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The influence of digitalization and new technologies on psychosocial work environment and employee health:
a literature review

The influence of digitalization and new technologies on psychosocial work environment and employee health: a literature review

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1 NORSK SAMMENDRAG

Digitale kommunikasjonsformer, digitale plattformer og sosiale media har endret måten arbeid må og kan utføres på, og har gitt muligheter til å organisere arbeid på en grunnleggende annerledes måte. Denne litteraturstudien ble gjennomført for å undersøke hvilke mulige konsekvenser digitalisering og nylig innførte teknologier i arbeidet har for arbeidstakeres psykososiale arbeidsmiljø, arbeidshelse og velvære.

Et systematisk litteratursøk ble utført for å identifisere fagfellevurderte empiriske studier publisert i vitenskapelige tidsskrifter fra og med år 2000. Studier ble vurderte som relevante dersom de rapporterte, kvantifiserte og statistisk testet sammenhenger mellom enten 1) Bruk av nylig innført teknologi eller teknologi som regnes som "ny" i arbeidet, eller konsekvenser av slik teknologibruk, og faktorer i det psykososiale arbeidsmiljøet, eller 2) Bruk av ny teknologi i arbeidet, eller konsekvenser av slik teknologibruk, og helse (psykiske eller somatiske symptomer, velvære, plager eller sykdom). Til sammen 6172 publikasjoner ble gjennomgått. Etter eksklusjon av studier som ikke samsvarte med inklusjonskriteriene, samt gjennomgang av referanselistene til gjenværende studier, ble totalt 53 studier inkludert i fulltekstgjennomgang, hvorav 40 var tverrsnittstudier. Basert på en narrativ gjennomgang ble de 53 studiene gruppert i følgende kategorier; i) Innføring av nye teknologier, ii) Technostress, iii) Informasjons- og kommunikasjonsteknologi (IKT)-krav, iv) "Telepress" fra arbeidet, tilgjengelighetskrav og forstyrrelse av balansen mellom arbeid og privatliv, v) Holdninger angående teknologi og vi) Teknologi-relatert trakassering og utilbørlig atferd.

Gjennomgangen avdekket en betydelig variasjon i tilnærminger og metoder, noe som gjør det vanskelig å trekke generelle konklusjoner. Med dette som forbehold viser denne systematiske gjennomgangen at det foreligger dokumentasjon på at nye teknologier og nye måter å arbeide på er assosiert med både helse og arbeidsfaktorer. Noen studier viste at høyere nivåer av teknologisk utvikling var assosiert med dårligere arbeidsforhold og lavere velvære, mens andre studier identifiserte faktorer som kan moderere den potensielt negative effekten av nye teknologier slik at de oppleves som mindre krevende. Noen studier fokuserte også spesifikt på positive aspekter av nye teknologier, eksempelvis hvordan de kan fasilitere arbeidet og hjelpe arbeidstakere. Flere studier indikerte at graden av teknologisk utvikling ("high-tech" versus "low-tech") kan påvirke arbeidstakeres opplevelse av autonomi. Men selv om arbeidstakeres autonomi kan reduseres og andre arbeidsfaktorer kan bli negativt påvirket når arbeidsinnhold og arbeidsprosesser bestemmes av teknologien, var det studier som tydet på at økt tilgang til kommunikasjonsverktøy eller "enkle" teknologiske nyvinninger som ikke hindret autonomien, kunne ha fordelaktige effekter på arbeidstakeres velvære. Det ble funnet dokumentasjon de samme teknologiske endringene kunne ha både negative og positive effekter på arbeidstakeres velvære, men at potensialet for negative eller positive effekter i stor grad avhenger av aspekter ved konteksten som teknologien implementeres i, den spesifikke funksjonen den har og måten den innføres på.

Flere studier indikerte at arbeidstakeres autonomi var en viktig faktor som kan avgjøre om digitalisering og nye teknologier har negative eller positive effekter. Hvis innføring av ny teknologi fører til en opplevelse av tapt autonomi kan det ha uheldige konsekvenser for arbeidshelsen, mens styrket autonomi, for eksempel som en konsekvens av adekvat opplæring som

fremmer kontroll og mestring, kan hjelpe til med utføring av arbeidsoppgaver og ha positive effekter på helse og velvære.

Det bør imidlertid understrekes at mange av studiene som er inkludert i denne kunnskapsgjennomgangen ikke kunne trekke et tydelig skille mellom effekter av teknologien i seg selv og de psykologiske og sosiale arbeidsfaktorene som teknologien understøtter. Som en følge av dette var det i mange studier uklart i hvilken grad effekter på velvære etter innføring av nye teknologier kunne skyldes teknologien i seg selv og i hvilken grad det kunne skyldes andre, mer "tradisjonelle" faktorer som jobbkrav og organisasjonsendring, som ville ha hatt innflytelse selv om de hadde blitt drevet av teknologi som ikke blir ansett som ny.

Når produksjonsmåter endrer seg kan viktige egenskaper ved jobben endre seg på en måte som også påvirker arbeidstakeres velvære. Denne kunnskapsgjennomgangen fant dokumentasjon som viser at noen aspekter av nye teknologier (informasjons- og kommunikasjonsteknologier i særdeleshet) kan ha problematiske effekter på både arbeidsmiljøet og arbeidstakeres psykiske og somatiske helse. Teknologier som benyttes i arbeidet kan ledsages av problemer mer å balansere arbeid og privatliv, manglende restitusjon grunnet økte tilgjengelighetskrav eller -normer, økte kvantitative såvel som kvalitative krav og en rekke andre potensielle utfordringer for velværen. Det ser imidlertid ut til å være mange forskjellige effekter som kan fremme og hemme godt arbeidsmiljø og god helse. Dette understreker behovet for å undersøke de mer spesifikke aspektene av forskjellige innføringer av nye teknologier slik at man kan studere og kontrollere effekter av nye teknologiske utviklinger på arbeidshelse og velvære. Det er altså et behov for å klargjøre hvorfor, når og hvordan nye teknologier påvirker arbeid og arbeidstakere.

2 EXECUTIVE SUMMARY

Digitalized communication forms, digital platforms, and social media have altered the ways work must and can be carried out, and have provided opportunities to organize work in fundamentally different ways. The current literature review was conducted to explore the consequences of digitalization and new technology in the workplace for the psychosocial work environment and occupational health and well-being.

A systematic literature search was conducted by which peer-reviewed empirical studies published in scientific journals dating from 2000 to and including June 2018 were identified. Studies were considered relevant if they reported, quantified, and statistically tested associations of either 1) Workplace technology use or consequences thereof with factors of the psychosocial work environment, or 2) Workplace technology use or consequences thereof with health (psychological or somatic symptoms, well-being, disorder, or disease). A total of 6172 publications were screened. Application of exclusion criteria and additional browsing of reference lists of included studies resulted in a total of 53 studies being reviewed, 40 of which had a cross-sectional design. When conducting the narrative review the 53 included studies were grouped into the following thematic categories; i) Introduction of new technologies, ii) Technostress, iii) Information and communication technology (ICT) demands, iv) “Workplace telepressure”, availability demands, and work-private life interference, v) Attitudes towards technology and vi) Technology-related harassment and incivility.

The review revealed considerable heterogeneity in approaches and methodology, making generalizability of findings challenging. Keeping this in mind, associations of new technologies and new ways of working were observed with both health and work factors. Some studies suggested that a higher level of technological advancement in general was associated with deterioration of working conditions and well-being. On the other hand, some studies identified factors that may moderate the negative impact of novel technologies in ways that make them less straining. Some studies also focused specifically on the positive aspects of novel technologies, i.e. how their applications may facilitate work and aid workers. Several studies highlighted the potential of the degree of technological advancements (”high-tech” vs. ”low-tech”) to affect the experience of autonomy for workers. While worker autonomy and may be reduced and other work factors may be negatively influenced when work content and -processes are determined by new technologies, some studies also indicated that increased access to communication or ”simple” technological advancements that did not impede autonomy had beneficial effects on employee well-being. There was evidence that the same technological changes had both negative and positive effects on employee well-being, but that the potential for negative or positive effects to a large extent depended on elements of the context in which the technology was being applied, its specific function, and the way in which it was implemented.

Several studies suggested worker autonomy to be an important factor in determining the positive or negative effects of digitalization and new technologies. When a perceived loss of autonomy results from the application of new technologies, negative health consequences may also result, whereas enhanced autonomy, for instance by adequate training that promotes control and mastery of technology, may aid the execution of work and have positive

effects on health and well-being. However, it should be highlighted that many of the studies included in the present review seemed unable to distinguish between the effects of technology itself and the psychological and social work factors the technology may support. Hence, when the introduction of a new technology seems to influence employee well-being, it is often unclear to what extent this influence stems from the technology itself and to what extent it stems from other, "traditional" factors such as job demands and organizational change, that would have taken effect also when driven by not so novel technology.

When the means of production change, so may important features of the job that are essential to workers' well-being. The current review summarized evidence that some aspects of novel technologies (information technologies in particular) can be aversive both to the work environment and workers' psychological and somatic health. Work technologies may be accompanied by problems balancing work with private life, lack of restitution due to extended availability requirements or -norms, quantitative as well as qualitative work overload, and a range of other potential challenges to well-being. However, the potential effects seem to be manifold, and both enhancing and detrimental. This highlights the need to address the more specific aspects of different implementations of new technologies in order to adequately study and control the effect of new technological developments on worker health and well-being. Hence, there is a need to clarify why, when and how technologies influence work and employees.

3 PREFACE

Technological changes in the work domain can have far-reaching implications for working conditions. In recognition of this, research has been conducted throughout the previous decades in order to shed light on how new technologies at work may influence health, well-being, and psychosocial working conditions. The current report summarizes such research. This work was carried out as part of a larger project - "The future of work: Opportunities and challenges for the Nordic models" - which is a collaborative project funded by the Nordic Council of Ministers and organized by the Norwegian Institute for Labour and Social Research (Fafo) in cooperation with a consortium of researchers from the five Nordic countries. The overarching aim of the project is to examine how contemporary transformations of work and labour markets due to, for instance, digitalization, demographic change, and new forms of employment may influence future work in the Nordic countries. The project consists of seven pillars, adressing main drivers of change (Pillar I), digitalization of traditional forms of work (Pillar II), self-employed, independent and atypical work (Pillar III), New labour market agents (Pillar IV), occupational health and work environment (Pillar V), labour law & regulations (Pillar VI), and a final synthetizing report pertaining to the Nordic model of labour market governance (Pillar VII). The current report comprises the first output of Pillar V, and is a collaboration between the National Institute of Occupational Health (STAMI) in Norway and the National Research Center for the Working Environment (NFA) in Denmark. Pillar V aims to shed light on how contemporary and future developments of work may pose challenges related to occupational health and the work environment. As a first step the current literature study was conducted to gain an overview of research that has addressed questions pertaining to the current research question.

The research team that produced the current report consisted of:

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Jan Olav Christensen (Project Manager)

4 BACKGROUND

4.1 Introduction

The introduction of new technologies at work has long been recognized as a source of worry, uncertainty, and new work environment risks (Schabracq and Cooper, 2000). Existing skills may become redundant and having to acquire new skills and adapt old ones can represent immense challenges for workers. During recent decades, new work tools and new ways of working have been spawned in particular by increasing digitalization. Digitalized communication forms, digital platforms, and social media have altered the ways work must be and can be carried out in traditional workspaces and has provided opportunities to organize work in fundamentally different ways. Schabracq and Cooper (2000) stated - in a text published in the year 2000 - that ”during the last two decades, the development of new technologies all over the world and the growing globalization of the economy have together produced the fastest and biggest technological changes ever. An avalanche of new products and production processes have inundated us and although these developments are, at least in essence, deeply ingrained in our culture, we are confronted with an unprecedented acceleration of change”. That message seems even more relevant today. The uncertainty implicated by rapidly changing technologies may force individuals to constantly have to educate themselves about recent developments, and may cause feelings of inadequacy and fears of becoming not adequately skilled (Tarafdar et al., 2007). A seemingly continuous flow of information and communication has given rise to a never-resting ”polylogue” that may have a profound psychological influence on workers (Bucher et al., 2013). Several terms have been used to describe different facets of this, including ”techno-overload”, ”information overload”, and ”information anxiety” (Tarafdar et al., 2007; Ragu-Nathan et al., 2008).

While the changes occurring in present work life may seem confusing and perhaps incalculable, some consensus seems to have emerged regarding the most influential drivers of change (Dølvik and Steen, 2018). Four such ”megatrends” can be delineated that will shape the development of work in the foreseeable future - *globalization*, *climate change*, *demographic change*, and *technological developments*. While all of these are powerful drivers of change (and they are not independent of each other), the current report aimed to explore how technological developments may influence the psychosocial work environment and what the consequent health impacts may be. The notion of a fourth industrial revolution, marked by rapid and accelerating progress in areas such as computing, robotics, and artificial intelligence has heavily influenced discussions pertaining to this topic. Technological developments imply pervasive digitalization of existing work tasks and fears of technological unemployment and the disappearance of jobs. While ”technology” is a generic term describing any application of knowledge for a practical purpose, technologies associated with computerization and digitalization of work processes have become ubiquitous and permeate current debates on the future of work. Digitalization is, of course, not an entirely new phenomenon, and has been transforming workplaces and the way we work for many decades already, creating opportunities to design new products as well as new work processes and -techniques. However, new ways of working also imply new ways for workers to experience work, which in turn poses new

challenges to employers and employees.

