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Ergonomics/human factors and the future of work: A global systems perspective

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ABSTRACT

In a webinar series hosted by the International Ergonomics Association, the Future of Work Committee of the International Ergonomics Association gathered inputs about the future of work from ergonomics/human factors (E/HF) experts representing different regions around the world. Through these insights, four global megatrends relevant to E/HF driving the future of work were identified: labour-market supply; work informality; technology; and climate change. Next, we applied an E/HF systems approach, using causal loop diagrams, to explore the unfolding interrelationships between these megatrends at a global level and with a national level example to determine what novel insights can be uncovered using systems analysis. We demonstrate the power of E/HF systems thinking that can enable national E/HF societies and regional think-tanks to move beyond a siloed approach to megatrends. We conclude with some high-level suggestions for E/HF to consider in order to meet the future of work challenges.

1. Introduction

Since ergonomics/human factors (E/HF) is a discipline where the study of work has been an historically important component, it is imperative that we keep abreast of the future challenges arising from the evolving nature of work. However, apart from the challenges arising from technological innovations, Bentley et al. (2021) argued that E/HF has made limited contributions to understanding the impact of these global trends on its research and practice. This is not to say that E/HF has not been interested in speculating about the future of work and how we, as a discipline, need to address the challenges. There have been numerous publications (e.g., Drury, 2008; Dul et al., 2012; Hancock, 1997; Moray, 1995; Thatcher et al., 2018; Žunjić, 2019) as well as a recent State of Science paper (Bentley et al., 2021) on this topic. It is not the purpose to critically evaluate the history of predictions made by E/HF concerning the future of work, other than to acknowledge that prediction is hard. Interested readers are directed to Bentley et al.'s (2021) review, critical reflections, and research suggestions for E/HF and the future of work. Following Bentley et al.'s (2021) recommendation, we build on this past research by using the views of regional E/HF subject-matter experts to explore the complex interplay between the emergent megatrends impacting the future of work and what this means for E/HF to prepare regionally or nationally for this future.

1.1. Background to this study

One of the primary policies of the International Ergonomics and Human Factors Association (IEA) is to maintain a future focus for E/HF. The IEA established their Future of Work Task Force in 2018 partly in response to the International Labour Organization's (ILO) Future of Work Centenary Initiative. The ILO's (2017) inception report for the Future of Work Centenary Initiative observed four interrelated global megatrends (see Table 1). It is interesting to note that this report's megatrends were almost identical to Drury's (2008) four trends from nearly a decade earlier. In addition to the ILO's (2017) inception report there have also been several regional ILO reports (ILO, 2019a; Salazar-Xirinachs, 2017), industry-specific reports (Berg et al., 2018; Golman and Ernst, 2022), and national and regional reports on the future of work (European Commission, 2021). The "Future of work: jobs and skills in 2030" (Rhisiart et al., 2017) from the United Kingdom is an example of the reflections from a country-specific report (Table 1). In E/HF the two most recent reviews of the trends in the future of work (Bentley et al., 2021; Dul et al., 2012), produced similar sets of future of work trends to the ILO's (2017) global megatrends (Table 1), although Dul et al. (2012) emphasised competitiveness and innovation as a separate trend, while Bentley et al. (2021) emphasised new forms of work and organisational systems as two separate trends.

Table 1
Examples of previous work identifying trends and megatrends of the future of work.

ILO (2017) Future of Work Centenary Initiative	UK Commission for Employment and Skills (UKCES): Future of Work: Jobs and Skills in 2030 [a]	E/HF: Dul et al. (2012)	E/HF: Bentley et al. (2021)
Globalisation (disruptions in where work is carried out through global supply chains) **Technology** (especially artificial intelligence and robotics)	**Business and the economy** (de-globalisation; shift to Asia; Internet/online disruptors) **Technology and innovation** (artificial intelligence and robots; digitalisation of production; ICT; big data)	**Globalisation** (shifts in where work and under what working conditions that work is carried out in global supply chains) **Information and communication technology** (changes where, when, and how work is carried out; remote work; new types of organisations)	**Globalisation and trade liberalisation** (migration, low-wage economy, and internationalisation of labour force) **Technological enhancements** (especially automation and robotics)
Demographics (particularly ageing and migration)	**Society and the individual** (growing diversity; ageing; fragmented and zero-hour contracts)	**Cultural diversity** (diverse workforces and diverse customer base)	**New organisational forms** (informal/gig economy, distributed, networked, and virtual organisations)
Climate change (leading to extreme climate disasters, changes in food production systems, and transitions to green jobs).	**Resources and the environment** (growing scarcity of resources and disruptions to ecosystems; resource conflicts; climate disasters threaten supply) **Law and politics** (growing populism; decreasing fiscal scope for legal and political action)	**Ageing** (work systems and products that fit ageing populations) **Sustainability and corporate social responsibility** (focusing on more than just corporate profits, but also people and planet) **Competitiveness and innovation** (constant drive for innovation resulting in work intensification)	**New ways of working** (distributed and virtual teams, activity-based working, telehealth, and flexible work arrangements) **Demographic shifts** (including shifts in ageing, gender equality, and diversity shifts) **Environmental pressures** (resource scarcities, renewable systems, and recycling systems)

