stars or less for cohort and intervention, and 2 stars or less if cross-sectional studies were considered. All activities with regard to article searches, excluding relevant studies, collecting relevant information from the article, and the risk of bias analysis were done and checked by two other individuals. Discrepancies were thoroughly discussed and a conclusion was suggested. It was not possible to perform a meta-analysis as the study designs, considered outcomes and exposures, varied tremendously between the studies.

Results

Cumulatively, 189 articles were identified and after exclusion, 29 cross-sectional studies, 4 cohort studies, and 2 intervention studies were retrieved. (see Figure 1).

Study methods, study origin, and study quality are presented in Table 1 for cross-sectional studies and in Table 2 for intervention and cohort studies. Studies were published from various countries worldwide, excluding African countries, with the majority of studies taking place in Europe. Most studies used office-working personnel in diverse private and public settings, and ICT use by nurses, caregivers, social workers, and teachers was also studied. Fifty per cent ($n = 16$) of the cross-sectional studies had a medium risk of bias and 50% had a high risk of bias. All follow-up design (cohort or intervention studies) was evaluated with a high risk of bias. The risk of bias analyses showed no association with publication year or study location.

ICT use was estimated differently by the publications used. Mostly, it was categorised as the percentage of working time using ICT (mostly only connected to computer), or counting the hours working with ICT. Only a few studies checked more specific ICT-related topics, such as Internet use [29], email [30], separate analysis for laptop and desktop use [31,32], smartphone use [33], and ICT experience [34].

With regard to the association between ICT use and stress (Table 3), 14 study results are presented of which 5 used technostress as the stress-related outcome [6,35–38]. Some used self-developed scores [30,33,39], some did not describe the stress variable [31,40], and some used different, but already existing scores, like Cohen's perceived stress score [41,42] and the Norwegian Carer stress score [43,44]. Cross-sectional studies revealed a very clear positive association between ICT use and stress measured in different dimensions, like general stress scores [30,31,33,39,41], stressors [45], and technostress [6,35–38]. The two intervention studies analysed the same research question. The intervention study design allows a better causal interpretation as it contains a follow-up and makes it possible to measure the exposure (ICT use) before the outcome (stress). Both interventions present no connection between ICT use and stress [40,43].

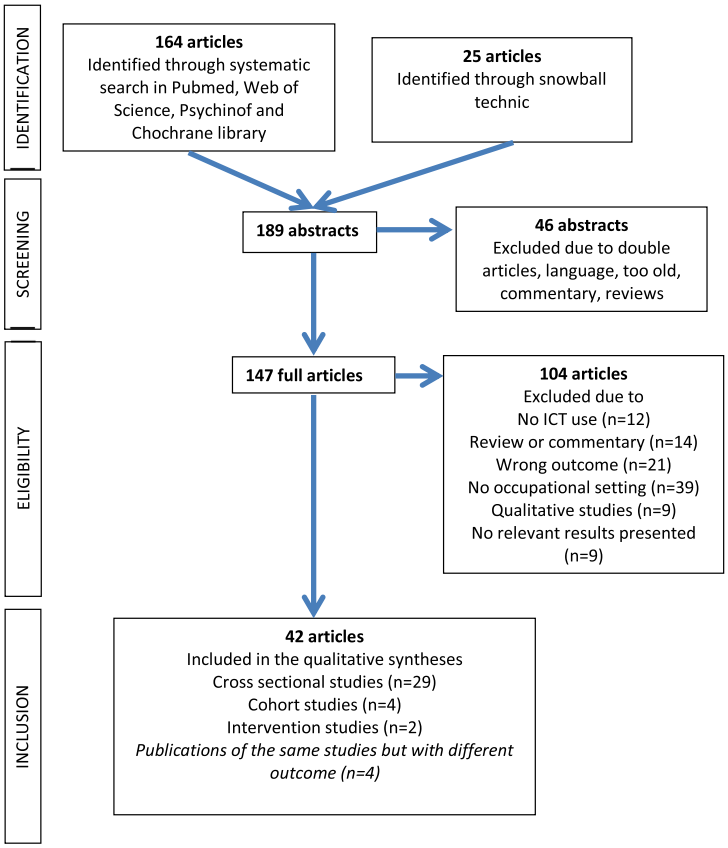

Figure 1. Flow chart for article identification and selection.

Table 1. Methods and risk of bias analyses in cross-sectional studies.