Technological advancements have always shaped history. New technologies as well as new uses of existing technologies have transformed how work tasks are executed and workers and working conditions have been affected. Also throughout history, worries about the consequences of novel technologies have surfaced. One salient example was the 19th-century Luddite movement in England that protested by destroying mechanized production equipment, since they saw the growing use of machines as a cause of unemployment and deterioration of working conditions (Grint and Woolgar, 2013). In more recent history, the term ”Neo-Luddism” has been coined to describe a philosophy prescribing the minimization or abandonment of technologies that we often regard as ”modern”, such as those based on digital technology (Kryszczuk and Wenzel, 2017). However, despite frequently voiced concerns about the effects new technologies ultimately have on individuals and society, the exact consequences for working conditions and employee health remain unclear. Therefore, the purpose of the current review was to obtain and review research published during the previous two decades pertaining to effects of new technology on working conditions and employee health and well-being.

4.2 Why may psychological and social work factors influence employee health?

The mechanisms that explain the connection of psychological challenge with health remain obscure and are probably multifaceted, but some specific pathways have been suggested. For instance, as neural regions processing social/emotional- and somatic pain may overlap, short term effects could occur due to affective responses to working conditions that provoke immediate changes in the appraisal of somatic sensations (Eisenberger, 2012). In the longer term effects could result e.g. from physiological responses to psychological challenge (”stress response”) causing dysregulation of neuroendocrine systems that control levels of inflammation (Cohen et al., 2012; Mcewen, 2000). Moreover, emotional responses to hardship in the work situation may instigate or exacerbate unhealthy behaviors e.g. of overeating, smoking and alcohol consumption (McEwen, 1998).

Despite the sustained obscurity of the mechanisms generating it, the link of psychological and social work factors (commonly referred to as ”the psychosocial work environment”) with mental and somatic health is well established. Several systematic reviews have reported associations of factors such as job demands, autonomy, social support, exerted effort and received reward with the occurrence, duration, or recurrence of e.g. clinical depression (Madsen et al., 2017; Rugulies et al., 2017), back pain (Linton, 2001; Lang et al., 2012; Koch et al., 2014), neck/shoulder pain (Kraatz et al., 2013; Hauke et al., 2011), and cardiovascular disease (Fishta and Backe, 2015; Kivimäki et al., 2012; Dragano et al., 2017). This evidence base also clearly demonstrates that a few explanatory models have dominated existing research - most prominently the Job strain model of Robert Karasek (Karasek, 1979; Karasek and Theorell, 1992) and the Effort-reward imbalance model of Johannes Siegrist (Siegrist, 1996). However, in theory ”the psychosocial work environment” encompasses a wide variety of more specific factors, some of which may emerge or become more relevant as the future of work unfolds. Rosen

et al. (2010) suggested a taxonomy of psychological work factors that affect performance and health; *role stressors* (i.e. role expectations that are in conflict, unclear, or too extensive to satisfy with allocated resources), *workload* (e.g. quantitative workload - the amount of work - and qualitative workload - the difficulty of tasks), *situational constraints* (i.e. organizational factors that interfere with the ability to complete work tasks, for instance bureaucracy, faulty equipment, and inaccurate information), *lack of control* (i.e. low autonomy or opportunity to participate in decision-making), *social characteristics* (e.g. interpersonal conflict, social support or abusive supervision), *career outcomes* (e.g. job insecurity, underemployment, lack of learning and advancement opportunities, or work-private life conflict), *job conditions* (i.e. physical conditions such as temperature, noise, lighting, the nature of job tasks, such as emotional labor, and the design of tasks, such as work hours and shiftwork), and *acute stressors* (i.e. non-regular, unplanned episodes and happenings that are psychologically challenging, such as natural disasters or terrorist attacks).

4.3 Workplace technology and health

The impact of production technologies on workers has been a recurring theme in occupational health psychology throughout several decades (Tetrick and Quick, 2011). Among the early examples of such thinking is Karl Marx with the concept of alienation during the industrialization of the 1800s. More recently, the psychological implications of digitalized technologies have been a topic of particular interest, as reflected by terms such as ”technostress”, which seem to have gained popularity recently. A number of similar terms have been used about the psychological impact of new work technologies, such as ”technophobia”, ”cyberphobia”, ”computerphobia”, ”computer anxiety”, ”computer stress”, ”negative computer attitudes”, ”ICT demands”, ”ICT resources”, ”new ways of working”, and ”workplace telepressure” (Wang et al., 2008). Conceptually, these terms overlap to a large extent and are sometimes indistinguishable in the literature. However, a common denominator is that they all refer to the potential of technology (usually information- and communication technology) to alter the experience of work for those carrying it out.

Craig Brod coined the term ”technostress” in the early 1980s (e.g., Brod 1982, 1984) to denote the psychological problems associated with people adapting to the introduction of new technologies. It has since been conceptualized as a multidimensional construct comprising five components describing conditions that may cause distress if commonly occurring; referred to as ”technostress creators”: (1) Techno-overload (the technology forces the employee to work faster); (2) Techno-invasion (pervasive ICTs invade personal life); (3) Techno-complexity (complexity of new ICTs render employees with feelings of incompetence); (4) Techno-insecurity (job security may be threatened by rapidly changing ICTs); and (5) Techno-uncertainty (rapid changes, upgrades and bug fixes of hardware and software are challenging since nothing seems reliably constant, and one does not know what to expect) (Tarafdar et al., 2007). The increased amount of available information may elicit *information* overload (Ragu-Nathan et al., 2008; Edmunds and Morris, 2000), but also *work* overload as employees attempt to gain an overview of relevant information and apply it to their work. In addition, workplace norms that increasingly value speed and the accomplishment of multiple tasks si-

multaneously may exacerbate the problem of overload (Stephens et al., 2012) and contribute to ”time panic”, the feeling of not having enough time and not being able to understand and remember everything and finish tasks on time (Doronina, 1995).

”New ways of working” (Nijp et al., 2016) reflects the separation of work activities from time and space, i.e. working away from the traditional work space, which is enabled by digital network technologies. Being able to work anytime anywhere enables more flexible approaches to organizing work, by creating time and place-independent work environments. Asynchronous message-based technologies enable us to send and receive work-related information at all times. Mobile computers in many forms paired with rapidly increasing Internet coverage, accelerating data transmission and virtual access have resulted in many work roles becoming potentially boundaryless (Kingma, 2018). Smartphones and -devices have furthered the potential of email to deliver messages, and one potential consequence is that receivers may feel pressured (by themselves or others) to respond quickly, and may not be able to detach. Therefore, while this flexibility may represent increased autonomy for many workers, the varying levels of preoccupations with and urges to respond quickly to work messages may be seen as an added demand in the form of ”workplace telepressure” (Barber and Santuzzi, 2015).

During recent years, the increased use of social media for work purposes, combined with increasingly sophisticated smartphones, may have furthered the potential for work- and information overload, uncertainty, and blurring of boundaries between work and private life (Bucher et al., 2013). Employees seem to be confronted with exponentially growing amounts of information, which may be challenging to process in a meaningful way in order to maintain a coherent experience of being knowledgeable and competent. Also, social media do not usually have opening hours and can be accessed continuously on mobile devices. Hence, employees may have the opportunity, and feel pressured, to be connected to different communication platforms continuously. The accelerating availability of such platforms may amplify the potential of work interfering with private life and recreation time (Ayyagari et al., 2011), potentially prolonging psychological work exposures and impairing recovery. Moreover, digitalized communication takes place on many platforms at once, and many of these platforms frequently change, so that it may become challenging to keep track of relevant sources and community movements, possibly creating a high level of uncertainty (Ayyagari et al., 2011).

Recognizing the extinction of natural boundaries between work and private life, France implemented a law on the ”right to disconnect” in 2017, mandating organizations of more than 50 employees to explicitly define times during which employees are not required to respond (Schlachter et al., 2018). In Germany, the labor council enforced decisions in 2012 and 2014 to ban the after work hours use of work-related communicative devices at Volkswagen and BMW (Hesselberth, 2018), implying that all mail reaching company servers after office hours is put on hold or deleted, and that company phones go off-service outside of work hours.

New technologies are usually introduced to facilitate work, but undesirable side effects may occur that were not foreseen upon implementation. Work intensification, for instance, may in some instances turn out to be consequences of technologies that were originally developed to make work easier. For instance, while technological improvements during the 1970s and 1980s transformed how household labor was carried out, household workloads

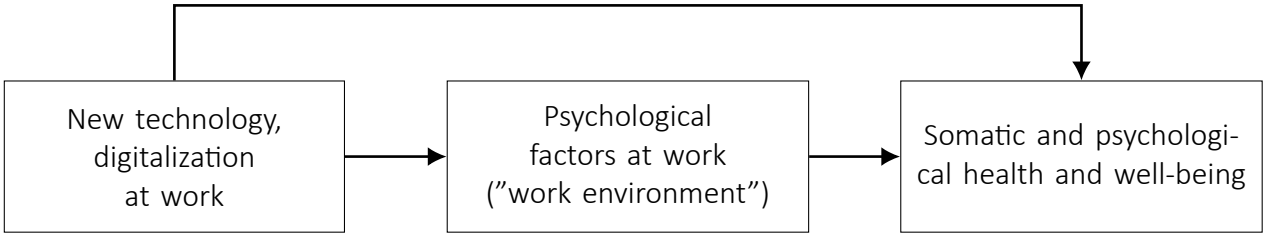

Figure 1. Conceptual model of the relationships investigated in the current review

were not reduced, since norms of household cleanliness shifted and leftover time was allocated to other tasks such as shopping or servicing the new equipment (Chesley, 2014). Technological change does not only alter how work can be performed but also norms and expectations about what should be done and how it should be carried out (Wallace, 2004). In more recent times, a similar question could be posed about the consequences of time- and location-independent ways of working. While they could imply freedom and control, which could improve employee well-being, the opposite may also be true, if perceived demands and role overload result (Nijp et al., 2016). In many cases an "empowerment/enslavement" paradox exists (Schlachter et al., 2018; Jarvenpaa and Lang, 2005). That is, while the increasing availability of advanced portable ICTs may potentially disrupt work-private life balance by facilitating constant availability pressure, it may also empower employees by providing flexibility to manage work-private life balance effectively. Some tasks, such as calculation and data processing, may have become more manageable, but task complexity, information processing requirements, and information overload may have increased, demanding greater memory, precision, and concentration, as well as multi-tasking abilities. Current debates may seem polarized, with "techno-optimism" on one side and "techno-pessimism" on the other, but the net effect of different technologies remains unknown.

4.4 Research question

The overarching question that the current study was conducted to clarify was "what are the consequences of digitalization and new technology for the psychosocial work environment, health, and well-being of employees?". With regards to health, we were primarily interested in effects attributable to changes in psychosocial working conditions.

Figure 1 shows a conceptual overview of the relationships of interest to the current review.

5 METHODS

5.1 Scope of the current review

For the current review, empirical studies published in peer-reviewed scientific journals since 2000 were pursued that elucidated the link of the introduction and use of new technology

at work with psychosocial working conditions and/or employee health. Hence, studies were considered relevant if they reported, quantified, and statistically tested associations of

1. Technology use or consequences thereof with factors of the psychosocial work environment
2. Technology use or consequences thereof with health (psychological or somatic symptoms, well-being or disease)

5.2 Exposures studied

The exposures of interest comprised all aspects of work that may be influenced by technology, such as working with e-mail, social media, automation, artificial intelligence, cyber-bullying, automation, and digital platform work.

5.3 Condition or domain studied: Outcomes

Outcome variables of interest were indicators of somatic and mental health and well-being (e.g. burnout, depression, work ability, and pain complaints) as well as psychosocial working conditions (e.g. job demands, job control, ”stress”, and effort-reward imbalance). Both self-reported measures and clinical diagnosis were included.

5.4 Participants/population

The population of interest included all currently employed individuals, including self-employed.

5.5 Literature search

During May-June 2018, a librarian performed the literature search in the databases PsycINFO, MEDLINE and Web of Science. Search terms were specified for **exposure domain** (e.g. ”job”, ”occupation”, ”employment”), **type of subject** (e.g. ”worker”, ”employee”, ”workforce”), **exposure** (e.g. ”digitalization”, ”automation”, ”industry 4.0”, ”internet”, ”social media”), **outcome** (e.g. ”health”, ”well-being”, ”illness”, ”disability”, ”work environment”, ”stress”, ”psychosocial”), and **study design** (e.g. ”cohort”, ”experiment”, ”intervention”, ”observational”). The complete search strings are enclosed in the appendix in table 5. Reference lists of relevant studies were also searched to detect relevant literature not picked up by the main literature search.

5.6 Screening of titles and abstracts

To determine preliminary eligibility, titles and abstracts of retrieved studies were screened independently by five researchers in pairs. A web-application, Covidence (www.covidence.org), was used to assign each study to two reviewers consecutively throughout the screening process. Disagreements were resolved by discussion, with a third reviewer where necessary.