[a] Rhisiart et al. (2017).

The ILO's (2017) inception report was followed by the ILO's (2019b) centenary declaration on the future of work, committing signatory countries to a "just transition" to decent and sustainable work, including equitable skills and competency acquisition, supporting older workers, ensuring gender equality in the workplace, eradicating forced and child labour, and enhancing workplace health and safety (amongst other commitments). These goals align with the United Nations' Sustainable Development Goals (SDGs), most notably SDG 5 (gender empowerment) and SDG 8 (decent work), although as Bolis et al. (2023) have noted, apart from workplace health and safety (as well as sporadic efforts to support older workers and to enable equality in the workplace), E/HF's contributions to these goals are marginal.

Bentley et al. (2021) noted that the future of work trends were interconnected and required a more systemic analysis; for example, that technological advancements drove new organisational forms. Similarly, globalisation increases workplace diversity and reinforces some of the migration patterns. In addition, the ILO (2017) acknowledged that the megatrends will have variable geographical impacts. For example, the impacts of ageing will be much greater in wealthier countries (Kühn et al., 2018), while artificial intelligence will create job opportunities in some areas (e.g., skilled machine learning specialists) and job losses in other areas (e.g., those performing repetitive work). What is important to note is that the trends are interlinked within national, regional, and global systems and E/HF is defined as a systems discipline (Dul et al., 2012). Here we embrace Bentley et al.'s (2021) challenge, applying E/HF systemic thinking to the future of work to understand how the megatrends interact with one another at a global and national scale in a way that can help E/HF groups to prepare. This requires a broader, transdisciplinary systems perspective touching on cultural, political, and geographical dynamics (Moray, 2000; Scott, 2008).

2. Methods

From 2021 to 2024 the IEA's Future of Work Task Force gathered detailed inputs from federated societies around the world through a webinar series (the webinars can be viewed on the IEA's YouTube channel: https://www.youtube.com/@iea-internationalergonomic9925/videos). This consisted of 15 webinars with speakers from 19 countries representing all six permanently inhabited continents. The webinars were structured with two speakers. For each webinar one speaker was a leading or established E/HF professional/researcher and the second speaker was a young or emerging E/HF professional/researcher. The principle behind this choice was to identify someone who had considerable experience in E/HF and a second person who would be working for longer who could identify emerging trends of longer-term concern. In most instances the speakers were identified by the IEA federated societies in their country or region. The details of the speakers and their expertise is given in Appendix 1. Each webinar included time for questions and discussion points from the audience. The presenters were asked to identify the key drivers for the future of work and where appropriate, the key technologies that would address these drivers in their specific country. To direct their thinking the presenters were asked to follow the guidelines for prospective ergonomics (Colin et al., 2022). These guidelines included using higher-order autobiographical thinking, making detailed representations of the future, and decreasing the temporal distance by focusing on the near future (Colin et al., 2022). The webinars were augmented by three panel discussions (one in Chile and two in South Africa) and a workshop at the IEA 2024 Congress where a draft of the themes and their systemic relationships from the webinars were discussed and refined.

The webinar contents were analysed using inductive, reflexive Thematic Analysis (Clarke and Braun, 2017) to derive the themes across countries. The main themes are described as the megatrends in the results and subsidiary themes were characterised as system components for later analysis. The evolving themes were distributed regularly for vetting and refinement, with the research team debating the core issues arising from the Thematic Analysis. The relationships between the identified themes were then analysed and the megatrends and system components were graphically represented using Causal Loop Diagrams (CLDs) which characterised the functional feedback loops within the system (Sterman, 2000).

