

## WG3 CONCEPTUAL FRAMEWORK for Digitalisation and Health of Older Workers

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### Introduction

Digitalisation is reshaping the world of work through remote and hybrid models, data-intensive tools, and automation, while the proportion of older workers continues to rise. These shifts create intertwined risks and opportunities for the physical health and socio-emotional well-being of late-career employees. A coherent framework specific to the impact of digitalisation and the health of older workers can help align concepts, theorise mechanisms, and guide research and interventions across sectors and countries.

Beyond average effects, digitalisation tends to amplify or mitigate existing inequalities among older employees, particularly across gender, education, and occupational profiles, influencing both exposure to physical risks and psychosocial experiences such as technostress, loneliness, or social support.

Below is a synthesis of the theoretical and empirical work within WG3 “Digitalisation and Health,” focusing on the physical and socio-emotional health of older workers. The articles underlying this conceptual framework employed a diverse set of methodologies, reflecting both the breadth of research on digitalisation and the health of older workers, as well as the relative novelty of the topic. Several studies employed a scoping or systematic review approach, using Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines, to map the evidence base on digitalisation, workplace health, and ageing. These reviews synthesised findings across various domains, including musculoskeletal health, visual strain, cardiovascular and metabolic risks, and psychosocial well-being, highlighting both risk and protective mechanisms. By integrating observational and interventional evidence, they offered a broad conceptual map of physical health outcomes in relation to digital exposure. Other contributions relied on empirical observational designs, including cross-sectional surveys.

Important works within WG3 “Digitalisation and Health”

1. Spijker J, Barlin H, Grad DA, Gu Y, Klavina A, Korkmaz-Yaylagul N, Kulla G, Orhun E, Ševčíková A, Unim B, Tofan CM (2024). The Impact of Digital Technology on the Physical Health of Older Workers: Protocol for a Scoping Review. *JMIR Research Protocols* 13:e59900. <https://doi.org/10.2196/59900>
2. Nedeljko, M., Gu, Y. & Bostan, C.M. (2024). The dual impact of technological tools on health and technostress among older workers: an integrative literature review. *Cogn Tech Work* 26, 47–61 <https://doi.org/10.1007/s10111-023-00741-7>
3. Spijker et al. The impact of digital technology on the physical health of Older Workers: Scoping Review. *JMIR Aging*. In press.
4. Spijker et al. (submitted to Springer book). The Impact of Digitalisation on Physical Health in Older Workers. (Springer book chapter).
5. Tofan et al. (submitted to BMC Public Health). The Effect of Digital Technologies on the Social Support of Older Workers. A Scoping Review.

Commented [JS1]: These are only for scoping reviews.

6. Tofan CM, Șoitu DT, Crivoi S. (forthcoming book, *Older Workers and Digital Literacy*) From Resistance to Resilience: Digital Skills and Older Workers' Attitudes .
7. Tânculescu-Popa et al. (submitted to Research Protocols). Workplace Loneliness Experience Among Older Professionals (50+) in the Context of Digitalisation: A Protocol for a Scoping Review
8. Dalaylı et al. (submitted to Springer book). Older Academics in the Digital Age: A Comparative Analysis of Challenges and Solutions
9. Magalhães et al (submitted to Springer book). Digitalisation and Healthcare Workers: European Trends, Workforce Competencies.
10. Magalhães et al. Digital Competencies Required by Healthcare Professionals Across Diverse Care Settings: A Scoping Review. Submitted to BMC Health Services Research

### Key concepts & definitions

**Digitalisation at work.** Adoption of digital technologies (e.g., platforms, devices, apps), ICT infrastructure, algorithms/AI, and datafied workflows embedded in tasks, coordination, and monitoring. This concept is characterized by several key dimensions:

- a) *technological integration*, reflecting the use of digital tools for data manipulation, storage, transmission, and processing (e.g., computers, cloud-based platforms, digital communication systems, robotic systems) to enhance or replace traditional work methods;
- b) *transformation of work practices*, reflecting reconfiguring how tasks are performed, enabling remote or hybrid work, increasing flexibility, and reshaping job demands and required skills. These changes affect not only workflows but also the physical and social environments of work; c) *digital communication and interaction*, reflecting that digitalization mediates professional interactions through communication platforms (e.g., video conferencing, messaging apps), which can both facilitate connection and create new challenges such as social isolation or technostress, particularly for older workers;
- d) *physical and psychosocial implications*, reflecting the increased use of digital technologies in workplace and that it can have both beneficial and detrimental effects. Benefits include reduced physical demands and increased flexibility, and risks include ergonomic issues, prolonged screen exposure, and altered patterns of social support and workplace belonging.
- e) socio-organizational impact as reflecting that digitalization is not limited to technology adoption, but rather it involves broader organizational transformation, influencing structures, leadership, communication norms, and social support networks among workers - especially older employees.