5.7 Screening of full text

The current report summarized empirical studies published after the turn of the millennium that included some form of quantification and statistical test of relationships between new technology, work environment, and employee health. We included studies published in scientific journals. We did not include books or book chapters, or dissertations. The full-texts of identified potentially eligible studies were independently assessed by two reviewers to determine eligibility for inclusion in the final summary. Additionally, reference lists of the full-text studies included for scoring were hand-searched for further eligible studies. A standardized form was used to extract information from the included studies. A short version of this form is given in table 3.

5.8 Exclusion criteria

Studies were excluded based on the following exclusion criteria:

- The study was published before year 2000
- The study did not address topics involving work and workers
- The study was not published in a peer-reviewed scientific journal
- The study contained no original, quantitative data
- The study was purely descriptive or theoretical
- The study was not available in English, Norwegian, Danish or Swedish
- The paper was a presentation, personal communication, unpublished paper, book, book chapter or dissertation - i.e. not a primary study

As mentioned in our aims, we were interested in the health effects of new technologies, we were primarily interested in effects attributable to psychological mechanisms. Hence, studies reporting on the biomechanical consequences of digitalization, such as the ergonomic impact of computer work, were not included. Reviews of this topic are available elsewhere (Wærsted et al., 2010; Veiersted et al., 2017).

Studies of interventions utilizing new technologies with the explicit aim of promoting positive health or performance were not included, as the primary interest was in assessing the consequences of new technologies used for the organization of work as it occurs, and not the potential uses of it.

6 RESULTS

6.1 Screening and selection of publications

Figure 2 shows the results of the screening process. The original search resulted in 6238 references retrieved, 43 of which were included in the final summary. Ten publications were identified and added by searching reference lists, making the total 53 studies that were included in the current review.

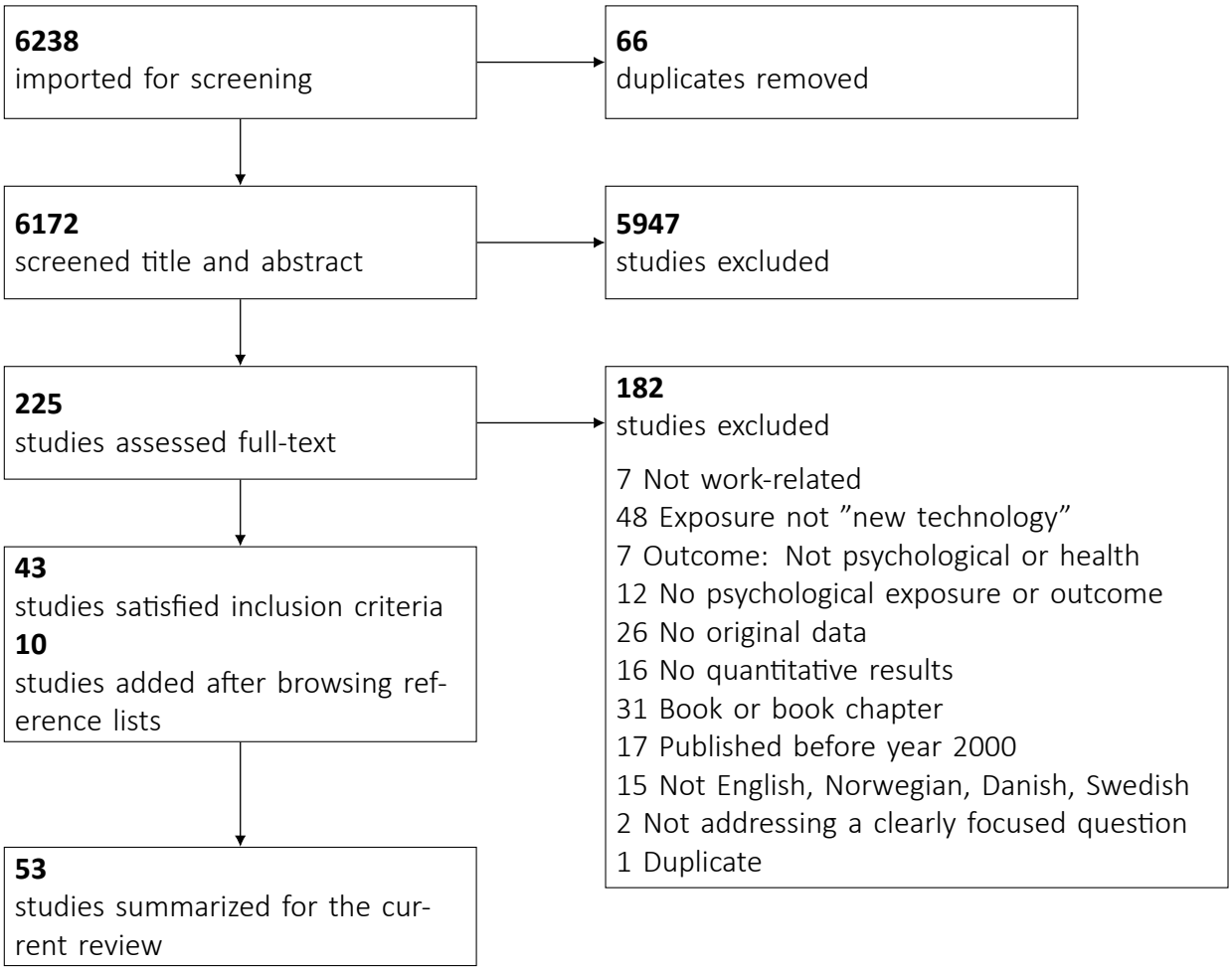

Figure 2. The screening and selection process of the current review

6.2 Exposures studied

Table 1 lists the different exposures reported in the final 53 reviewed studies. Based on the narrative review of the studies, exposures were sorted into six different domains that will be applied to organize the report of results; 1) Introduction of new technologies, 2) ”Information- and communication Technology (ICT) demands”, 3) ”Technostress”, 4) ”Workplace telepressure”, availability demands, and work-private life interference, 5) Attitudes towards technology, and 6) Technology-related harassment and incivility. It should be noted that due to the heterogeneity of the included studies this classification scheme is not intended to be exhaustive, with mutually exclusive categories. Rather, it serves as a broad scheme to organize the narrative review. Interestingly, no studies were found that pertained to digital platforms such as e.g. Uber or Foodora. Presumably, this reflects a provisional lack of research of implications of new forms of digitally driven employment for psychosocial working conditions and occupational health.

Table 1. Exposures reported in the included studies

Exposure domain	Exposure	No. of studies
Introduction of new technologies	Introduction of a new technology	6
	Access to internet communications	4
	Automation	3
	Level/degree of technology implemented	2
	Technological pacing of work	1
	Smartphone-based gamified job design	1
ICT demands	ICT demands	5
	ICT use intensity	5
	Work overload	2
	Social media demands	2
Technostress	Techno-strain	3
	Technostress-creators	2
”Workplace telepressure”, availability demands, and work-private life interference	Availability demands	8
	Work-life conflict	5
	Workplace telepressure	2
	Smartphone use at work	2
	Off-work hours tech-assisted job demands	1
Attitudes	Attitudes towards technology	2
Technology-related incivility	Cyber-incivility	1
	Virtual harassment	1

6.3 Outcomes studied

Table 2 gives an overview of the different outcomes reported in the included studies. The outcomes are sorted into two general categories; ”health and well-being” and ”work factors”, and by the number of studies reporting them. Burnout and components of burnout were the most frequently studied health/well-being outcome, while ”stress” and ”job satisfaction” were the most frequently studied work factor outcomes. However, similarly to the exposure classifications, it must be noted that these classifications are very general and not necessarily directly comparable. For instance, ”stress” is a term that could encompass a variety of experiences pertaining to work, including many of the other outcomes listed in table 2, such as job demands and role conflict. Similarly, ”time pressure” could be considered a ”job demand”. Also, some concepts, e.g. ”job satisfaction”, could be classified under both ”work factors” and ”health and well-being”. In general, there was a vast heterogeneity of concepts and measurements reported, and in several studies factors were conceptualized as both exposures and outcomes, such as when modeling a work factor or health complaint as a mediator.

Table 2. Outcomes reported in the included studies

Outcome domain	Outcome	No. of studies
Health and well-being	Burnout and components of burnout	18
	Pain	9
	Psychological detachment and recovery	7
	Distress (including anxiety and depression)	7
	General health	3
	Sleep problems	3
	Strain symptoms	2
	Gastrointestinal symptoms	2
	Cardiovascular symptoms	2
	Negative affect	2
	Positive affect	1
	Vigor	1
	Psychosomatic health	1
	Cognitive functioning	1
	Techno-strain	1
	Techno-addiction	1
	Techno-overload	1
	Perceived general tension	1
	Cortisol awakening response (CAR)	1
	Start-of-day mood	1
	Well-being	1

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Outcome domain	Outcome	No. of studies
	Family satisfaction	1
	Life satisfaction	1
Work factors	”Stress”	11
	Job satisfaction	11
	Work - private life balance	9
	Job demands	6
	Job control/autonomy	6
	Organizational commitment	5
	Exerted effort	3
	Work engagement	3
	Turnover and turnover intentions	3
	Abseentism	2
	E-mail responding	2
	Perceived reward	2
	Social support	2
	Role conflict	2
	Job motivation	2
	Performance	2
	Perceived usefulness of technology	2
	Computer anxiety	1
	Presenteeism	1
	General perception of work environment	1
	Job strain (high demands with low control)	1
	Effort-reward imbalance	1
	Time pressure	1
	Job commitment	1
	Job tension	1
	Job involvement	1
	Role ambiguity	1
	Knowledge sharing	1
	Collaboration with colleagues	1
	Perceived ”illogical” workload allocation	1
	Work speed	1
	Interruptions	1
	Multitasking	1
	Workaholism	1
	Job insecurity	1
	Workplace telepressure	1
	Means efficacy	1

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Outcome domain	Outcome	No. of studies
	IT satisfaction	1
	Goal achievement	1
	Awareness of new opportunities and tools	1
	User resistance	1

6.4 Narrative review of included studies

The current section provides a summary description of main features of the included studies. More detailed and comprehensive summaries of each individual study are included in tables 3 and 4.

6.4.1 Introduction of new technologies

Some of the included studies evaluated results of explicit implementation of new technology in the workplace or the degree to which work and the workplace were characterized by technology recognized as ”new” or ”novel”. Some evidence suggested that a higher level of technological advancement was associated with deterioration of working conditions and well-being of workers. One study reported that employees of a ”low-tech factory” were more satisfied, less bored, less fatigued, more committed, and exhbited lower levels of turnover intention than employees in a nearby factory of the same company which utilized state-of-the-art production technologies (Lovett et al., 2004). ”High-tech factories” were also found in another study to be characterized by more job strain, lower job control, and more health problems than ”low-tech factories” (Rafnsdottir and Gudmundsdottir, 2004). Low job control was also associated with on board computer systems (OBC-systems) for collecting and transmitting data about mileage, fuel consumption, waiting times, and queues for lorry drivers (De Croon et al., 2004). However, job demands and need for recovery were not affected.

A number of studies highlighted both the positive and negative potential of new technologies for working conditions and worker well-being. For example, Kraan et al. (2014) observed that while employees experienced enhanced autonomy as a result of working with computers, technological pacing of such work counteracted this effect by diminishing control and intensifying demands. Moreover, experiencing low job control had a stronger aversive impact on the mental well-being of technologically paced workers versus other workers experiencing diminished job control. Hence, the loss of control to machine-automated procedures seemed to have a greater impact than low control in itself. Rangarajan et al. (2005) reported that the perceived complexity of a new automated sales system technology was associated with role ambiguity and role conflict, suggesting the *complexity* of the automation procedure determined the extent to which it impacted the work environment.

Several studies investigated factors that may *moderate* the impact of novel technologies, focusing on ways in which undesirable effects may be mitigated. Employees that received

”resources workshops” to facilitate adjustment to a new IT system exhibited higher satisfaction with IT after implementation (Chen et al., 2009). Conversely, employees that did not receive the workshop reported lower satisfaction with IT as well as increased levels of exhaustion after the new system was implemented. Drawing attention to the role of employee *participation*, another reported that the introduction of an organizational internet portal was associated with health problems only for employees that were not included in the planning and implementation of the new service (Elfering et al., 2010).

Some studies exclusively focused on positive potentials of novel technologies, i.e. how their applications may facilitate work and aid workers. Sliskovic and Penezic (2016) found that seafarers were less likely to experience gastrointestinal and cardiovascular symptoms when they had unlimited internet access onboard. However, a similar effect was not observed for mental health, job satisfaction or life satisfaction. Technology may also be utilized to improve job characteristics (”job enrichment”), as suggested by one study that found *smartphone-based gamified job design (SGJD)* to be associated with increased job motivation, job satisfaction, and operational performance (Liu et al., 2017). Another study found that mental health professionals in a rural area reported higher job satisfaction when ICT resources provided good access to communicate with other professionals, i.e. prevented professional isolation and ensured professional support (Meyer, 2006). However, this was true only for those with high technology skills, once again highlighting the role of contextual factors that may determine the impact of new technologies. Another way in which technological advancements may promote worker well-being is by mitigating aversive effects of ”traditional” work exposures. One study found that high job demands were less detrimental to intrinsic motivation for individuals with an ICT-assisted opportunity for ”blended working”, i.e. working time- and location-independently (Van Yperen et al., 2016).