Author[d]	Pub. year	Country	Occupation	*N*	RR[b]	Age range[c]	ROB score[a]
Europe							
[37] Fuglseth	2015	Norway	Administration	216	54	$\mu = 46$	3
[60] Mikkelsen	2002	Norway	Industrial enterprises	342	49	$\mu = 41$; SD = 11	3
[6] Salanova	2013	Spain	ICT users	1072	nn	18–58	**2**
[10] Ragu-Nathan	2008	Spain	ICT users	608	89.4	~20–65	**2**
[53] Beas	2006	Spain	Public sector	496	nn	20–58	**2**
[41] Eijckelhof	2014	NL	Office worker	93	77.5	nn	**2**
[47] Fieseler	2014	EU	Industrial enterprises	491	nn	~36–56	**2**
[70] Koivunen	2013	Finland	Nurses	146	81	~20–60	3
[32] Korpinen	2011	Finland	Different sectors	6121	41	18–65	3
[58] Seppälä	2001	Finland	Different sectors	379	42.4	21–623	**2**
[16] La Paglia	2008	Italy	Teachers	77	nn	28–61	**2**
[45] Rangarajan	2005	Belgium	Sales professionals	154	64	nn	3
[15] Bozionelos	2001	UK	Manager	228	nn	$\mu = 30$; SD = 7	**2**
Asia							
[13] Srivastava	2015	Asia/EU	Manager	152	22	~21–60	**2**
[38] Jena	2015	India	Academician	54	54	~20–60	**2**
[33] Yun	2012	Korea	Different sectors	1200	40	20–50	3
[35] Koo	2011	Korea	Different sectors	98	98	26–50	**2**
[50] Leung	2011	Hong Kong	Office worker	612	58.8	$\mu = 36$; SD = 10	3
[8] Shu	2011	China	Different sectors	289	82.6	20–45	3
[7] Wang	2008	China	Different sectors	951	70.4	~20–40	3
[36] Tu	2005	China	Different sectors	437	62.4	~20–40	**1**
America							
[11] Tarafdar	2015	USA	Sales professionals	237	47	26–56	3
[59] Chesley	2014	USA	Civilian labour force	2256	60	$\mu = 42$; SD = 12	3
[29] Hennington	2011	USA	Nurses	71	nn	20–59	**2**
[30] Brown	2014	Canada	University setting	215	nn	$\mu = 42$; SD = 11	**2**
[39] Day	2012	Canada	Different sectors	258	85.7	$\mu = 35$; SD = 9	3
[48] Rocha	2003	Brazil	System analysts	553	85	18–56	3
Australia/New Zealand							
[31] Goldfinch	2011	New Zealand	Public servant	240	51	$\mu = 43$	**2**
[57] Lam	2009	Australia	Care giver	784	nn	> 60 years	3

[a]ROB score: Risk of bias analysis. Scores marked in bold show a high risk of bias; unmarked scores have a medium risk of bias.
[b]RR: response rate; nn: not named in the article.
[c]μ: mean age; SD: standard deviation, nn: not named in the article.
[d]Only first author is named.

Table 2. Methods and risk of bias analyses in cohort and intervention studies.

Author[d]	Pub. year	Country	Occupation	N	RR[b]	Age range[c]	ROB score[a]
Intervention studies							
[40] Chen	2009	Israel	ICT user	218	nn	nn	**4**
[43] Torp	2008	Norway	Care givers	19	nn	57–85	**3**
Cohort studies							
[34] Kouvonen	2015	Finland	Computer jobs	370	67	49–61	**5**
[55] Stenfors	2012	Sweden	Different sectors	3644	65	16–64	**5**
[56] De Croon	2004	Netherlands	Lorry driver	73	72	$\mu = 42$;SD = 9	**4**
[54] Choi	2002	USA	Social worker	244	76.5	20–58	**2**

[a]ROB score: Risk of bias analysis. Scores marked in bold show a high risk of bias; unmarked scores have a medium risk of bias.
[b]RR: response rate nn: not named in the article.
[c]μ: mean age; SD: standard deviation, nn: not named in the article.
[d]Only first author is named.

Table 4 presents results with regard to exhaustion, burnout, and depression. Most publications (5 out of 9) are based on the Maslach Burnout inventory (MBI) [46]. The intervention study [40] showed an association of ICT-related overload with exhaustion and a five-day intervention with exhaustion. From the eight listed cross-sectional studies, five show a clear positive association [30,47–49], but three of them did not find a significant association [13,50,51].

Results for computer anxiety and mental health are shown in supplementary Table I. For computer anxiety, the methods used to estimate it are various and differ tremendously. Comparing the results from all studies, no clear result was found. Either no association [16,52] or a positive association [46,53,54] was found. With regard to mental health, the results are even more diverse and also all the studies used different scoring methods to measure mental health. One cohort study [55] and two cross-sectional studies [46,56] revealed a negative effect of the pattern of computer use on cognitive complaints, mental health and the need for recovery; one intervention study [43] and one cross-sectional study [32] showed no association. Finally, an Australian survey showed that use of ICT was associated with better mental health [57].

Age as an effect modifier was not considered as a main research question in any stress-related study. Three studies [32,39,58] did not find any linear relationship between stress and age in this occupational ICT context. The Finnish survey mentioned that middle-aged employees were most stressed about the changes in their task [58]. Finally, a cross-sectional study in the USA directly considered no linear effect of age (age + age^2), which revealed significant results [59]. Two Chinese cross-sectional studies [7,8] found a positive association between technostress and age, but they only observed young employees up to 45 years of age. The same finding, but with a wider age range for *elderly* (defined as older than 35 years of age), was illustrated in the last Chinese cross-sectional study [36]. A Norwegian survey [37] found a positive association with age and technostress, whereas a Spanish survey found a negative association [10] (Table 5).