In conclusion, digitalization at work refers to the systemic integration of digital technologies and infrastructures into organizational structures, work processes, and communication systems. This transformation involves the adoption and use of digital technologies, such as information and communication technologies (ICT), cloud-based platforms, automation systems, and teleworking solutions. Digitalization alters both the **technical** and **social fabric** of workplaces. On the one hand, it enables greater flexibility, efficiency, and access to information; on the other, it introduces new physical, psychological, and social dynamics—such as technostress, changes in collaboration patterns, and shifts in social support structures. For older workers in particular, digitalization intersects with age-related factors (e.g., digital literacy, physical changes, social network dynamics), making it both an **enabler**

**of continued participation in the workforce and a potential source of exclusion or strain.**

**Older workers.** Typically ≥50 years (flexible by occupation and context), reflecting age-related changes and distinct labour-market dynamics. While there are ongoing debates regarding what age defines older workers (see examples below), we include individuals 50 years or older based on the growing presence of this cohort in the labour market and their likelihood of remaining in the workforce longer than previous generations.

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<p>EUROPEAN COMMISSION Directorate-General for Employment, Social Affairs and Inclusion Directorate, A — Employment &amp; Social Governance, Unit A4 – Thematic analysis. 2015. Employment of older workers Research Note no. 5/2015. Available at: <a href="https://www.euro.centre.org/downloads/detail/1555">https://www.euro.centre.org/downloads/detail/1555</a></p>	<p>The European criteria define the older workforce as those employees aged 55 and over</p>
<p>McCarthy J, Heraty N, Cross C, Cleveland JN (2014). Who is considered an 'older worker'? Extending our conceptualisation of 'older' from an organisational decision maker perspective. Human Resource Management Journal, 24(4), 374-393</p>	<p>define older workers as those aged 45 and over, but also suggest considering a definition depending on the perspective (i.e., psychological, sociological, economic, etc.)</p>
<p>Marvell R, Cox A. What do older workers value about work and why? Brighton (UK): Centre for Ageing Better &amp; Institute for Employment Studies; 2017.</p>	<p>Older workers are defined as those of 50 years old due to age-related declines in physical functioning and longer recovery times.</p>
<p>Spijker J, Barlin H, Grad DA, Gu Y, Klavina A, Korkmaz Yaylagul N, Kulla G, Orhun E, Ševčíková A, Unim B, Tofan CM (2024). The Impact of Digital Technology on the Physical Health of Older Workers: Protocol for a Scoping Review. JMIR Research Protocol 13:e59900.</p>	<p>While there are ongoing debates regarding what age defines older workers, we have opted to include individuals 50 years or older. This decision is based on the increasing presence of this cohort in the labor market, their likelihood of remaining in the workforce longer than previous generations, and the need to recognize the diversity within this demographic group. People in their 50s may have varying career trajectories, skill sets, and motivations for remaining in the workforce. By defining older workers as those aged 50 and over, organizations can more effectively cater to the unique needs and experiences of this diverse and increasing group of older individuals in the labor market.</p>

**Physical health outcomes.** Vision/eye strain; musculoskeletal disorders; headaches/migraines; cardio-metabolic risks (sedentariness vs. digital support for activity/weight); hearing/sound exposure; overall physical functioning and work ability.

Health Domain	Negative Effects	Positive / Mitigating Effects
<b>Musculoskeletal</b>	Back/neck/shoulder pain, repetitive strain, poor ergonomics	Ergonomic design, posture feedback systems, assistive devices
<b>Visual</b>	Eye strain, headaches, visual fatigue	Screen optimisation tools, adjustable lighting, ergonomic setup
<b>Cardiovascular</b>	Sedentary behaviour, hypertension, metabolic risk	Digital health apps, wearable tracking, fitness platforms
<b>Hearing &amp; Neurological</b>	Headset noise exposure, stress-related tension	Sound ergonomics, digital mindfulness, health-oriented training
<b>Overall physical health</b>	Fatigue, reduced mobility, chronic strain	Telehealth, AI-based monitoring, remote wellness interventions

**Technostress:** Strain arising from ICT demands, rapid change, and constant connectivity has mixed and context-dependent effects for older workers. It appears especially when the demands of digitalised work exceed the workers perceived resources, skills, or adaptive capacity. In the context of older workers, technostress is not merely a reaction to new technologies, it reflects the interaction between digital demands, age-related changes, and organisational factors (e.g., lack of training/support, or poor design of digital tools).