In some cases where technology has the potential to facilitate and make work easier, it also has the potential to do the contrary if it does not work as intended. Andersen et al. (2015) studied the implementation of personal digital assistants (PDAs) in combination with an organizational aid (job checklists). They concluded that overall, these resources did not affect work demands or employee health. However, subgroup analyses revealed that employees that did *not* have difficulties using the new technology experienced a reduction of work demands. On the other hand, employees that experienced difficulties using the new technology also experienced increased work demands.

Some studies noted none or few effects of (in some cases quite extensive) technological changes in the workplace. James et al. (2013) reported that while the introduction of an automated dispensing system (ADS) for pharmacy staff was associated with reduced perceived stress and perceptions of more logical workload allocations, for most of the specific work environment factors studied (e.g. work-private life conflict, autonomy, workload, job satisfaction) there was no effect. Blok et al. (2012) studied a move from a ”traditional” work environment with separate department workspaces to a ”new way of working” with one shared work area comprising a variety of different shared workspaces (e.g. brainstorm areas, meeting rooms, silent open workspaces and project places) as well as increased digitalization of work tools (digital smart boards, laptops, cellphones, digital business networks). Despite this quite extensive change in the organization of work, no changes were observed in variation

of work location and work times, knowledge sharing, employee satisfaction, collaboration, or rating of the suitability of the work environment for executing work tasks. The only observed change was a *decrease* in knowledge sharing. Another study of the implementation of ”new ways of working” similarly reported few effects on work content and -environment (Nijp et al., 2016). A comprehensive introduction of increased control over working time and -location was introduced, coupled with a ”personal standard equipment”-package consisting of a laptop, smartphone, and necessary ICT applications (e.g. email, chat applications, phone software) to enable communication and cooperation from remote locations. Meeting rooms at the work location were equipped with smart boards and roundtable cameras to facilitate virtual meetings. This intervention resulted in large decreases in commuting time (i.e. people worked more from home), more evening work and more work hours per week (but not more weekend work). However, perceived job demands, job autonomy, support from colleagues and supervisors, work–private life conflict, ”stress”, fatigue, performance, organizational commitment, and job satisfaction were unaffected. Nevertheless, the overall health of the sample deteriorated - suggesting there were ways in which the working arrangements affected health that did not operate through the work factors measured in the study.

The generalizability of findings of the abovementioned studies is limited, since most studies focused on specific technological applications and specific groups of workers. However, bearing methodological limitations in mind, it seems several studies highlight the potential of the degree of technological advancements (”high-tech” vs. ”low-tech”) to affect the experience of autonomy for employees. Reduced autonomy may in turn affect other work-related factors negatively. Some studies indicate that increased access to communication or ”simple” technological advancements that do not alter levels of experienced autonomy, can have beneficial effects on employee well-being. From the current evidence no clear general effect of new technologies seemed evident. Rather, the ”empowerment/enslavement”-paradox seems contiguous as there is evidence that the same technological change may have both negative and positive effects on employee well-being. Also, the potential for negative or positive effects may to a large extent depend on elements of the context in which the technology is being applied, it’s specific function, and the way in which it is implemented.

6.4.2 Technostress

The concept of ”technostress”, as developed by Ragu-Nathan et al. (2008), consists of two dimensions: ”technostress creators” and ”technostress inhibitors”. ”Technostress creators” comprises 1) techno-overload, 2) techno-invasion, 3) techno-complexity, 4) techno-insecurity, and 5) techno-uncertainty. ”Technostress inhibitors” includes 1) technical support provision, 2) literacy facilitation, and 3) involvement facilitation. In the currently reviewed studies ”technostress creators” as a unified construct was found to be associated with lower organizational commitment (due to lower job satisfaction), negative affect, and lower technology-enabled performance (Ragu-Nathan et al., 2008; Jena, 2015). Conversely, ”technostress inhibitors” was associated with higher job satisfaction, organizational commitment, and commitment to continue one’s current employment (Ragu-Nathan et al., 2008; Jena, 2015). Job burnout and job engagement were also associated with both facets of technostress (Srivastava et al.,

2015). Moreover, personality traits were also found to play a role, as technostress creators were more strongly associated with burnout for individuals high on agreeableness, and less so for those high on extraversion, while they were more strongly associated with job engagement for individuals high on openness and less so for those high on neuroticism. Overall, in the reviewed studies technostress creators were associated with psychosocial work environment factors typically linked to negative health outcomes, whereas technostress inhibitors were associated with psychosocial work environment factors often linked to positive health outcomes.

While most studies of technostress have focused on ”technostress creators” or consequences of technostress, Salanova et al. (2013) studied the relationship of two facets of the actual experience of ”technostress” - ”techno-strain” and ”techno-addiction” - with different aspects of the work environment. ”Techno-strain” refers to anxiety, fatigue, skepticism, and feelings of inefficacy tied to the use of ICTs, and ”techno-addiction” to the excessive and compulsive use of ICTs. Bullying, low autonomy and low ICT use facilitators (i.e. measures put in place to ease the use of ICTs) were associated with techno-anxiety, while work overload, role ambiguity, ICT use obstacles and low social support were associated with techno-fatigue. Transformational leadership was associated with less techno-skepticism and less emotional overload, less mobbing, less low autonomy, more social support, while lower mental competence was associated with techno-inefficacy. For intensive ICT users, role ambiguity, mobbing, and lower emotional competence were associated with techno-anxiety, work overload, and role ambiguity were associated with techno-fatigue, and work overload and mobbing were associated with techno-addiction.

Recognizing the potential impact of the emergence of social media in work contexts, Bucher et al. (2013) developed and validated a questionnaire instrument specifically to measure aspects of ”techno-stress” derived from social media. Their results supported three distinct aspects of the impact of social media on employees, namely ”techno-overload”, ”techno-invasion”, and ”techno-uncertainty”.

In summary, the term ”technostress” has been coined specifically to capture harmful effects of technology, and was found to be associated with a range of adverse outcomes, such as low organizational commitment, low job satisfaction, higher levels of negative affect, burnout and even bullying. In contrast, ”technostress inhibitors” were associated with positive outcomes such as job satisfaction and organizational commitment. With regards to factors that may be modified in order to alleviate ”technostress”, some results suggested certain leadership styles (”transformational leadership”) can attenuate ”techno-skepticism” and emotional overload due to ”techno-strain”.

6.4.3 ”Information and communication technology (ICT) demands”

New technologies at work may influence job demands in several ways, and various aspects of this were studied under headings such as ”ICT demands”, ”ICT use intensity”, ”computer use”, ”work overload due to office-home smartphone use”, ”mental social media demands”, ”e-mail stressors/overload”, ”off-work hours technology-assisted job demands (off-TAJD)”, and ”workplace telepressure”. A specific conceptualization of ”ICT demands” has been proposed,

identifying eight types of demands associated with the use of ICT at work (Day et al., 2012); 1) ”availiability”, 2) ”poor communication”, 3) ”ICT lack of control”, 4) ”ICT hassles”, 5) ”employee monitoring”, 6) ”learning expectations”, 7) ”response expectations”, and 8) ”workload”. These dimensions have been found to be associated with experiences of strain and burnout (Day et al., 2012). However, the terminology applied in the studies included in the review was quite heterogeneous and many studies included a variety of both exposures and outcomes. The majority of these studies, however, investigated some kind of ICT-mediated job demand or the influence of ICTs on job demands or ”stress”.

A number of studies investigated the effects of some type of *quantification* or *intensity* of more specific demands associated with the use of technology, such as the number of hours spent working with computers, or quantity of received emails. Giahi et al. (2015) found that the duration of daily video display terminal (VDT) use was associated with impaired sleep quality for tellers working more than 6 hours/day with those terminals, especially when levels of stress and job dissatisfaction were high. Another study found that the total time working with ICTs was associated with adverse ”psychosocial stress”, measured as a composite of several factors (”working through pain”, ”social reactivity”, ”limited workplace support”, ”deadlines”, ”self-imposed workspace”, ”breaks”, ”mood” and ”autonomic response”) (So et al., 2017). Carlson et al. (2017) found that technology-based job overload (too high demands due to work technology) was associated with job tension, job dissatisfaction, and turnover intention.

A number of studies investigated stressors specifically associated with the quantity of e-mails. The perceived quantity of workplace e-mail was found to be associated with appraisals of ”e-mail overload” and ”e-mail uncertainty”, as well as emotional exhaustion (a component of burnout) (Brown et al., 2014). Similarly, Reinke and Chamorro-Premuzic (2014) found e-mail overload to be associated with burnout, while Stenfors et al. (2013) reported that having to respond to too many e-mails was associated with cognitive complaints such as memory deficits and not being able to make decisions and think clearly. Conversely, Goldfinch et al. (2011) reported that number of hours of email use was not associated with stress or pain among public servants in New Zealand.

Not only the quantity of emails may play a role, but also the content - one study found that emails that were perceived as demanding and more difficult to deal with were found to be associated with impaired well-being (Russell et al., 2017). Brown et al. (2014) found that workplace emails characterized by high emotionality and ambiguity were associated with appraised ”e-mail overload” and ”e-mail uncertainty” as well as emotional exhaustion, and Ford (2013) found that harassing emails were associated with depression, anxiety, and psychosomatic health complaints.

Stadin et al. (2016) studied a range of both quantitative and *qualitative* demands attributed to ICT (availability expectations on and off work, call- and email overload, call- and email immediate response expectations, phone and email interruptions, computers and other equipment not working properly) and found them to be associated with suboptimal self-rated health as well as factors of the psychosocial work environment, such as high job demands, high effort, low control, and low perceived rewards.

Regarding the question of whether new technologies promote work intensification, Chesley (2014) found that daily work-related ICT use was associated with employee experiencing

a faster-paced job and greater levels of interruptions and multitasking. These job conditions were in turn associated with distress, even after taking into consideration the autonomy that such tools may facilitate.

While a number of studies reported associations of technology use with adverse outcomes, several studies reported mixed findings or no such findings. For instance, Goldfinch et al. (2011) reported that while laptop use was associated with ”stress”, desktop use, hours on laptop, hours on desktop, cell phone use, email use or total ICT hours were not associated with stress or pain. Also, Koivunen et al. (2013) found that computer- or Internet use were not associated with level of ”stress”, job satisfaction, or perceived work environment. However, employees reporting positive attitudes towards Internet use tended to report less ”stress” and higher job satisfaction. Andersen and Garde (2015) found no association of computer use at work with experiencing sleep problems more frequently than three days a week.

Perhaps indicative of the distinction between ”empowerment” and ”enslavement” by technology are the findings from Carlson et al. (2017). They found that while *technology-based job monitoring* (technology used by the organization to monitor employees) was associated with job tension, job dissatisfaction, and turnover intentions, *technology-based job autonomy* (autonomy enhanced by the implementation of technology) was related to job satisfaction, job engagement, organizational commitment, and lower turnover intention.

With regards to ICT demands, the included studies provide a number of examples of the potentially aversive impact of demands that may arise due to the way the technology organizes work communications. However, in many cases it is difficult to distinguish the medium from the message - that is, isolating the effect of the technology from the content of the communication it facilitates. In the currently reviewed studies, ICT demands often appeared to be very similar to ”traditional” psychosocial work demands, such as time pressure and work overload. Hence, whether demands were generated by the technology itself or merely mediated by it remained unclear in most of the studies. Some of the studies did demonstrate the potential of ICTs to intensify work demands, suggesting that demands would have been lower with traditional work forms. However, the current review does not allow any general conclusion about the extent of this in the working population.

6.4.4 ”Workplace telepressure”, availability demands, and work-private life interference

A frequently cited topic pertaining to ICT demands is how they affect the boundaries between the work- and private life domains. Several of the reviewed studies supported the notion that work technologies may affect these boundaries, and that this may be harmful to employee well-being. Wright et al. (2014) reported that the use of communication technology outside of work hours was associated with elevated work-life conflict, which partially explained burnout symptoms. Similarly, Derks and Bakker (2014) found that employees using smartphones on the initiative of their employer experienced higher levels of work-home interference and emotional exhaustion (a component of burnout) after intensive after-work smartphone use. Also, daily recovery experiences (psychological detachment and relaxation) seemed to be more important for intensive smartphone users - as they were more strongly protective against work-home interference for this group than for less intensive smartphone users (Derks and Bakker,

2014). Grawitch et al. (2018) oberved an association of work ICT demands (response expectations, availability, control over demands) with dissatisfaction with work-life balance, and Stenfors et al. (2013) reported that ”ICT demands”, including the erosion of boundaries between work and private life, were both cross-sectionally and prospectively associated with an impaired capacity to concentrate, remember, make decisions, and think clearly. van Zoonen et al. (2016) specifically investigated the impact of work-related social media use on work-private life boundaries, and found that the utilization of social media for work purposes was associated with exhaustion, which could partially be explained by conflicts between the work- and private life domains. This association was not mitigated by social media policies of the company.