CLDs are useful for representing and understanding the feedback loops that may be responsible for a particular problem (Sterman, 2000). Arrows represent the causal relationships between relevant elements in the system. The relationships between relevant system elements can be represented either as reinforcing (positive) or balancing (negative) loops. CLDs have been used numerous times in E/HF to provide a concise way to represent relationships in complex systems (Naweed et al., 2022; Salmon et al., 2020, 2022). CLDs are typically a group model-building process using data gathered and considered relevant by subject-matter experts. The CLDs were built through iterative interactions between the subject-matter experts in online discussions and workshops. During several stages of the vetting and refinement of the CLDs the research team were asked to consider whether the included CLD components were necessary, whether the directions of the relationships were appropriate, and whether any components or relationships were missing.

3. Key driving forces for the future of work

Four megatrends were discerned from the thematic analysis. The key drivers for the future of work by country are shown in Table 2 and, where relevant, the key technologies envisaged to address those drivers. Table 2 shows that some drivers are common across many regions (e.g., migratory patterns, remote/distance work or automation), while other drivers appear to be common across a smaller cluster of countries with similar attributes (e.g., ageing workforce, unreliable energy supplies, increasing informal economy, or critical skills shortages in healthcare). Therefore, to place the megatrends in their national context, a sample of the national socio-demographic (Table 3) and socio-economic (Table 4) indicators is given. Given the emphasis that E/HF places on an appreciation of context (Wilson, 2014) it was deemed necessary not to overgeneralise the results. While there are some similarities between countries in Tables 3 and 4, it should be noted that the profiles of economic, historical, geographical, political, and developmental factors contribute to unique pathways for each country.

The thematic analysis showed that the reasons for the megatrends were not uniform across countries, producing interesting differences which would suggest that alternative approaches might be required to prepare societies for the changing nature of work. The main differences are highlighted for each megatrend.

3.1. Labour-market supply

Issues related to the labour-market supply have several underpinning factors leading to issues with skills availability. These factors include differentials in gender access, ageing, and skills mobility (i.e., emigration/immigration). The first factor was how to ensure gender equity in access to employment opportunities. In many countries there is a fair to good representation of women in the workplace, but in other countries women face barriers related to culture and religion. Some cultures fear that with more women entering the workforce pregnancies may be fewer or delayed, exacerbating labour market shortages in the future. However, research shows that with appropriate organisational (and community) support for families (e.g., childcare, paid maternity leave, and flexible work schedules), there is a positive relationship between women in the workforce and fertility (Oshio, 2019). The second factor is an ageing workforce. This produces workforce supply issues, evolving workplace accommodation requirements, and/or increasing pressures on healthcare systems that must be addressed. With a highly skilled workforce and a robust technology focus, shortfalls might be addressed through advanced technological solutions (e.g., automation, robotics,

Table 2
Key drivers for the future of work by country and key technologies to address the drivers.