**Workplace loneliness / social connection:** Perceived lack of meaningful ties at work, distinct from solitude; shaped by digital communication norms and inclusion practices. Workplace loneliness shaped by digitalization refers to the perceived absence of meaningful social connection and belonging within digitally mediated work environments, where communication, collaboration, and interaction increasingly occur through technological platforms rather than in-person exchanges.

The conceptualization of workplace loneliness shaped by digitalization builds upon three intersecting theoretical frameworks that together explain how technological transformation influences social connection at work. First, the socio-cognitive theory of loneliness posits that loneliness arises from a discrepancy between desired and actual social interactions, driven by cognitive appraisals and perceived social adequacy. Within digitalized workplaces, this gap can widen as online communication satisfies instrumental needs but often fails to meet emotional and relational ones, leading to a diminished sense of belonging. Second, organizational and structural perspectives emphasize that workplace design, hierarchies, and communication norms shape the opportunities for social connection. Digitalization alters these structures by replacing face-to-face exchanges with mediated

interactions, reducing informal contact, and sometimes reinforcing social distance between employees and management. Third, from a lifespan developmental perspective, older workers prioritize emotionally meaningful and stable social relationships rather than broad networks of weak ties. As digital work tools and hybrid arrangements reduce opportunities for rich, affective exchanges, older employees may experience heightened vulnerability to loneliness and social withdrawal. Together, these frameworks highlight that workplace loneliness in the digital era is not solely an individual emotional state but a socially and technologically mediated experience emerging from the interplay between cognitive expectations, organizational structures, and age-related motivational shifts. Accordingly, because loneliness in the digital era is not merely an individual emotional state but a socially and technologically mediated experience, **social support—both online and offline—** assumes a central buffering role: by providing emotional, informational, and instrumental assistance within teams and via digital media, it mitigates strain and fosters engagement and retention among older workers.

**Other outcomes that could be included in future research:** Digital inclusion/exclusion, Work–life interface (digital context).

Related terms that contextualize the above include digital literacy and upskilling, ergonomics, organizational age culture, lifelong learning, intergenerational collaboration, and policy and standards for safe inclusive digital work.

**Job satisfaction.** How an older person's sense of purpose, control, and worth in their work are impacted by the flexibility, learning, and communication opportunities offered by digital technologies.

**Psychological resilience.** It is the ability to adjust, manage stress, and stay motivated in the face of swift changes in technology and expectations from the digital world.

### Analytical dimensions

**Digital exposure & task demands:** Type/intensity of screen work; device/robotics use; algorithmic controls; hybrid/remote arrangements.

**Worker resources:** Digital literacy, prior experience, health status, adaptability, and access to training/assistive tech.

**Social environment:** Team cohesion, communication tools/practices, managerial support, inclusion of older staff, and intergenerational knowledge sharing.

**Organizational context:** Age culture/stereotypes, workload norms (availability/after-hours), ergonomics and Occupational Health and Safety (OH&S) policies, Human Resources (HR) training and knowledge investment, age-conscious leadership.

**Sectoral & national context:** Automation intensity, regulatory landscape, and cross-country differences in digital transformation, differences in pension systems and retirement age.

**Control and Autonomy in Digital Work Environments:** Decision-making power, time management, task control, and independence in digitalized work situations.

**Digital Determinants of Health (DDoH) for workers:** Access to devices/connectivity, digital literacy and confidence, usability/fit of systems, and inclusive design. These shape who benefits from digitalisation and who is burdened by it, and should be considered alongside traditional social determinants when studying older workers.

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## Theoretical foundations

**Digital divide & capability perspectives:** Inequalities in access/skills shape who benefits or is burdened by digitalisation.

**Job Demands–Resources (JD-R):** Digital features add demands (e.g., screen time, pace) and resources (e.g., autonomy, assistive tools); balance predicts strain vs. engagement and downstream health.

**Person–Environment fit & lifespan development:** Fit between abilities, tools, and work design evolves with age; selective optimisation and compensation matter for late-career performance/health.

**Stress & coping / social support models:** Social support (including online) buffers stressors and enhances well-being beyond stress buffering (constructionist/relational views).