In one of few studies utilizing objective outcome measures, Dettmers et al. (2016) found that extended work availability requirements were associated with cortisol awakening response (CAR) - a physiological marker of distress - as well as daily start-of-day mood. Lack of control over off-job activities resulting from the demand to be available mediated the relationship with start-of-day mood but not with CAR. Hence, the results suggested that non-work hours during which employees are required to remain available for work cannot be considered leisure time since employees' control over leisure time activities is constrained, resulting in restricted recovery from work.

As a more specific concept pertaining to availability demands, ”workplace telepressure” has been proposed, referring to the perceived pressure to respond to and preoccupation with received work-related messages that employees may experience as a result of the widespread availability of asynchronous messaging technologies (Barber and Santuzzi, 2015). Hence, this concept concentrates on the potential of ICTs to facilitate the flexibility of work communications at the expense of the opportunity of workers to recuperate. Aiming to clarify the content of the concept, Grawitch et al. (2018) found that workplace telepressure was associated with the specific ICT demands ”response expectations”, ”availability”, and ”control over demands”, which were in turn associated with emotional exhaustion, lack of psychological detachment, and dissatisfaction with work-life balance. Furthermore, workplace telepressure has been found to be associated with physical and cognitive burnout, absenteeism, and impaired sleep quality (Barber and Santuzzi, 2015), high mental demands, longer weekly work hours, evening work and weekend work, more irregular work hours, and work-related health complaints (Arlinghaus and Nachreiner, 2014).

Some studies reported mixed findings, or associations of technology-assisted availability with conditions generally regarded as positive. One study reported that off-work hours technology-assisted job demands (off-TAJDs) were associated with work-family *conflict* (WFC) for some employees, but work-family *enrichment* (WFE) for others (Ghislieri et al., 2017). Arlinghaus and Nachreiner (2014) found workplace telepressure to be associated with higher employee control over work hours and autonomy in general, and Windeler et al. (2017) reported that high demands to socially interact with other people in the work role were less likely to lead to work exhaustion after introduction of a part time telework practice. This highlights the potential of telework to relieve pressure as well as promoting it.

Given studies that suggest both positive and negative effects of technologies facilitating availability, there is a need for knowledge about the specific conditions under which they may

exhibit harmful effects. Some of the herein reviewed studies investigated factors that may contribute to explaining *why and when* such technologies are a source of strain for workers. Leung (2011) found that individuals who experienced a highly permeable boundary between the home- and work domain were satisfied with their jobs when the work domain was highly flexible and ICTs were helpful in accomplishing work tasks. On the other hand, employees experiencing high degrees of spillover from work into the home domain reported low job satisfaction and higher levels of burnout. Their conclusion was that being able to connect with ICTs to perform work tasks outside of work was not the main challenge, but rather the degree of *control* the worker has over what passes through the boundaries that distinguish work from private life. Another study reported that work-related smartphone use in the evenings was actually associated with recovery, psychological detachment, and positive affect when it was ”autonomously motivated”, meaning that the smartphone was utilized at the workers' own discretion because it was considered important, interesting, or fun (Ohly and Latour, 2014). On the other hand, using the smartphone for work tasks was associated with negative affect when it was based on a ”controlled motivation”, i.e. because it was demanded by others and because not using it would result in feelings of guilt. Yun et al. (2012) also studied smartphone use and found that work overload attributed to the use of office-home smartphone (OHS) was related to user resistance and work-to-life conflict, but not directly to ”job stress”. Flexibility attributed to OHS was not associated with work-to-life conflict directly, but was associated with work overload. However, high productivity attributed to OHS was associated with less work overload, suggesting that while smartphone use could represent added demands it could also be an effective resource to gain control over demands. Moreover, a work culture that supported a clear boundary between work and home was associated with less work-to-life conflict, underscoring the role of the work environment in influencing the extent to which new technologies are harmful or helpful.

In summary, results regarding the health effects of workplace telepressure and related concepts are mixed. There are certainly studies that indicate adverse effects on both working conditions and health, but most likely there are numerous mitigating factors or circumstances under which such technology is beneficial. The current studies suggest that employee autonomy is one important such factor. This factor has previously been highlighted by pivotal theoretical models of occupational (health) psychology, such as the Demand-control and Job characteristics models. Hence, future studies may aim to gain more insight into the role of employee autonomy specifically in managing the interface between the work- and private life domains.

6.4.5 Attitudes towards technology

In the current context, ”attitudes towards technology” refers to workers' thoughts and perceptions of new technologies and their implications for work and workers. Vieitez et al. (2001) found that the extent to which employees perceived advanced manufacturing technology as a cause of increased unemployment and job insecurity was associated with impaired well-being in terms of symptoms of anxiety and depression, but not with general worries. Patel et al. (2018) observed higher levels of job insecurity, and in turn poorer physical and psychological

health, among occupational classes at higher risk of automation of jobs. Another study reported that incompatibility between information systems and the employee's personal values constituted a role conflict which in turn was associated with burnout, i.e. emotional exhaustion, cynicism, and reduced perceived personal accomplishment (Hennington et al., 2011). Finally, Rajeswari and Anantharaman (2005) observed that higher "computer self-efficacy", i.e. the belief that one masters computerized technology, and perceived control over technology were associated with less "stress" and work exhaustion.

Taken together, the current studies reported some associations of workers' attitudes towards technology with health, both in aversive and beneficial ways. In some cases the driver of the relationship seemed to be the fear of a negative outcome, such as technological unemployement. However, there were also indications of perhaps less readily apparent mechanisms, wherein information systems can misalign with workers' personal values, creating role conflict, and in that way promote health problems. Finally, once again job control seemed an important factor as the perceived control and mastery over computerized technology seemed to be a factor that can counteract negative health effects.

6.4.6 Technology-related harassment and incivility

ICTs are used to facilitate the social transmission of messages. As non-physical harassment and incivility require such social transmission, ICTs may be used to facilitate such behaviors also. Two of the currently reviewed studies focused on harassment and incivility related to technology. Ford (2013) found that virtual harassment was associated with depression, anxiety, and psychosomatic health complaints. This association was partly due to victims of virtual harassment experiencing fear of future harassment. Furthermore, the extent of this fear depended on the "media characteristic". That is, "richer", more elaborate harassing e-mails were associated with more fear than "leaner" harassing e-mails. Anonymous harassing e-mails were also more likely to induce fear of future harassment and frequent anonymous harassment induced more fear than frequent harassment from a known perpetrator.

Giumetti et al. (2012) found that cyber-incivility perpetrated by supervisors was associated with burnout, absenteeism, and turnover intentions among subordinates. These associations were strongest for employees that exhibited higher levels of the personality trait neuroticism, indicating that these individuals were more vulnerable to developing health problems following cyber-incivility.

With the increase of work-related media use both at work and at home, technology may facilitate harassment and incivility that may affect employee health- and well-being. The study by Ford (2013) found that virtual harassment was more frequent than face-to-face harassment, and the two types of harassment frequently co-occurred. Hence, technologies that enable harassment and incivility to be perpetrated in virtual environments may even contribute to increased prevalences of such behaviors. However, there seems to be a strong need for more research to determine the corresponding prevalences in the working population and to clarify the ways in which the impact of technology-related incivility may differ from the impact of other forms of incivility.

7 GENERAL DISCUSSION

Among the strengths of the current approach was the systematic literature search and the complete and transparent report of the procedures. While the nature of the topic and the questions that motivated the study implied a base of heterogeneous studies comprising a variety of exposures and outcomes, a systematic search should increase the probability of obtaining a literature pool that represents the current knowledge on the topic. And although the narrative review with no rating of study quality precludes any strong conclusions about the level of evidence associated with the different factors, only studies published in peer-reviewed journals were selected, implying a certain level of scientific rigor.

Nevertheless, while the review should provide considerable insights into challenges associated with the use of technology at work, certain limitations should be kept in mind when interpreting the overall evidence. Among the more general concerns is that in many cases it is difficult to distinguish the studied technology from, for instance, the context of the study, the implementation of the technology, or the content of information it is being used to convey. Hence, while a study of emails that were perceived as demanding (Russell et al., 2017) may seem to pertain to something quite similar to ”traditional” psychosocial work exposures (i.e. ”demands”), a study of the extent to which ICT promotes work intensification (Chesley, 2014) may seem to address more directly the impact of technology itself on working conditions. Hence, conceptual clarity and development should be a priority for future studies, as it is necessary in order to at least analytically separate the effects of technological developments themselves from the work activities that they are associated with.

Due to the focus of the present review on the explicit links of digitalization and new technology with health and work environment, a number of topics were not covered that are nevertheless typically included in discussions about future work. For instance, no studies were found that pertained to digital peer-to-peer businesses (e.g. Uber, Foodora). Presumably, this reflects a provisional lack of research on the implications of these new forms of digitally driven employment on psychosocial working conditions and worker health. Also, the topic of *job security* is often linked to technological advances such as automation and robotization. However, comprehensively capturing this topic was outside the scope of the present review, although some of the included studies investigated it as an outcome of the application of new technologies (e.g. Nijp et al. (2016); Vieitez et al. (2001)). For a more general systematic review of the health impacts of job insecurity on employee health, see Kim and von dem Knesebeck (2015). Several of the studies reviewed in the present study included the interface between work and private life as a topic associated with the use of new work technologies. For instance, Derks and Bakker (2014) studied consequences of work-home interference specifically linked to smartphone use, and both Ghislieri et al. (2017) and Wright et al. (2014) studied work-private life balance as an outcome of telepressure. As with job insecurity, there is already an established line of research on consequences of imbalance between demands and expectations from the work and family domains - see (Michel et al., 2011) or (Nijp et al., 2012) for systematic reviews. Another topic that is linked to the current topic is *organizational change*. Technological change often leads to changes in ways of organizing and executing work, and the impact of organizational change on health and working conditions is

a well established topic in occupational health psychology. Different types of organizational changes can be associated with health effects, partially due to their influence on the work environment (Fløvik et al., 2019).

While a thorough review of methodological quality of the included studies was outside the scope of the review, some general comments about methodological strengths and limitations of the review and the included studies are appropriate. For instance, the majority of the included studies utilized cross-sectional observational designs, i.e. self-reported data collected at one point in time. Hence, the typical limitations of cross-sectional designs apply to the current results. As such, assumptions regarding causality and the direction of causal effects can in most cases not be confidently made. This problem is most prominent in studies investigating somewhat ambiguous concepts such as ”stress” and ”strain”. As evident from table 2, 11 studies included ”stress” as an outcome variable. In most of the studies ”stress” was intended to represent a work factor. However, when subjects report their levels of ”stress” it often remains unclear whether this pertains to working conditions or subjects' reactions to work and working conditions. This is a general problem with the usage of the term ”stress” in psychology and medicine, but is tellingly reflected by the use of the term ”technostress” in many of the current study reports. When posing the question of whether ”technostress” causes changes in the psychosocial work environment this becomes particularly clear. For instance, when observing a cross-sectional association of ”technostress” with role ambiguity, the question remains whether work technologies shape the experience of roles or whether ambiguous work roles is a stressor that intensifies the experience of problems associated with the use of technology.

The current review summarized studies from a wide range of countries. Therefore, interpretations should take into account the possible impact of unique aspects of culture, socioeconomic conditions, and other relevant factors that may vary across nationalities. Many such variables may also vary over time, and there may be possible differential impacts of macroeconomic fluctuations in different countries. In sum, this means that the impact of technology on working conditions and worker well-being may be differential across nationalities. Future studies should consider the possiblity of conducting meta-analyses that take such variation into account to gain a more detailed and comprehensive view of the current topic.

Finally, in the absence of a quality assessment of the included studies, caution should be taken when interpreting the evidence summarized in tables 3 and 4. In many cases, failure to detect associations could hinge on methodological limitations of the study. In other cases findings could be spurious due to methodological flaws. Also, publication bias could imply that many non-findings remain unpublished and unreported. Hence, we cannot with certainty claim that the overall pattern of findings reported in the current review reflects what would have been found after weighting or exclusion of low quality evidence.

8 CONCLUDING REMARKS

The current review summarized 53 scientific studies published during the previous 18 years pertaining to effects of new work technologies on psychosocial working conditions and work-

ers' health. The included body of research was quite diverse, comprising a wide range of both exposures and outcomes that overlapped to various degrees between studies. This makes it challenging to arrive at a uniform overall conclusion. However, it seems safe to conclude that there is evidence that some aspects of novel technologies (information technologies in particular) can be aversive both to the work environment and workers' psychological and somatic health. When the means of production change, so may important features of the job that are essential to workers' well-being. Novel work technologies may be accompanied by problems balancing work with private life (e.g. van Zoonen et al. 2016), lack of restitution due to extended availability requirements or -norms (e.g. Dettmers et al. 2016), quantitative as well as qualitative work overload (e.g. Yun et al. 2012), and a range of other potential challenges to worker well-being.