Country	Key drivers for the future of work	Key technologies to address drivers
Aotearoa New Zealand	Access to healthcare	Telehealth technology
	Ageing workforce: workplace accommodation and support needed	Gerontechnology
	Ethnicity inequities	
	Migration and population growth concerns	Remote working tools
	Remote/distance work challenges: work socialisation, work management, and informalisation	Equitable technologies
Australia	Access to healthcare	Telehealth technology
	Ageing workforce: workplace accommodation/support needed	Gerontechnology
	Automation of routinised, repetitive, manual work	
	Environmental/sustainability challenges from climate change and resource-scarcity	Green technology
	Immigration and diversity to fill skills gaps	Automation
	Remote/distance work challenges: work socialisation, work management, and informalisation	Remote working tools
Brazil	Emigration (external) of skilled people for higher paying jobs	
	Informal work with little formal protections	
	Migration (internal) resulting in pockets of skills deficits	
	Unequal economic and working conditions across the country	
	Younger workforce	
China	Ageing population: challenges to healthcare delivery	
	Informalisation of work through e-commerce and gig work	Remote working tools
	Workload and work pace too high to meet demand (planning and transportation)	Artificial Intelligence; Automation; Big data analytics
Colombia	Informal work with little formal protections	
	Small proportion of high skills/ technology	Robotics; Exoskeletons; VR
	Skills shortages in critical social systems (e.g., healthcare and education)	
	Unequal economic and working conditions across the country	
Finland	Ageing workforce: workplace accommodation/support needed	Telehealth technology; Gerontechnology
	Efficient use of new technologies for industry	Robotics; Smart manufacturing systems
	Informalisation of work through e-commerce and gig work	Remote working tools
	Skills shortages in critical social systems (e.g., healthcare))	
France	Ageing workforce: workplace accommodation/support needed	Artificial Intelligence; Automation; Robotics; Gerontechnology
	Informalisation of work through gig work	
	Remote/distance work challenges: work socialisation, work management, and informalisation	Remote working tools
	Skills gaps in critical sectors due to negative population growth	
Germany	Advanced technology displacing some work opportunities	Artificial Intelligence; Automation
	Remote/distance work challenges work socialisation, work management, and informalisation	Remote working tools
	Skilled labour shortages	
	Sustainability as a core component of work	
Ghana	Digitalisation of services: e-government initiatives, mobile money payments, national identification systems	E-learning and educational technology for capacity building
	Emigration of skilled workers trained in the nation to seek “greener pastures” abroad	
	Growing, young population but technical skill levels remain low	
	High unemployment rate and low wages for the few available jobs	Automation of physically demanding tasks
	Informal work with little formal protections	
	Low advanced technology adoption in industrial sectors due to unreliable energy supplies	
India	Informal work with little formal protections	
	Manual work with high rates of MSDs and MMH injuries	
	Need for low-cost interventions	
Japan	Ageing workforce: workplace accommodation/support needed	Exoskeletons; Robotics; Telemedicine; Gerontechnology
	Support drive towards optimal service delivery	Artificial Intelligence; AR; VR; XR
	Remote/distance work challenges: work socialisation, work management, and informalisation	Remote working tools
Philippines	Disaster preparation and management skills needed for climate change impacts	
	Emigration of skilled people for higher paying jobs, especially healthcare	
Poland	Ageing workforce: workplace accommodation and support needed	Gerontechnology
	Investment in advanced technologies industry	Artificial Intelligence; Cybersecurity; Robotics
	Skilled employment prospects good	
Romania	Increasing demand and prevalence of remote and hybrid work	Remote working tools
	Slow digitalisation despite the high growth rate of ICT market	Artificial Intelligence; Automation; Robotics
	Skilled employment prospects good, especially for people speaking local languages	
Singapore	Automation of routinised, repetitive, manual work	Artificial Intelligence; Automation
	Skilled immigration rate is high	
South Africa	Growing population, low skills	
	High unemployment, especially among youth	
	Low advanced technology adoption due to unreliable energy supplies	Solar-power technologies

(continued on next page)

Table 2 (*continued*)

Country	Key drivers for the future of work	Key technologies to address drivers
	Unequal economic and working conditions across the country	
South Korea	Ageing population/low birth rate leading to employment shortages (immigration considered controversial)	
	Ageing workforce: workplace accommodation and support	Artificial Intelligence; Automation; Exoskeletons; Robotics
United Kingdom	Perceived skill gap challenges from Brexit and exodus of skilled immigrant workers	
	Skills gaps in critical sectors (e.g., healthcare, transport, construction, education) to be filled	Artificial Intelligence; Automation, Robotics
United States of America	Diverse workforce sharpens challenges in reskilling and upskilling, and technological implementation (e.g.: algorithmic decision-making)	AR/VR; Big data analytics; Remote working tools
	Innovation economy increases demand for reskilling and upskilling, job displacement rates, and rates of hazard introduction	Artificial Intelligence; Automation; AR/VR; Cybersecurity; Nanotechnology; Robotics
	Nontraditional work arrangements (e.g.: gig work) challenge traditional data collection and protection approaches	Artificial Intelligence; Automation; Big data analytics, AR/VR; Cybersecurity; Robotics

exoskeletons, and artificial intelligence). In other countries, the factor is not an ageing workforce, but a younger workforce with fewer available formal employment opportunities. The third factor is workforce migration (i.e., emigration and immigration). Existing global policies on the exchange of labour currently promote inequality (Hickel et al., 2024). In countries with strong language and cultural barriers, immigration is low but workforce deficits from ageing and gender imbalances persist. In these instances, workforce deficits may be addressed through technological considerations. Other countries seek to attract a highly skilled workforce through favourable immigration policies. It should be noted that such policy decisions are often fickle and may change with political fluctuations. Several countries experience labour-market shortages despite having positive population growth rates and good education systems. This is primarily due to a combination of high rates of emigration for higher paying jobs (or higher perceived personal safety and security) in other countries and high rates of immigration with lower skill levels.