Discussion

ICT use in occupational settings is associated with stress in cross-sectional studies, but not in intervention studies. Cross-sectional studies allow only to consider an undirected association between ICT use and stress. However, in intervention studies, a causation from ICT use to stress would be supported. Contrary to that, there is an association between ICT and burnout independently from the study design. The observed associations are mostly present in the middle-aged working population.

Though no study searched for age as an effect modifier as the main research question, the results are surprisingly concordant. Even though different outcome measurements for stress or burnout and exposure to several forms of ICT use were considered, older employees were not shown to be experiencing more stress or burnout when using ICT. These findings contrast with studies on management attitudes, which support decreased enthusiasm and increased concern to use new technologies like ICT in older employees [22,23]. Given the presented results, an effect modification of age on the association between ICT use and stress can be discussed. At a younger age (up to 35 years of age), there is only a small or no association between ICT use and stress. In the middle age group (between 35 and 45), there is a clear positive association between ICT use and stress and/or burnout, which disappears or reduces once again in the older age group. This model is supported by studies with younger employees (up to 45 years of age) where a positive trend was found [7,8]. Studies looking at the whole range of working populations support our model as well, while not finding a linear association with age and technostress [33,39]. The Finnish survey, already conducted in 2001, pointed out that the middle-aged group is the most vulnerable working population when looking at the association between ICT use and stress/burnout [58]. Finally, one cross-sectional study considered age as a squared variable in the model (age + age^2), which also fits with our suggested model. However, none of the presented studies aimed to look at the age effect, and therefore our suggestions need to be regarded with caution and further research is necessary.

Table 3. Association between ICT use and stress seen from cross-sectional studies and two intervention studies (presented in italics) [40,43].

Author[a]	Year	Country	Outcome	Exposure	Result
[6] Salanova	2013	Spain	Technostress	Intensity of ICT use and other predictors	Workload, role ambiguity, emotional overload, mobbing (or bullying), obstacles hindering ICT use, lack of autonomy, transformational leadership, social support, ICT use facilitators, and mental competencies predict technostress
[35] Koo	2011	Korea	Technostress	Innovation culture, self-efficacy, task complexity	Self-efficacy and technostress is insignificant related. Task complexity and technostress is positive associated, however, mediated by computer literacy
[36] Tu	2005	China	Technostress	Age, computer literacy, task complexity	Age, task complexity and reward predict nearly all parts of technostress, but computer literacy predicts different scores for technostress with a lesser amount
[37] Fugelseth	2015	Norway	Use of ICT	Technostress (creators)	Factors that create and inhibit technostress affect the intention to use ICT
[38] Jena	2015	India	Techn. performance	Technostress (creators)	Strong association between technical performance and technostress creators
[30] Brown	2014	Canada	Stress	E-mail quantity and quality	High quantity and poor quality of e-mails are positively associated with stress
[41] Eijckelhof	2014	UK	Computer use pattern	Stress	Daily duration of computer use was on average 30 min lower for workers with a high compared to a low level of over-commitment and perceived stress
[39] Day	2012	Canada	Stress	ICT demands and ICT support	ICT demands and ICT support are positively associated with stress
[31] Goldfinch	2011	New Zealand	Stress	ICT use	Results are not shown, but association is postulated in the abstract
[40] Chen	*2009*	*Israel*	*Stress*	*5 days ICT use intervention*	*No association*
[43] Torp	*2008*	*Norway*	Job stress	*Use of IT equipment*	*In the intervention group there was increase or decrease of stress*
[33] Yun	2012	Korea	Stress as work-to-life conflict	Office /home work, work overload, flexibility smartphone use	Workload is significantly related to work-to-life conflict. Flexibility does not affect work-to-life conflict significantly
[45] Rangarajan	2005	Belgium	Stressors	Task complexity	Task complexity is positively associated with the level of stressors (ambiguity and conflict)

[a]Only first author is named.

Table 4. Association between ICT use and burnout, depression, and exhaustion from cross-sectional studies and one intervention study [40], marked in italics.

Author[b]	Pub year	Country	Outcome	Exposure	Result
[40] Chen	*2009*	*Israel*	*Exhaustion*[a]	*5 days ICT use intervention*	*Group without intervention had higher exhaustion*
[47] Fieseler	2014	EU	Exhaustion[a]	Technostress, leadership	Technostress is associated with exhaustion. In ICT-induced stress, leadership aspects compensate effect on exhaustion
[30] Brown	2014	Canada	Emotional exhaustion[a]	E-mail quantity and quality	High quantity and poor quality of emails are positively associated with emotional exhaustion
[39] Day	2012	Canada	Burnout[a]	ICT demands and ICT support	ICT demands and ICT support are positively associated with burnout
[49] Salanova[c]	2000	Spain	Burnout[a]	ICT use, computer training	Positive association given, computer self-efficacy moderates the relationship between training and burnout
[13] Srivastava	2015	ASIA, EU	Burnout	Hours of ICT use	Hours of ICT use are not associated with job burnout
[50] Leung	2011	Hong Kong	Burnout	Internet use	Connectedness with ICT use is not associated with burnout
[52] Korpinen[c]	2009	Finland	Depression, Exhaustion	Desktop, portable computer	No association detectable
[48] Rocha	2003	Brazil	Depression	Computer analysts versus people not working with computer	Depression often seen in computer-oriented work

[a]Maslach Burnout inventory was used.
[b]Only first author is named.
[c]Another article from the same study population was used in Table 1: Beas et al. (2006) was used for method description of Salavona et al. (2000) and Korpinen and Pääkönen (2011) for Korpinen and Pääkönen (2009).