On the other hand, some studies specified conditions under which potentially adverse health effects could be avoided (e.g. Ohly and Latour 2014). And while most studies seemed to investigate potential adverse effects, some studies identified ways in which new technologies facilitated and benefitted employee well-being, for instance by providing flexibility and autonomy as well as job enrichment (e.g. Liu et al. 2017).

Given the mixed evidence and the mixture of approaches to elucidating the topic, the actual empirical net consequence of new technologies and ways of working seems to depend on numerous factors. Effects may be attributed to the technology itself, the way in which it is implemented, the purpose it serves, and the extent to which concerns about effects on working conditions are properly taken into account. A main priority of future research should be to identify and disentangle the various components of the effects of new work technology on work environment and well-being. In other words, there is a need to clarify *why*, *when*, and *how* technologies influence work and employees. For instance, employee autonomy/job control was suggested to play an instrumental part in the association of technology with well-being in a number of the included studies (for instance, but not limited to Salanova et al. 2013; Kraan et al. 2014; Carlson et al. 2017; Arlinghaus and Nachreiner 2014). Job control is a well documented "traditional" psychological work factor that has been shown to attenuate the risk of many types of health problems (see e.g. Madsen et al. 2017; Theorell et al. 2016). Future studies and practice should aim to gain more insight into the role of employee autonomy specifically in managing new technologies and related challenges. However, other known and unknown factors may also exacerbate or alleviate these challenges. Hence, future inquiries must be open to the consideration of a wide range of work factors.

9 COMPREHENSIVE SUMMARIES OF INCLUDED STUDIES

The following tables 3 and 4 provide more extensive and detailed summaries of each individual study included in the current review. Table 3 provides summaries of cross-sectional studies, and table 4 provides summaries of prospective studies. Both tables are sorted by the year of publication of the included studies.

Table 3. Overview of cross-sectional studies included in the current review

Authors	Title	Brief summary	Exposure	Outcome	Type of work	Country	N
(Grawitch et al., 2018)	Self-imposed pressure or organizational norms? Further examination of the construct of workplace telepressure.	Workplace telepressure (urge to respond to and preoccupation with messages received) was associated with perceived work ICT demands (response expectations, availiability, control over demands), but also trait-like individual differences such as workaholism. Moreover, ICT demands were associated with emotional exhaustion, lack of psychological detachment, and satisfaction with work-life balance.	Perceived ICT demands, workplace Telepressure	Workplace telepressure, emotional exhaustion, psychological detachment, satisfaction with work-life balance, work-related email response frequency	NA	USA	742
(Patel et al., 2018)	County-level job automation risk and health: Evidence from the United States.	Occupational classes at higher risk of automation of jobs reported higher levels of job insecurity, which was in turn associated with poorer physical and psychological health.	Perceived risk of automation	Physical and psychological health	General working population	USA	1224
(Carlson et al., 2017)	Applying the job demands resources model to understand technology as a predictor of turnover intentions.	Technology-based job autonomy (autonomy enhanced by the implementation of technology) was associated with lower turnover intention through higher job satisfaction, job engagement, and organizational commitment. Technology-based job overload (too high demands due to technology at work) and job monitoring (technology used by the organization to monitor employees) were associated with higher turnover intention through job tension and job dissatisfaction, but not impaired organizational commitment.	Technology-based job autonomy, job overload, and job monitoring (i.e. autonomy, overload, and monitoring caused by/attributed to work tools judged to be ”technology at work”)	Work engagement, job tension, job satisfaction, organizational commitment, turnover intention	Diverse sample	USA	326
(Ghislieri et al., 2017)	New Technologies Smart, or Harm Work-Family Boundaries Management? Gender Differences in Conflict and Enrichment Using the JD-R Theory.	Off-work hours technology-assisted job demands (off-TAJDs) were associated with work-family conflict (WFC), but also - for males - with work-family enrichment (WFE).	Off-work hours technology-assisted job demands (off-TAJD)	Work-family conflict, work-family enrichment	Diverse sample	Italy	671
(So et al., 2017)	Cumulative IT Use Is Associated with Psychosocial Stress Factors and Musculoskeletal Symptoms.	Total IT time was associated with adverse ”psychosocial stress” measured as the composite of several factors (”working through pain”, ”social reactivity”, ”limited workplace support”, ”deadlines”, ”self-imposed workspace”, ”breaks”, ”mood” and ”autonomic response”). Whereas desktop computer time was associated with increased risk of shoulder- and wrist/hand pain, laptop time was associated with decreased risk of neck pain; keypad phone time with decreased risk of neck-, shoulder-, and upper back pain; touchscreen phone with decreased risk of shoulder pain.	Self reported daily hours use of IT-devices	Musculoskeletal discomfort in the neck and upper limbs	Diverse sample	China	285
(Sliskovic and Penezic, 2016)	Testing the associations between different aspects of seafarers' employment contract and on-board internet access and their job and life satisfaction and health.	Seafarers that had unlimited internet access onboard were less likely than those who did not to experience gastrointestinal and cardiovascular symptoms. This effect was not observed for mental health, job satisfaction or life satisfaction.	Free, unlimited internet access	Job satisfaction, life satisfaction, mental health, gastrointestinal symptoms, cardiovascular symptoms	Seafarers on cargo ships	Croatia	298

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Authors	Title	Brief summary	Exposure	Outcome	Type of work	Country	N
(Stadin et al., 2016)	Information and communication technology demands at work: the association with job strain, effort-reward imbalance and self-rated health in different socio?economic strata	ICT demands were associated with higher job demands, higher effort, lower control, lower rewards, and suboptimal self-rated health.	Availability expectations on and off work, call- and email overload, call- and email immediate response expectations, phone and email interruptions, computers and other equipment not working properly.	Job demands, job control, effort, reward, job strain, effort-reward imbalance, self rated suboptimal health.	General working population	Sweden	14757
(Van Yperen et al., 2016)	Workers' intrinsic work motivation when job demands are high: The role of need for autonomy and perceived opportunity for blended working.	High job demands were less detrimental to intrinsic motivation for individuals with an opportunity for blended working, i.e. working time-independent and location-independent with the use of information and communication technology.	Blended working, i.e. working time-independent and location-independent with the use of information and communication technology	Intrinsic work motivation	Diverse sample	NA	657
(van Zoonen et al., 2016)	Social media's dark side: inducing boundary conflicts.	Work-related social media use was associated with exhaustion through work/life and life/work conflict. This association was not mitigated by social media policies.	Work-related social media use	Work-life conflict, life-work conflict, emotional exhaustion	Diverse sample	Netherlands	575
(Andersen and Garde, 2015)	Sleep problems and computer use during work and leisure: Cross-sectional study among 7800 adults.	Computer use at work was not associated with risk of experiencing sleep problems more often than three days a week. However, heavy computer use (>30 hrs per week) during leisure time was associated with such risk.	Computer use at work, computer use during leisure	Sleep problems (difficulties initiating, maintaining, early morning awakening, nonrestorative sleep, daytime impairment, dissatisfaction with sleep) > 3 days a week	General working population	Denmark	7883
(Barber and Santuzzi, 2015)	Please respond ASAP: workplace telepressure and employee recovery.	"Workplace telepressure" was supported as a single factor construct separate from personal factors (job involvement, affective commitment) and separate from - but associated with - general work demands and ICT work demands such as techno-overload (the perception that technology used at work requires one to work faster and that it creates more work than one can handle). Moreover, workplace telepressure was associated with physical and cognitive burnout, absenteeism, sleep quality, and faster e-mail responding, beyond personal factors and other work environment factors.	Workplace telepressure	ICT techno-overload, response norms, workaholism, work engagement, work-home ICT boundary creation and -crossing, job involvement, organizational commitment, work demands, work ICT demands relevant to message-based responding (response expectations, availability, poor communication, and workload), burnout, presenteeism, absenteeism, psychological detachment, restorative sleep, e-mail responding	General working population	USA	354 and 303
(Giahi et al., 2015)	Visual Display Terminal use in Iranian bank tellers: Effects on job stress and insomnia.	Duration of daily video display terminal (VDT) use was associated with impaired sleep quality for tellers working more than 6 hours/day with these terminals. Furthermore, low levels of stress and high job satisfaction was associated with weaker associations of VDT with sleep quality for tellers working less than 6 hours per day with the terminals.	Duration of daily work with VDTs	Sleep problems (difficulty sleeping, awakening during the night, final awakening earlier than desired, total sleep duration, overall quality of sleep), effect of insomnia on work on the next day (sense of well-being during the day, functioning during the day, sleepiness during the day)	Finance	Iran	382

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Authors	Title	Brief summary	Exposure	Outcome	Type of work	Country	N
(Jena, 2015)	Technostress in ICT enabled collaborative learning environment: An empirical study among Indian academician.	Technostress creators (Ragu-Nathan et al., 2008) were associated with lower job satisfaction, lower organizational commitment, higher negative affect, and lower technology-enabled performance. Technostress inhibitors were associated with lower levels of technostress, and with the same outcomes as technostress, in the opposite direction.	Technostress creators, technostress inhibitors	Job satisfaction, organizational commitment, negative affectivity, technology-enabled performance.	Academic	India	216
(Srivastava et al., 2015)	Technostress creators and job outcomes: theorising the moderating influence of personality traits.	Technostress creators were associated with job burnout as well as job engagement. Technostress creators were more strongly associated with burnout for individuals high on agreeableness, and less so for those high on extraversion. Technostress creators were more strongly associated with job engagement for individuals high on openness and less so for those high on neuroticism.	Technostress creators	Job burnout, job engagement	Managers	Europe and Asia	152
(Arlinghaus and Nachreiner, 2014)	Health effects of supplemental work from home in the European Union.	”Workplace telepressure” - being contacted outside regular work hours about work matters, and working outside regular work hours to meet work demands - was associated with high mental demands, longer weekly work hours, evening work and weekend work, more irregular work hours, and an increased probability of reporting at least one work-related health complaint. However, it was also associated with conditions generally regarded as positive, such as higher socio-economic status, more employee control over work hours, and more autonomy in general.	Being contacted regarding job matters outside of the job, working outside of working hours to meet work demands	Numerous health complaints attributed to work, e.g. musculoskeletal, psychological, gastrointestinal, cardiovascular	General working population	EU	22836 and 34399
(Brown et al., 2014)	E-mail in the Workplace: The Role of Stress Appraisals and Normative Response Pressure in the Relationship Between E-mail Stressors and Employee Strain.	High quantity and poor quality (high emotionality and ambiguity) of workplace e-mail - were associated with stress appraisals (”e-mail overload” and ”e-mail uncertainty”) and with emotional exhaustion (a component of burnout). Effects of e-mail stressors on emotional exhaustion were mediated by appraised e-mail overload. Perceived normative response pressure was also associated with emotional exhaustion, and with stronger effects of e-mail ambiguity on emotional exhaustion. However, this did not seem to be due to normative response pressure exacerbating the impact of e-mail stressors on stress appraisals.	E-mail stressors - quantity received, read, and sent, and quality - the degree of emotional charge, abruptness, insensitivity, emotionality, complexity, ambiguity, clarity, difficulty, normative response pressure, e-mail overload and -uncertainty.	Stress appraisals, emotional exhaustion	Academic	Australia	218
(Chesley, 2014)	Information and communication technology use, work intensification and employee strain and distress	Daily work-related ICT use was associated with employee experiences of a faster-paced job and greater levels of interruptions and multitasking. These job conditions were in turn associated with higher work strain and distress, even after controlling for job autonomy. However, personal ICT use outside of work was associated with lower levels of work strain.	Daily use of ICT to perform job tasks	Work speed, interruptions, multitasking, work strain, distress	General working population	USA	2556

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Authors	Title	Brief summary	Exposure	Outcome	Type of work	Country	N
(Kraan et al., 2014)	Computers and types of control in relation to work stress and learning.	Working with a computer more than half of the time and technological pacing of computer work were both associated with distress and intensification of work. While working with a computer was associated with higher autonomy, technological pacing of computer work was associated with lower autonomy. Low autonomy was more strongly associated with distress for technologically paced computer workers.	Technological pacing of the work rhythm	Work-stress, learning, and method-order (m-o) autonomy	Diverse sample	Netherlands	18723
(Ohly and Latour, 2014)	Work-Related Smartphone Use and Well-Being in the Evening The Role of Autonomous and Controlled Motivation.	Work-related smartphone usage in the evening was associated with psychological detachment, but not with recovery and negative affect, and negatively related to positive affect. Autonomous motivation for smartphone usage in the evening - i.e. using it out of one's own volition because one views it as important, interesting, or fun - was positively related with recovery, psychological detachment, and positive affect. However, controlled motivation - i.e. using it because it is demanded others and that feelings of guilt would ensue if not doing so - was associated with less positive and more negative affect.	Work-related smartphone use during evening hours	Psychological recovery, positive affect, negative affect	General working population	Germany	1714
(Reinke and Chamorro-Premuzic, 2014)	When email use gets out of control: Understanding the relationship between personality and email overload and their impact on burnout and work engagement.	Email overload - the perception of being overwhelmed by dealing with emails - was associated with burnout. However, employees high on extraversion and conscientiousness and low on neuroticism were less likely to experience email overload, since they tend to exhibit more positive core self-evaluations (i.e. positive self-esteem).	Email overload	Burnout	Diverse sample	UK	210
(Wright et al., 2014)	Work-related communication technology use outside of regular work hours and work life conflict: The influence of communication technologies on perceived work life conflict, burnout, job satisfaction, and turnover intentions.	Use of communication technology outside of work hours was associated with work-life conflict. It also showed that work-life conflict together with perceived usefulness of the communication technology could partially explain burnout symptoms after use of ICT outside of work hours, even after adjusting for perceived stress.	Work-related ICT use outside of regular work hours	Work-life conflict attributed to ICT, perceived ICT usefulness for work-related puposes (outside of regular work hours), Technology-sssisted supplemental work (TASW), job burnout, job satisfaction, turnover intentions	Diverse sample	USA	168
(Bucher et al., 2013)	The stress potential of social media in the workplace.	A questionnaire instrument was developed and validated to measure aspects of "techno-stress" derived from social media specifically for communications professionals. Three distinct factors were supported - overload, invasion, and uncertainty.	Mental social media demands	Mental social media demands	Communi-cation, private and public enterprises and organizations	Europe	234