**Organisational age culture & inclusion:** Stereotypes and training access mediate technology adoption and outcomes for older staff.

**Active Ageing approaches:** By providing supportive environments and opportunities for lifelong learning and inclusion, these approaches highlight—and enable—the ongoing engagement, health maintenance, and well-being of older persons in the workplace and in society.

**Productive Aging and Digitalization:** Productive aging highlights the value of continued participation, learning, and contribution in later life for individual health and well-being. Within this perspective, digitalization plays a dual role: it can enhance opportunities for engagement, skill use, and social connection, thereby promoting mental and physical well-being, but it may also introduce new challenges if access or adaptability are limited. Ensuring inclusive and supportive digital environments is therefore essential to translate digital engagement into a driver of healthy and productive ageing.

**Digital Determinants of Health (DDoH):** Positions digital access, skills, design, and governance as structural factors affecting both patients and workers; integrates with equity-focused analyses of ageing workforces.

## Proposed framework (model & mechanisms)

**Core proposition:** Digitalisation influences older workers' physical and socio-emotional health and quality of working life through **three interconnected pathways** that interact dynamically and are shaped by individual, organisational, and policy-level conditions:

- A) *biomechanical & sensory load* (screen/ posture/ sound/ repetition),
- B) behavioural *routines* (sedentariness vs. digitally supported activity), and
- C) *psychosocial climate* (technostress, loneliness vs. social support, self-efficacy, meaning/purpose).

Organisational and policy levers influence all pathways (ergonomics and health policies; training and upskilling; social and managerial practices; regulatory frameworks and standards).

## Implications & applications

**Policy & regulation:** Encourage age-inclusive digital upskilling and lifelong learning; set ergonomic standards for prolonged screen work; and ensure right-to-disconnect policies; promote assistive technologies and accessible, age-friendly design. Align organisational practice with current European digital policy instruments (e.g., European Health Data Space and AI governance), with explicit attention to workforce inclusion and usability.

**Build social support infrastructures:** Mentoring across ages, peer-help channels, and manager training to recognise digital strain/loneliness. Design collaboration/tools to support informal connection alongside task work.

**Public awareness.** Shift narratives from “older = tech-averse” to “older = adaptable with the right design/support,” emphasizing dual impacts and evidence-based mitigations.

### **Organizational strategy.**

Effective strategies should address the physical, behavioural, and psychosocial pathways identified in the framework while embedding inclusion and lifelong learning into daily practice, e.g.:

#### **1<sup>o</sup> Design of hybrid and digital work environments.**

Establish guardrails for healthy digital work (break nudges, meeting load caps); Conduct regular ergonomic and environmental audits to ensure that workplaces (on-site and remote) meet occupational health and safety standards. Examples:

##### **DIGI-COACH concept. BALANCED STEPS for older workers.**

- focused on physical health, motivation, and social support for engaging in physical health.
- a web-based platform with integrated assessments, adapted exercises, and social support features.
- identifies the level of motivation for physical health based on a summary of medical history and need assessments.

#### **2<sup>o</sup> Training, coaching, and skill development.**

Provide modular and adaptive training programmes. Encourage digital coaching that integrates technical, cognitive, and well-being components.

#### **3<sup>o</sup> Continuous assessment and personalised feedback.**

Deploy digital tools and platforms specifically designed for older workers that assess physical health (e.g., musculoskeletal symptoms, cardio-metabolic risk), socio-emotional wellbeing (e.g., loneliness, digital strain), and work-ability. Such systems should generate individualised reports, allow monitoring over time, and use data to tailor coaching, ergonomic interventions or peer support. For instance, Brandão et al. (2022a) describe the e.cuidHaMUs™ e-health monitoring programme deployed in a Portuguese higher-education institution, and Brandão et al. (2022b) report its use for cardiovascular-risk profiling. These examples illustrate how continuous feedback loops support sustainable healthy working for older employees.

#### **4<sup>o</sup> Social connection and inclusion.**

Promote mentoring and peer-learning structures. Fostering social connection and inclusion is essential for transforming digital work environments into supportive spaces for well-being

and engagement. Organizations should promote mentoring and peer-learning structures that encourage mutual learning, and reciprocal support in digital contexts. Designing digital collaboration tools and workflows that facilitate teamwork and informal communication helps prevent isolation and sustain a sense of belonging. Moreover, initiatives such as virtual communities of practice, well-being check-ins, and recognition platforms can strengthen social cohesion and contribute to psychological safety.