Up until now, there has been no literature available discussing the age effect on the association between ICT use and stress/burnout. Possibilities include that the family structure, such as small children at home, may complicate the work–life balance. Furthermore, concerns about one's own job and career are additional stressors that mediate together with ICT stress or burnout, particularly in middle-aged employees. Another potential mediator of the decreased ICT-related stress or burnout in elder workers might be the duration of work experience with ICT. The association not being found in elder employees can be explained by their life experiences, which might help them cope with ICT-related stress. Furthermore, it is well established that management structure and work environment are important mediators in the associations between ICT use and stress [45,59–61]. Future research is necessary to find plausible explanations to solidify this hypothesis, as well as to clarify reasons for the discrepancy in management attitudes towards older ICT users and their own stress and burnout perception during use.

As summarised above, ICT use in occupational settings is evidently associated with increased stress in cross-sectional studies, but not in the intervention studies. Additionally, cross-sectional studies only make it possible to estimate the association between the two variables of interest, but it is not known which is exposure (having the effect on, independent variable) and which is outcome (being affected, dependent variable). Therefore, a clear definition of exposure and outcome cannot be made. Both directions are discussed in the presented cross-sectional article. Some studies discussed that ICT work may lead to stress [6,30,31,35,36,39], but in more recent studies the effect of stress on ICT use is discussed as well [37,38,41]. Advantages of cross-sectional studies are the fast data collection procedure, cheap costs, and it allows the estimation of prevalence's. Most often mentioned disadvantage of cross-sectional studies is the missing timeline and therefore causality cannot be discussed. Another systematic review of 18 cross-sectional studies looking at the association between Internet use and mental health and stress found some positive and some negative associations between Internet use and stress [18]. An explanation for this inconclusive result might be that the potential effect between ICT use and stress differs between occupational and private settings. In the private setting, one can independently decide one's use of ICT, and so positive aspects of ICT use will be more present. In the occupational setting, personnel commonly do not have a choice regarding their ICT use, or whether they can enjoy using it for leisure purposes, and therefore such factors might increase the negative aspects inducing stress and mental health problems. The association between ICT use and stress seemed to be present, as most studies in occupational settings showed a positive association. However, the evidence of the results that were found is poor, as only cross-sectional studies found an association between ICT use and stress, but not intervention studies. Comparing scientific evidence between these two study designs, the intervention study is evaluated far better. Due to time-dependent collection of the outcome before and after the interventions, intervention studies can directly support causality between the intervention and the outcome of interest. Further research is necessary and in particular, cohort studies and further intervention studies are missing.

Table 5. Age effect of ICT use on stress and mental health from cross-sectional studies and one cohort study [34], marked in italics.

Author[a]	Pub year	Country	Outcome	Exposure	Age effect
Stress					
[33] Yun	2012	Korea	Job stress	Office home, smart phone, work overload	Age does not correlate with any variable
[21] Day	2012	Canada	Stress	ICT use, ICT demand and support	Age is positively correlated with workload, and negatively with lack of job control, but there is no association with ICT and stress
[58] Seppälä	2001	Finland	Stress	Technological change	Computer-related tasks were perceived as more stressful for workers < 45 years of age compared to older ones. Stress score is not linearly associated with age
[59] Chesley	2014	USA	Distress	Age, daily computer use	(Age + age^2) is significantly associated with stress
[37] Fugelseth	2015	Norway	Use of ICT	Technostress	Age has a significant positive association with technostress creators and inhibitors
[8] Shu	2011	China	Technostress	Computer self-efficacy, technological dependency	Technostress increases with age
[7] Wang	2008	China	Technostress	Education, age and sex	Technostress increases with age
[10] Ragu Nathan	2008	Spain	Job satisfaction	Technostress	Older workers experience less technostress
[36] Tu	2005	China	Technostress	Age, computer literacy, task complexity and reward	Age group > 35 years has more stress than the younger ones (with regard to overall, overload, task complexity, but not invasion, insecurity, and uncertainty
Burnout, exhaustion, depression					
[34] Kouvonen	*2015*	*Finland*	*Exhaustion*	*Overload, job, control information overload*	*Not age, but over time (follow-up of two years) overload is decreasing but exhaustion in increasing*
[21] Day	2012	Canada	Burnout,	ICT use, ICT demand and support	Age is positively correlated with workload, and negatively with lack of job control, but there is no association with ICT burnout
[29] Hennington	2011	USA	Burnout	Perceived compatibility of ICT use	Age is negatively correlated with exhaustion
[52] Korpinen	2011, 2009	Finland	Depression	Use and importance of Internet at leisure time; Mobile phone, desktop, portable computer	Age considered linear, has a very small but significant positive effect on depression
Anxiety					
[71] Korpinen	2011	Finland	Anxiety	Use and importance of Internet at leisure time; mobile phone, desktop, portable computer	Age considered linear, is not correlated with exhaustion. Furthermore, an age interaction considered, particular the age group 30–40 experience mental symptoms when exposed to ICT use. In the other age groups, no such effect is visible
[60] Mikkelsen	2002	Norway	Computer anxiety	Looking for several predictors	Computer anxiety increases with age
[15] Bozionelos	2001	UK	Computer anxiety	General predictors, but also age and experience	Youngest sample had highest computer anxiety scores. In the older group (advanced manager), anxiety and age are positively correlated, in the other groups they are negatively correlated