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Authors	Title	Brief summary	Exposure	Outcome	Type of work	Country	N
(Ford, 2013)	Virtual harassment: media characteristics role in psychological health.	The frequency of experienced virtual non-sexual harassment was associated with impaired psychological health (depression, anxiety, psychosomatic health) both directly and mediated by fear of future harassment. Furthermore, media characteristic played a role; 1) "Richer", more elaborate harassing e-mails were associated with more fear of future harassment than leaner harassing e-mails, 2) anonymous harassing e-mails were more likely to induce fear of future harassment and the relationship between level of harassment and fear of future harassment was stronger for anonymous harassing e-mails, 3) at high levels of fear of future harassment, anonymity of the harasser was associated with lesspsychological impairment, 4) receiving harassing e-mails at work was more strongly associated with fear of future harassment than receiving such e-mails outside work, 5) however, location (at or outside of work) did not determine the strength of the relationship between virtual harassment and psychological health. Virtual non-sexual harassment was more frequent than face-to-face harassment, and the two were highly correlated.	Insider-initiated non-sexual harassment; virtual harassment compared to face-to-face harassment	Depression, anxiety, psychosomatic health	Diverse sample	USA and Canada	492
(Koivunen et al., 2013)	Occupational stress and implementation of information technology among nurses working on acute psychiatric wards.	Computer or Internet use, or attitudes to computers were not associated with level of stress or job satisfaction or perceived work environment. However, reporting positive attitudes to Internet use was associated with reporting less stress and higher job satisfaction.	Computer use, internet use	Perceived work environment, perceived stress	Nurses	Finland	146
(Salanova et al., 2013)	The dark side of technologies: Technostress among users of information and communication technologies.	Mobbing, low autonomy and low ICT use facilitators were associated with techno-anxiety. Work overload, role ambiguity, ICT use obstacles and low social support were associated with techno-fatigue. Transformational leadership was associated with less techno-skepticism. Emotional overload, mobbing, low autonomy, higher social support and lower mental competence were associated with techno-inefficacy. For intensive ICT users, role ambiguity, mobbing and lower emotional competence were associated with techno-anxiety, work overload and role ambiguity were associated with techno-fatigue, and work overload and mobbing were associated with techno-addiction.	Work overload, role ambiguity, role conflict, monotony, mental overload, emotional overload, mobbing, obstacles hindering ICT use, autonomy, transformational leadership, social support, ICT use facilitators, mental and emotional competences	Technostrain (anxiety, fatigue, skepticism, inefficacy related to technology use), technoaddiction (self-evaluated excessive and compulsive use of technologies)	Diverse sample	NA	1072

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Authors	Title	Brief summary	Exposure	Outcome	Type of work	Country	N
(Day et al., 2012)	Perceived information and communication technology (ICT) demands on employee outcomes: the moderating effect of organizational ICT support.	A measure of specific ICT-demands and -support at work was developed and related to employee strain, stress and burnout, accounting for general job demands (role overload, job boredom, role ambiguity, lack of job control). Eight specific ICT demands were identified; ”availability”, ”poor communication”, ”ICT lack of control”, ”ICT hassles”, ”employee monitoring”, ”learning expectations”, ”response expectations”, and ”workload”. Two facets of ICT support were discovered; ”personal assistance” and ”resources/upgrades support”. The ICT demands were associated with increased strain, stress and burnout even after adjustment for general job demands. The two scales of ICT support were associated with less stress, strain and burnout. The ICT support facet ”resources/upgrades support” moderated the relation between the ICT demand ”learning expectations” and the outcomes and between ”ICT hassles” and strain while ”personal assistance support” moderated the relationship between ”ICT hassles” and strain.	ICT demands: Response expectations, 24/7 availability, ineffective communication, lack of control over ICT, hassles using ICT, employee monitoring, ICT learning expectations, workload, ICT support (personal assistance, ICT resource/upgrades support).	ICT Perceived Stress, strain symptoms, burnout	Diverse sample	Canada	258
(Giumetti et al., 2012)	Cyber incivility @ work: the new age of interpersonal deviance.	Supervisor cyber incivility predicted burnout, absenteeism, and turnover intentions. Neuroticism moderated these relationships - associations were stronger for participants with higher levels of neuroticism.	Cyber incivility	Burnout, absenteeism, and turnover	Education	USA	407 and 207
(Yun et al., 2012)	A new open door: The smartphone’s impact on work-to-life conflict, stress, and resistance.	Work overload attributed to the use of office-home smartphone (OHS) was related to user resistance and work-to-life conflict, but not directly to job stress. Flexibility attributed to OHS was not associated with work-to-life conflict directly, but was associated with work overload. High productivity attributed to OHS was associated with less work overload. A work culture that supported a clear boundary between work and home was associated with less work-to-life conflict. Work-to-life conflict was associated with both job stress and user resistance to OHS.	Work overload, flexibility, and productivity associated with office-to-home smartphone use	Work-to-life conflict, job stress, user resistance	Smartphone users	Korea	300
(Goldfinch et al., 2011)	Information and communications technology use, e-government, pain and stress amongst public servants.	Laptop use was associated with stress but not pain. Desktop use, hours on laptop, hours on desktop, cell phone use, email use or total ICT hours were not associated with stress or pain. However, stress was associated with pain.	Laptop use, desktop use, handheld use, landline use, cell phone use	Stress, pain	Public servants	New Zealand	240
(Hennington et al., 2011)	I’m just burned out: Understanding information system compatibility with personal values and role-based stress in a nursing context.	The degree to which the use of information systems (IS) was incompatible with personal values was associated with role conflict, which in turn was associated with emotional exhaustion, cynicism, and perceived inefficacy (i.e. reduced perceived personal accomplishment).	Degree of incompatibility of usage of information systems in one’s job with personal values	Role conflict, emotional exhaustion, cynicism, inefficacy	Nurses	USA	71

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Authors	Title	Brief summary	Exposure	Outcome	Type of work	Country	N
(Leung, 2011)	Effects of ICT connectedness, permeability, flexibility, and negative spillovers on burnout and job and family satisfaction.	Most "ICT connectedness" measures were not associate with work spillover into home, family spillover into work, job burnout, job satisfaction or family satisfaction. However, a 3g mobile phone connection was associated with lower levels of burnout, use of traditional media to work from home was associated with job satisfaction, and internet dependency was associated with family satisfaction. Goal scope, i.e. to what extent the internet is helpful in achieving one's goals, was associated with less family spillover into work, higher job satisfaction, as well as higher family satisfaction. Permeability of the boundaries between work and home was associated with more spillover and burnout, and for permeability of the home domain also with higher job satisfaction and lower family satisfaction. Flexibility of the work domain was associated with spillover both ways, burnout, but higher job satisfaction. Flexibility at the home domain was associated with higher family satisfaction. Negative spillovers from home to work and from work to home was associated with burnout, and work spillover into home with lower job satisfaction.	ICT activity intensity, -scope, use of traditional media to work home, mobile phone dependency, internet dependency, goal scope, mobile phone connection (3g or 2g), broadband internet access, office technologies, permeability of work and home domains, work spillover into home, home spillover into work	Burnout, job satisfaction, family satisfaction	Office workers	Hong Kong	612
(Ragu-Nathan et al., 2008)	The consequences of technostress for end users in organizations: Conceptual development and empirical validation.	A measure of "technostress" - strain resulting from the use of ICT - was developed and validated. Five dimensions of technostress were identified, i.e. techno-overload, -invasion, -complexity, -insecurity, and uncertainty. These were associated with lower organizational commitment, due to lower job satisfaction. Technostress inhibitors, e.g. technical support provision, were associated with higher job satisfaction and organizational commitment.	Technostress	Job satisfaction, organizational commitment	ICT users	USA	608
(Meyer, 2006)	Technology, job satisfaction, and retention: Rural mental health practitioners.	Among mental health professionals in a rural area, an association was observed of communication technology use with job satisfaction, but only for those with high technology skills. Although 90% of participants had access to a computer and the internet, only 45% used it to communicate with peers, hence it did not seem effective in preventing professional isolation and ensuring professional support.	Use of ICT to communicate with other professionals	Job satisfaction	Healthcare	USA	163
(Rajeswari and Anantharaman, 2005)	Role of Human-Computer Interaction Factors as Moderators of Occupational Stress and Work Exhaustion.	Computer self-efficacy was associated with less "stress" (information not provided about how "stress" was measured) in a sample of software professionals. "Stress" was associated with work exhaustion, but less so in subjects with perceived control over technology.	Stress	Exhaustion	Software developers	India	156
(Rangarajan et al., 2005)	Impact of sales force automation on technology-related stress, effort, and technology usage among salespeople.	Task complexity - the degree of difficulty salespeople perceived in integrating sales force automation (SFA) technology in their work tasks - was associated with role ambiguity and role conflict, which in turn were associated with decreased effort put into tasks. Lower effort and lower perceived usefulness were associated with lower degree of utilization of the technology.	Task complexity of automated sales system	Role conflict, role ambiguity, effort, infusion, perceived usefulness	Salespeople	NA	150

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Authors	Title	Brief summary	Exposure	Outcome	Type of work	Country	N
(Lovett et al., 2004)	Job satisfaction and technology in Mexico.	In a low-tech manufacturing company intrinsic job characteristics were more closely associated with overall job satisfaction and job commitment was a relatively more important factor than in a high-tech factory.	Degree of technology implemented in production	Job satisfaction /Job commitment	Industrial	USA	82
(Rafnsdottir and Gudmundsdottir, 2004)	New technology and its impact on well being.	An association was observed between the level of new technology implemented in fishing factories and employees' level of job strain, decision authority, and health. Employees in high-tech factories exhibited more job strain, lower decision authority, and more health problems than those employed in low-tech factories.	Degree of technology implemented in production	Job stress	Industrial	Iceland	350
(Choi et al., 2002)	Computer anxiety and social workers: Differences by access, use, and training.	Number of hours of computer use at work, higher quality of computer training received and higher levels of reliance on computers to perform work tasks were associated with lower levels of computer anxiety.	Number of hours of computer use at work, higher quality of computer training received, higher levels of reliance on computers to perform work tasks	Computer anxiety	Social workers	USA	244
(Vieitez et al., 2001)	Perception of job security in a process of technological change: Its influence on psychological well-being.	The extent to which employees perceived advanced manufactoring technology as a cause of increased unemployment and job insecurity was associated with impaired well-being in terms of anxiety symptoms and symptoms of depression. However, it was not associated with stress (general worries).	Technology perceived as a cause of unemployment and job insecurity	Depressive behaviour, stress, anxiety	Industrial	Spain	148
(Watanabe, 2000)	Workplace computerization and employee adjustment in Japan.	60.5 % of employees felt they were adjusted to the changes at their workplace due to introduction of PC/e-mail. 31.9 % were almost adjusted, and 7.6% not adjusted. 39.1 % complained of physical stress, 19.1 % of physical and mental stress, and 5.3% of mental stress due to work using PCs. 44.4% reported that their companies had taken measures to alleviate their mental and physical stress.	Office computerization - introduction of PC and e-mail technology	Adjustment to workplace, mental and physical stress	Diverse sample	Japan	548

Table 4. Overview prospective studies included in the current review

Authors	Title	Brief summary	Exposure	Outcome	Type of work	Country	Design	N
(Liu et al., 2017)	Gamification's impact on manufacturing: Enhancing job motivation, satisfaction and operational performance with smartphone-based gamified job design.	Smartphone-based gamified job design (SGJD) increased job motivation, job satisfaction, and operational performance. Furthermore, consent to SGJD was associated with improved job motivation. However, no association was detected between consent to SGJD and improved job satisfaction or operational performance	Smartphone-based gamified job design	Job motivation, job satisfaction, operational performance	Industrial	China	Experimental	60