[a]Only first author is named.

Concepts of technostress do not consider stress-reducing aspects of ICT use. Use of ICT might reduce stress by opening new possibilities to structure work, such as a home office, or options for Internet searches and other opportunities. It can be suggested that home office spaces might decrease stress in middle-aged workers, as they make it possible to take care of children and might help facilitate the work–life balance [62]. There are also some personal traits (e.g. conscientiousness, openness, and agreeableness) [13] that allow some individuals to be online day and night without experiencing mental health problems, whereas others cannot tolerate such a habit. It is important to understand both the benefits and the challenges regarding use of ICT in workplaces. Firstly, the positive aspects of ICT in the workplace are recognised in a growing body of evidence. These include: increased productivity, reinforced global communication, reduced turnover intentions, increased commitment to organisation, and a decrease in occupations that require manual labour work [63,64]. Increased flexibility has allowed the working force to work from home and provides new possibilities for long distance work [65]. Some evidence indicates an association between ICT and a stronger social capital, leading to greater job satisfaction [64]. In addition, ICT has a positive contribution on the educational system in terms of innovation for teaching and learning [66]. Research from The Work Foundation [67] found that 74% of their respondents agreed that technology makes it easier for them to do their job well; however, 13% of the employees felt it made work more complicated. Results indicated that new ICT in the workplace is associated with having a culture of mutual trust and loyalty, and is connected to greater trust between colleagues. This suggests that ICT can enforce a stronger working relationship and thereby reduce stress.

Results on the association of ICT use with burnout, exhaustion, and depression showed a concordant picture. Most studies (5 out of 9 articles) have used MBI [21,30,40,47,49]. Not only *most cross- sectional studies* (5 out of 9:21,30,47–49), but also the intervention study [40], found a positive association between ICT use and these outcomes. When the presentation of results is limited to studies using MBI, studies not showing an association are deleted. Because MBI is well accepted and quite often used in occupational settings, [12,14], the evidence of the discovered effect of technostress on burnout is confirmed. A causal explanation for this stringent finding can be seen in the systematic review of burnout. The authors concluded that high job demand and prolonged response to interpersonal stressors create burnout in the long run [14]. Not only ICT use, but also multi-tasking, disturbance of working routines, and overexposure of information [4] are potential chronic stressors.

Inconsistent results are present with regard to ICT use, along with computer anxiety and mental health. For computer anxiety, an explanation of these unclear associations might be derived from the several effect-modifying variables, which predict anxiety and might lead to varying results in different populations. The following effect modifiers were named: ICT use attitude [53], computer self-efficacy [16], gender, age, education, training, and decision authority in the leadership [60]. Results with regard to ICT use and mental health are inconclusive, as the same number of studies show positive, negative, and no association. Further research is necessary to clarify potential underlying mechanisms and the optimal way to measure mental health in an occupational setting.

An important limitation of this review is the missing homogeneity between the studies considered: different methods were used, different definitions of ICT use were applied, and different measurement scales for the outcome were presented. However, our deciding to present the collected information as a more specific presentation is not possible, due to the missing homogeneity in the presented research. This inhomogene exposure and outcome assessments limits the presentation and discussion of the results but it is still necessary and accepted by the Prisma guideline [26] to publish the results. It is important to sum up existing knowledge, diverse existing exposures and outcome definitions carefully to enable further research taking into account previous research limitations.

Another limitation is that we only include peer-reviewed articles in English, leaving some regional and more specific reports and studies in other languages unassessed. A further limitation can be seen in the risk of bias analysis, as it revealed poor results, particularly in cohort and intervention studies. This is mostly explained by missing representativeness, missing description of the ascertainment of exposure, and missing information about disease status at the beginning of the cohort/intervention. Even though methodological quality is better in cross-sectional studies, there are still no studies with a low risk of bias. The high risk of bias score in cross-sectional studies is mostly based on self-reported assessment of exposure and outcome. However, excluding at least the studies with a high risk of bias does not change the results. A further limitation is that most studies were collected in several sectors and did not allow for separate views on specific occupations or specific ICT tasks. Finally, technology changes rapidly and normal technological procedures used today will already be old-fashioned tomorrow. Although the fast-paced changes regarding ICT use in occupational settings greatly affect the occupational environment, our review can only display the impact of studies from today. Nevertheless, it allows for the identification and prioritisation of research directions, which are crucial for evolving towards a solid knowledge base on the association between ICT use and mental health.

Conclusion

ICT contributes to positive and negative aspects in relation to burnout and stress. As far as the current knowledge states, ICT use may not be the most important stress creator in occupational settings [68], but technostress can easily be avoided. The best way to prevent technostress is to secure the workplace organisational culture and provide support when implementing new technology. Negative attitudes should be avoided and support from management and colleagues is important, as well as the possibility of further qualifications [69]. Specific awareness of the middle-aged group should be made to better support their work–life balance.

Future cohort studies with careful data collection and lengthier follow-up are missing. Furthermore, the exposure assessment of ICT use needs to be developed, which needs to be used concordantly in different studies. Different ICT tasks facilitating or inhibiting stress-free work, and the ICT attitude of employees and the leadership need to be considered as potential exposures. Future research should additionally consider different types of ICT activity and different types of profession. The simple problem of desktop ICT work is less important nowadays, yet more perspective is required on permeating the availability at work, such as work-related smartphone or tablet use in private, and one's online presence for the majority of the day. Although such circumstances may create stress, they may also facilitate creative solutions, such as a home office and other systems that can also be used to reduce stress.

Disclosure statement

No potential conflict of interest was reported by the authors.

ORCID

Gabriele Berg-Beckhoff http://orcid.org/0000-0003-1614-938X
Grace Nielsen http://orcid.org/0000-0002-1711-3162

References

[1] Christensson, P.. ICT definition. TechTerms [internet]. Sharpened Productions, Jan 2010 04. [July 2015 21]. Available from: http://techterms.com/definition/ict
[2] Carayon P. Healthy and efficient work with computers and information and communication technology – are their limits? Scand J Work Environ Health. 2007;33(3):10–16.
[3] Green F. Work intensification, discretion and the decline in well-being at work. East Econ J. 2004;30(4):615–624.
[4] Mano RS, Mesh GS. E-mail characteristics, work performance and distress. Comput Human Behav. 2010;26(1):61–69.
[5] O'Driscoll MP, Brough P, Timms C, et al. Engagement with information and communication technology and psychological well-being. In: Perrewe PL, Ganster DC, editors. New developments in theoretical and conceptual approaches to job stress. Research in occupational stress and well-being. Connecticut, USA: Emerald; Vol. 8. 2010. p. 269-316.
[6] Salanova M, Llorens S, Cifre E. The dark side of technologies: technostress among users of information and communication technologies. Int J Psychol. 2013;48(3):422–436.
[7] Wang K, Shu Q, Tu Q. Technostress under different organizational environments: An empirical investigation. Comput Human Behav. 2008;24:3002–3013.
[8] Shu Q, Tu Q, Wang K. The impact of computer self-efficacy and technology dependence on computer-related technostress: a social cognitive theory perspective. Int J Human-Comput Interact. 2011;27(10):923–939.
[9] Tarafdar M, Tu Q, Ragu-Nathan B, et al. The impact of technostress on role stress and productivity. J Manag Inf Syst. 2007;24(1):201–328.
[10] Ragu-Nathan TS, Tarafdar M, Ragu-Nathan BS, et al. The consequences of technostress for end users in organisations: Conceptual development and empirical validation. Inf Syst Res. 2008;19(4):417–433.
[11] Tarafdar M, Pullins EB, Ragu-Nathan TS. Technostress: negative effect on performance and possible mitigations. Inf Syst J. 2015;25(2):103–132.
[12] Maslach C, Schaufeli WB, Leiter MP. Job burnout. Ann Rev Psychol. 2001;52(1):397–422.
[13] Srivastava SC, Chandra S, Shirish A. Technostress creators and job outcomes: theorising the moderating influence of personality traits. Inf Syst J. 2015;25(4):355–401.
[14] Seidler A, Thinschmidt M, Deckert S, et al. The role of psychosocial working conditions on burnout and its core component emotional exhaustion – a systematic review. J Occup Med Toxicol. 2014 Mar;9(1):10.
[15] Bozionelos N. Computer anxiety: relationship with computer experiences and prevalence. Comput Human Behav. 2001;17:213–224.
[16] La Paglia F, Caci B, Barbera LD. Technostress: a research about computer self-efficacy, internet attitude and computer anxiety. Ann Rev Cybertherapy Telemed. 2008;6:63–69.
[17] US-Department of health and human services: What is mental health? [Jul 2016 13]. Available from: https://www.mentalhealth.gov/basics/what-is-mental-health/
[18] Forsman AK, Nordmyr J. Psychosocial links between internet use and mental health in later life: A systematic review of quantitative and qualitative evidence. J Appl Gerontol. 2015;1–48.
[19] Czaja SJ, Charness N, Fisk AD, et al. Factors predicting the use of technology: findings from the center for research and education on aging and technology enhancement (create). Psychol Aging. 2006;21(2):333–352.
[20] Burton-Jones A, Hubona GS. Individual differences and usage behaviour: revisiting a technology acceptance model assumption. Adv Inf Syst. 2005;36(2):58–77.
[21] Day A, Scott N, Kelloway EK. Information and communication technology: implications for job stress and employee well-being. In: Perrewé og Ganster DC (red). New developments in theoretical and conceptual approaches to job stress. Research in occupational stress and well-being. Vol. 8. Emerald Group Publishing Limited; 2010. p. 317–350.