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Authors	Title	Brief summary	Exposure	Outcome	Type of work	Country	Design	N
(Russell et al., 2017)	Examining conscientiousness as a key resource in resisting email interruptions: Implications for volatile resources and goal achievement.	Employees high on conscientiousness take longer time checking work emails after email notifications, and even more so when high on negative affect. Demanding emails and emails that took longer time to check were associated with negative affect, and even more so for conscientious employees. Email checking time did not predict task goal achievement, but was associated impaired well-being, and even more so for conscientious employees.	ICT demands (email checking)	Goal achievement, well-being	Diverse sample	UK	Diary study	52
(Windeler et al., 2017)	Getting away from them all: Managing exhaustion from social interaction with telework.	In study 1, the association of interpersonal interaction demands with work exhaustion was attenuated after introduction of a part time telework practice.	Part-time telework practice	Work exhaustion	Diverse sample	USA	Prospective and cross-sectional	51 and 258
(Dettmers et al., 2016)	Extended work availability and its relation with start-of-day mood and cortisol.	Extended work availability requirements were associated with daily start-of-day mood and cortisol awakening response (CAR). Furthermore, the lack of control over off-job activities resulting from the demand to be available mediated the relationship with start-of-day mood but not with CAR. Hence, the results suggested that non-work hours during which employees are required to remain available for work cannot be considered leisure time since employees' control over leisure time activities is constrained and their recovery from work is thusly restricted.	Extended availability operationalized as a day-level variable that corresponded to the employees' on-call shifts (i.e., the week with on-call duty vs. the week without on-call-duty)	Recovery experiences, psychological detachment from work, job control, start-of-day mood (valence, energetic arousal, calmness), cortisol awakening response (CAR)	Diverse sample	Germany	Diary study	132
(Nijp et al., 2016)	Effects of new ways of working on work hours and work location, health and job-related outcomes.	"New ways of working" (NWW) was implemented in the form of increased control over working time and -location coupled with a 'personal standard equipment'-package consisting of laptop, smartphone, and necessary ICT applications (e.g. email, chat applications, phone software) to enable communication and cooperation from remote locations. Meeting rooms were equipped with smart boards and roundtable cameras to enable virtual meetings. This resulted in large decreases in commuting time (i.e. people worked more from home), more evening work and more work hours per week, but not more weekend work. Job demands, job autonomy, and support from colleagues and supervisors were unaffected. Work-private life conflict, "stress", fatigue, performance, organizational commitment, and job satisfaction were unaffected. However, overall health decreased after implementation of NWW.	Employee control over working time and -location	Job demands, autonomy, social support, stress, health, job satisfaction, job insecurity	Finance	Netherlands	Prospective	2912

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Authors	Title	Brief summary	Exposure	Outcome	Type of work	Country	Design	N
(Andersen et al., 2015)	Work demands and health consequences of organizational and technological measures introduced to enhance the quality of home care services - A subgroup analysis.	The introduction of a technological aid (personal digital assistants, PDAs) in combination with an organizational aid (job checklists) did not result in overall changed work demands or employee health. However, a subgroup of employees experienced increased work demands due to difficulties using the new technology. For employees not experiencing such difficulties, work demands were reduced.	Technological aid (PDA) combined with organizational aid (job checklists)	Work demands (physical, mental, social, emotional), musculoskeletal health (shoulder-neck pain, low back pain), perceived general tension, perceived change in time pressure	Healthcare	Norway	Prospective	46
(Derks and Bakker, 2014)	Smartphone Use, Work-Home Interference, and Burnout: A Diary Study on the Role of Recovery.	Among employees using smartphones on the initiative of their employer, higher experienced levels of work-home interference (WHI) and emotional exhaustion were observed for intensive after-work smartphone use. Also, daily recovery experiences (psychological detachment and relaxation) seemed more important for intensive smartphone users - i.e. they were more strongly protective against WHI for this group than for less intensive smartphone users.	Intensive smartphone use	Daily psychological detachment, daily relaxation, work-home interference, burnout (exhaustion and cynicism)	Not given	Netherlands	Diary study	69
(James et al., 2013)	The impact of automation on pharmacy staff experience of workplace stressors.	Introducing an automated dispensing system (ADS) for pharmacy staff was associated with an overall reduction of perceived stress and an improvement in the perception of whether workload was logically allocated. However, theere was no change in specific psychosocial work factors (work overload, fair allocation of work, autonomy, career/growth opportunities, job satisfaction, work-life conflict, employability, organizational commitment). Technicians reported that ADS devalued their skills.	Automation	Stress , illogical workload allocation, work-life balance	Pharmacy staff	UK	Prospective and cross-sectional	45 and 32
(Stenfors et al., 2013)	Psychosocial working conditions and cognitive complaints among Swedish employees.	ICT demands (i.e. interruptions by- and demands of having to answer too many emails and telephone calls, technical problems with ICT and the role that ICT might play in eroding boundaries between work and leisure) were both cross-sectionally and prospectively associated with cognitive complaints (impaired concentration, memory, decision-making and ability to think clearly).	ICT demands	Cognitive complaints	General working population	Sweden	Prospective and cross-sectional	9751 and 3644

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Authors	Title	Brief summary	Exposure	Outcome	Type of work	Country	Design	N
(Blok et al., 2012)	New ways of working: does flexibility in time and location of work change work behavior and affect business outcomes?	Three departments that changed from a traditional way of working to a "new way of working" characterized by more flexibility in timing and location of work tasks as well as increased digitalization of work tools. These departments studied with respect to change in variation of work location and work times, knowledge sharing, employee satisfaction, collaboration, and rating of the suitability of the work environment for executing work tasks. Six months after implementation no changes were observed in these areas, except for a decrease in knowledge sharing.	Move from a "traditional" work environment where each department had their own work space to one shared work area with a variety of different shared workspaces (e.g. brainstorm areas, meeting rooms, silent open workspaces and project places). Digital smart boards were introduced to support project work, as well as laptops, cellphones, and access to the business network in order to enable employees to work everywhere throughout the office space.	Awareness of new opportunities and tools, collaboration with colleagues, job satisfaction, knowledge sharing	Office workers	NA	Prospective	39
(Elfering et al., 2010)	Participation during major technological change and low back pain.	Lack of employee participation in the planning and implementation of a new internet service was associated with development of low back pain. There was no change in back pain among employees that were able to participate in planning and implementation.	Implementation of an organizational internet portal, which included the offer of organizational services via the internet	Low back pain	Public servants	Switzerland	Prospective	20
(Chen et al., 2009)	Impact of enhanced resources on anticipatory stress and adjustment to new information technology: A field-experimental test of conservation of resources theory.	After implementation of a new IT system, employees that received a resources workshop to facilitate their adjustment to the new system reported higher satisfaction with IT than prior to the implementation and the same level of exhaustion. Employees not receiving the workshop reported lower satisfaction with IT and higher levels of exhaustion. Levels of social support, perceived control and vigor were not affected, but means efficacy, i.e. the belief in IT as a utility in performing the job, was increased in the experimental group.	Introduction of new IT system, and workshop to enhance participants' psychological resources to reduce stress and facilitate adjustment	IT satisfaction, exhaustion, means efficacy, social support, perceived control, vigor	Office workers	Israel	Experimental	218
(De Croon et al., 2004)	Information technology and road transport industry: how does IT affect the lorry driver?	This study investigated how on board computer systems (OBC-systems) to collect and transmit data in a vehicle about mileage, fuel consumption, waiting times, and queues influenced lorry drivers' experience of job control, job demands, need for recovery after work, and organisational commitment. Results suggested that the application of the OBC-systems decreased the lorry drivers' job control and organizational commitment, but did not influence job demands and need for recovery.	On board computer system	Job control, job demands, need for recovery after work, organisational commitment	Lorry drivers	Netherlands	Quasi- experimental	78

10 SEARCH STRING

Table 5. Search string

Database: Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Ovid MEDLINE(R) Daily and Ovid MEDLINE(R) 1946 to Present

1	exp Employment/ or exp Workplace/	78029
2	((job or organi?ation* or occupation or work?) adj6 (chang* or trend* or transform* or evolution or impact)).tw.	41303
3	(employ * or labo* or employ* or occupied or workforce or personnel? or staff or worker).tw.	1322433
4	("independent work" or "sharing economy").tw.	153
5	((nonstandard or flexible or temporary) adj2 contract*).tw.	177
6	1 or 2 or 3	1397948
7	exp Internet/ or exp Computer Communication Networks/ or exp DIGITAL COMPUTERS/	153397
8	(digitali?ation or digiti?ation or ict or robot* or automat* or email or disruption or virtual reality or software or internet or world wide web or social media or artificial intelligence or 4 industrial revolution or machine learning or augment* reality).tw.	539933
9	(digital* adj2 (transformation or challenge or age or impact or platform or innovation)).tw.	1084
10	((information or communication or new or digital or computer or advanced) adj1 (technolog* or trend? or innovate*)).tw.	44500
11	7 or 8 or 9 or 10	686992
12	exp OCCUPATIONAL HEALTH/ or exp work related illnesses/ or exp Occupational Stress/	39724
13	(mental* adj1 (health or illness* or ill or disorder*)).tw.	161896
14	(occupational adj2 (burnout or health psychology or stress or strain or safety)).tw.	6476
15	((mood or dysthymic or depress*) adj1 disorder*).tw.	45476
16	((industrial or organizational) adj2 psycholog*).tw.	410
17	(work ability or disability or pain* or distress or well-being).tw.	846492
18	12 or 13 or 14 or 15 or 16 or 17	1059249
19	6 and 11 and 18	3591

Database:PsycINFO 1806 to June Week 2 2018

1	exp Organizations/	70500
2	((job or organi?ation* or occupation or work?) adj6 (chang* or trend* or transform* or evolution or impact)).tw.	43554
3	(employ * or labor or occupied or workforce or personnel? or staff or worker).tw.	174747
4	("independent work" or "sharing economy").tw.	264
5	((nonstandard or flexible or temporary) adj2 contract*).tw.	144
6	1 or 2 or 3 or 4 or 5	269072
7	exp INTERNET/ or exp COMPUTERS/ or exp Computer Applications/ or exp Human Computer Interaction/ or exp Technology/	151953
8	(digitali?ation or digiti?ation or ict or robot* or automat* or email or disruption or virtual reality or software or internet or world wide web or social media or artificial intelligence or 4 industrial revolution or machine learning or augment reality).tw.	149347
9	(digital* adj2 (transformation or challenge or age or impact or platform or innovation)).tw.	1220
10	((information or communication or new or digital or computer or advanced) adj1 (technolog* or trend? or innovate*)).tw.	23487
11	7 or 8 or 9 or 10	254845
12	exp Work Related Illnesses/ or exp Occupational Stress/ or exp Psychological Stress/	28846
13	(mental* adj1 (health or illness* or ill or disorder*)).tw.	242697
14	((occupational or professional or job or work or psychologic*) adj2 (burnout or health or stress* or suffering or strain or safety or illness or disease)).tw.	45508
15	((mood or dysthymic or depress*) adj1 disorder*).tw.	45614
16	((industrial or organizational) adj2 psycholog*).tw.	6293
17	(work ability or disability or pain* or distress or well-being or anguish).tw.	283462
18	(job* adj2 (control or demand* or characteristics)).tw.	6131
19	12 or 13 or 14 or 15 or 16 or 17 or 18	576268
20	6 and 11 and 19	1736

Database: Web of Science

#12 #10 AND #7 AND #4 2,287
Refined by: WEB OF SCIENCE CATEGORIES: (PUBLIC ENVIRONMENTAL OCCUPATIONAL HEALTH OR PSYCHOLOGY APPLIED OR PSYCHOLOGY CLINICAL)
DocType=All document types; Language=All languages;
#11 #10 AND #7 AND #4 15,138
DocType=All document types; Language=All languages;
#10 #9 OR #8 1,923,502
DocType=All document types; Language=All languages;
#9 TOPIC: (" work ability ") OR TOPIC: (disability) OR TOPIC: (pain*) OR TOPIC: (distress) OR TOPIC: (well-being) 888,376
DocType=All document types; Language=All languages;
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DocType=All document types; Language=All languages;
#7 #6 OR #5 1,763,941
DocType=All document types; Language=All languages;
#6 TOPIC: (computer*) OR TOPIC: ("information technology") OR TOPIC: ("new technology") OR TOPIC: (innovat*) 789,808
DocType=All document types; Language=All languages;
#5 TOPIC: (digital*) OR TOPIC: (robot*) OR TOPIC: (automat*) OR TOPIC: (email) OR TOPIC: (disruption) OR TOPIC: ("virtual reality") OR TOPIC: (internet*) OR TOPIC: ("artificial intelligence") OR TOPIC: ("4 industrial revolution ") OR TOPIC: ("machine learning") OR TOPIC: ("augment* reality") 1,078,749
DocType=All document types; Language=All languages;
#4 #3 OR #2 OR #1 3,049,697
DocType=All document types; Language=All languages;
#3 TOPIC: ("sharing economy") 329
DocType=All document types; Language=All languages;
#2 TOPIC: ("nonstandard contract*") OR TOPIC: ("flexible contract*") OR TOPIC: ("flexible contract*") 81
DocType=All document types; Language=All languages;
#1 TOPIC: (job) OR TOPIC: (organi?ation*) OR TOPIC: (occupation) OR TOPIC: (work*) OR TOPIC: (employ*) OR TOPIC: ("independent work") 3,049,395
DocType=All document types; Language=All languages;

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