[22] Furunes T, Mykletun RJ. Age discrimination in the workplace: validation of the Nordic Discrimination Scale (NADS). Scand J Psychol. 2010;51:23–30.
[23] Taylor P, Walker A. Employers and older workers: attitude and employment practices. Ageing Soc. 1998;18:641–658.
[24] Hasselhorn HM, Apt W, editors. Understanding employment participation of older workers: Creating knowledge base for future labour market challenges. Berlin: German Federal Ministry of Labour and Social Affairs; 2015.
[25] de Wind A, Geuskens GA, Ybema JF, et al. The role of ability, motivation, and opportunity to work in the transition from work to early retirement – testing and optimizing the Early Retirement Model. Scand J Work Environ Health. 2015;41(1):24–35.
[26] Liberati A, Altman DG, Tetzlaff J, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evlaute Healht care interventions: explanation and elabloration: the PRISMA statement. PLOS Med. 2009;6(7):1–28.
[27] Wells GA, Shea B, O'Connell D, et al. The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomized studies in meta-analyses. 2014. [Nov 15]. Available from: http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp
[28] Deeks JJ, Dinnes J, D' Amico R, et al. Evaluating non-randomised intervention studies. Health Technol Assess. 2003;7(27):iii–x, 1–173.
[29] Hennington A, Janz B, Poston R. I'm just burned out: Understanding information system compatibility with persons values and role based stress in a nursing context. Comput Human Behav. 2011;27:1238–1248.
[30] Brown R, Duck J, Jimmieson N. Email in the workplace: The role of stress appraisals and normative response pressure in the relationship between e-mail stressors and employee strain. Int J Stress Manag. 2014;21(4):325–347.
[31] Goldfinch S, Gauld R, Baldwin N. Information and communications technology use, e-government, pain and stress amongst public servants. New Technol Work Employ. 2011;26(1):39–53.
[32] Korpinen L, Pääkkönen R. Working-aged population's mental symptoms and the use of the internet. Mental Illness. 2011;3(1):25–28.
[33] Yun H, Kettinger WJ, Lee CC. A new open door: the smartphone's impact on work-to-life conflict, stress, and resistance. Int J Electron Comm. 2012;16(4):121–152.
[34] Kouvonen A, Toppinen-Tanner S, Kivistö M, et al. Job characteristics and burnout among aging professionals in information and communications technology. Psychol Rep. 2005;97:505–514.
[35] Koo C, Wati Y. What factors do really influence the level of technostress in Organizations? An empirical study. In: Nguyen NT, et al., editors. New challenges for intelligent information. Berlin Heidelberg: Springer-Verlag; 2011. p. 339–348.
[36] Tu Q, Wang K, Shu Q. Computer-related technostress in China. Commun ACM. 2005;48(4):1–9.
[37] Fugelseth AM, Sørebrø Ø. The effects of technostress with the context of employee use of ICT. Comput Human Behav. 2014;40:161–70.
[38] Jena RK. Technostress in ICT enabled collaborative learning environment: An empirical study among Indian academician. Comput Human Behav. 2015;51:1116–1123.
[39] Day A, Paquet S, Scott N, et al. Perceived information and communication technology (ICT) demands on employee outcomes: the moderating effect of organizational ICT support. J Occup Health Psychol. 2012;17(4):473–491.
[40] Chen S, Westman M, Eden D. Impact of enhanced resources on anticipatory stress and adjustment of new Information technology: a field experimental test of conservation of resources theory. J Occup Health Psychol. 2009;14(3):219–230.
[41] Eijckelhof BHW, Huysmans MA, Blatter BM, et al. Office workers' computer use patterns are associated with workplace stressors. Appl Ergon. 2014;45:1660–1667.
[42] Cohen S, Kamarck T, Mermelstein R. A global measure of perceived stress. J Health Soc Behav. 1983;24(4):385–396.
[43] Torp S, Hanson E, Hauge S, et al. A pilot study of how information and communication technology may contribute to health promotion among elderly spousal carers in Norway. Health Soc Care Community. 2008;16(1):75–85.
[44] Green JG, Smith R, Gardiner M, et al. Measuring behavioural disturbance of elderly demented patients in the community and its effects on relatives: a factor analytics Study. Age Ageing. 1982;11(2):121–6.
[45] Rangarajan D, Jones E, Chin W. Impact of sales, force automation on technology related stress, effort and technology usage among salespeople.. Indus Market Manage. 2005;34(4):345–354.
[46] Maslach CH, Jackson SE, Leiter MP. Maslach burnout inventory manual. 3rd ed. Palo Alto (CA): Consulting Psychologist Press; 1996.
[47] Fieseler C, Grubenmann S, Meckel M, et al. The leadership dimension of coping with technostress. 47th Hawaii International Conference on System Science. Washington, DC: IEE Computer Society; 2014. p. 530–539.
[48] Rocha LE, Debert-Ribeiro M. Working condition, visual fatigue, and mental health among system analysts in Sao Paulo, Brazil. Occup Environ Med. 2004;61:24–32.
[49] Salanova M, Grau RM, Cifre E, Llorens S. Computer training, frequency of usage and burnout: the moderation role of computer self-efficacy. Comput Human Behav. 2000;16:575–590.
[50] Leung L. Effects of ICT connectedness, permeability, flexibility, and negative spill overs on burnout and job and family satisfaction. Human Technol. 2011;7(3):250–267.
[51] Korpinen L, Pääkkönen R, Gobba F. Self-reported neck symptoms and use of personal computers, laptop and cell phones among Finns aged 19–65. Ergonomics. 2013;56(7):1134–1146.
[52] Korpinen L, Pääkkonen R. Mental symptoms and the use of new technical equipment. Int J Occup Safety Ergon. 2009;15(4):385–400.
[53] Beas MI, Salanova M. Self-efficacy beliefs, computer training and psychological well-being among information and communication technology workers. Comput Human Behav. 2006;22(6):1043–1058.
[54] Choi G, Ligon JH, Ward J. Computer anxiety and social workers: differences by access, use, and training. J Technol Human Services. 2002;19(1):1–12.
[55] Stenfors CUD, Magnusson LH, Oxenstierna G, et al. Psychosocial working conditions and cognitive complaints among Swedish empoyees. PloS One. 2013;8(4):1–6.

[56] de Croon EM, Kuijer PPFM, Broersen JPJ, et al. Information technology and road transport industry: how does IT affect the lorry driver? Appl Ergon. 2004;35(4):313–320.
[57] Lam L, Lam M. The use of information technology and mental health among older care-givers in Australia. Aging Mental Health. 2009;13(4):557–562.
[58] Seppäla P. Experience of stress, musculoskeletal discomfort, and eyestrain in computer-based office work: a study in municipal workplaces. Int J Human-Comput Interact. 2001;13(3):279–304.
[59] Chesley N. Information and communication technology use, work intensification and employees strain and distress. Work Employ Soc. 2014;28(4):589–610.
[60] Mikkelsen A, Øgaard T, Lindøe PH, et al. Job characteristics and computer anxiety in the production industry. Comput Human Behav. 2002;18:223–239.
[61] Harris kJ, Harris RB, Carlson JR, et al. Resource loss from technology overload and its impact on work-family conflict: Can leaders help? Comput Human Behav. 2015;50:411–417.
[62] O'Driscoll M, Brough P, Kalliath T. Work-family conflict and faciliatation. In: Jones F, Burke RJ, Westman M, editors. *Work-life balance: a psychological perspective*. Hoboken: Psychology Press; 2013. p. 117–142. doi:10.4324/9780203536810.
[63] Barnett K, Spoehr J, Moretti C, Gregory T, Chiveralls K. AISR -Technology at work: stress, work and technology across the life cycle – literature review. The University of Adelaide: Australian Institute For Social Research Reported prepared for SafeWork SA Adelaide, Australia 2011.
[64] Golden TD. Avoiding depletion in virtual work: telework and the intervening impact of work exhaustion on commitment and turnover intentions. Vocational Behav. 2006;69(1):176–187.
[65] Bradley G. Interplay – ict – human – society. UK-Nordic Meeting Copenhagen 1999; [cited May 2016 24]. Available from: http://virtualsociety.sbs.ox.ac.uk/nordic/cbsbradley.htm
[66] Olaore IB. The impacts (positive and negative) of ICT on education in Nigeria. Develop Country Studies. 2014;4(23):154–156.
[67] Blaug R, Kenyon A, Lekhi R. The Work foundation stress at work the work foundation 2007 London. [cited Jun 2006 01]. Available from: http://www.theworkfoundation.com/Reports/69/Stress-at-Work
[68] Koolhaas W, van der Klink JJL, Verfoort JPM, et al. In depth study of the workers' perspective to enhance sustainable working life: comparison between worker with and without chronic health condition. J Occup Rehabil. 2013;23:170–179.
[69] Bruque S, Moyano J, Eisenberg J. Individual adaptation to IT-induced change: the role of social networks. J Manag Inf Syst. 2008;25(3):177–206.
[70] Koivunen M, Kontio R, Pitkänen A, et al. Occupations stress and implementation of information technology among nurses working on acute psychiatric wards. Persp Psychiatric care. 2013;49(1):41–49.
[71] Korpinen L, Pääkkönen R. Working-aged population's mental symptoms and the use of the internet. Mental Illness. 2011;3(1):25–28.