3.2. *Informality*

The trend towards the informalisation of work is of two types: the lack of formal sector employment opportunities and increasing work flexibility. In the first type of informalisation countries experience a mismatch between the skills available and the formal sector employment opportunities. This is often exacerbated by a labour market that is too small to absorb the available skills. In these instances, people turn to informal work to obtain a livelihood for themselves and their families. In the second type of informalisation, countries experience a drive towards workers and employers seeking greater work flexibility (with or without technology) and in some case, to supplement primary income streams. In these instances, we see workers and employers seeking greater flexibility or additional income, leading to new forms of work such as gig work, zero-hour contracts, platform work, and other forms of work casualisation. In both types of informalisation, labour legislation and other labour directives and guidelines intended to protect workers' rights and wellbeing lags the actual uptake of these work forms.

3.3. *Technology*

The issues related to the technology megatrend are numerous and related to the national innovation climate. High-technology countries invest significantly in digital innovation, artificial intelligence, supercomputing, biotechnology, and nanotechnology (World Economic Forum, 2023). In high-technology countries new technology development is likely to lead to a net increase in employment (although the national internal distribution of job availability may shift and some low-skilled jobs will be lost) through the creation of skilled jobs in developing, constructing, selling, implementing, managing, and maintaining high-technology. In low-technology countries there is likely to be a net decrease in employment as jobs are lost to automation, robotics, artificial intelligence, and other new or still to emerge technologies. There will still be new formal jobs created in low-technology societies,

Table 3
Socio-demographic indicators by country.

Country	Percentage[a] population growth	Births to[a] deaths ratio	Migration[a] rate/1000	Percentage[b] population >65 years	Percentage[b] women employed +15 years
Aotearoa New Zealand	0.9	1.83	**3.8**	16.7	**68**
Australia	**1.1**	1.79	**5.9**	17.2	**62**
Brazil	0.6	1.89	*−0.2*	10.2	53
China	0.2	1.32	*−0.1*	14.3	**61**
Colombia	0.5	1.86	*−2.1*	*9.4*	51
Finland	0.2	*0.98*	**2.2**	**23.6**	58
France	0.2	1.09	**1.1**	**22.0**	53
Germany	*−0.1*	*0.74*	**1.8**	**22.7**	56
Ghana	**2.2**	**4.68**	*−0.2*	*3.6*	**65**
India	0.7	1.78	0.1	*7.1*	*33*
Japan	*−0.4*	*0.58*	0.7	**30.1**	55
Philippines	**1.56**	**3.56**	*−0.2*	*5.8*	*47*
Poland	*−1.0*	*0.69*	*−6.2*	18.5	52
Romania	*−0.9*	*0.58*	*−3.3*	18.4	*42*
Singapore	0.9	**2.05**	**4.2**	16.1	**62**
South Africa	**1.1**	**2.57**	*−0.2*	*5.9*	52
South Korea	0.2	*0.95*	**2.6**	18.4	56
United Kingdom	0.5	1.17	**2.9**	19.5	58
United States	0.7	1.44	**3.0**	17.6	57

[a] Obtained from the CIA World Factbook: https://www.cia.gov/the-world-factbook/countries/.
[b] This information was obtained from the World Bank's databank: https://data.worldbank.org/indicator/.

Table 4
Socio-economic indicators by country.

Country	GNI/capita[a] US$	Gini[b] coefficient	Unemployment[c] rate	Proportion[d] informal work	Energy[b] consumption/capita million Btu	Proportion[e] of Energy consumption – low carbon
Aotearoa New Zealand	48 610	36.2	3.7	–	**236**	42
Australia	**63 140**	34.3	3.7	26	**237**	15
Brazil	*9070*	*52.9*	8.0	37	50	**51**
China	13 400	37.1	4.7	*54*	122	18
Colombia	*6870*	*51.5*	9.6	*56*	*26*	29
Finland	**53 390**	**27.1**	7.2	**2**	181	**62**
France	45 070	30.7	7.3	**4**	122	**52**
Germany	**53 970**	31.7	3.0	**3**	132	25
Ghana	*2340*	43.5	3.1	*78*	*11*	34
India	*2540*	34.2	4.2	*89*	*25*	11
Japan	39 030	32.9	**2.8**	19	136	17
Philippines	*4230*	40.7	**2.2**	–	*16*	12
Poland	19 730	**28.8**	2.9	10	106	12
Romania	16 670	34.6	5.6	39	61	30
Singapore	**70 590**	45.9	3.5	–	**654**	*5*
South Africa	*6750*	*63.0*	*28.0*	34	96	*6*
South Korea	35 490	31.4	**2.6**	27	120	18
United Kingdom	47 800	32.6	4.1	14	99	26
United States	**80 300**	39.8	3.6	19	**285**	19

[a] Obtained from the World Bank: https://data.worldbank.org/indicator/NY.GNP.PCAP.CD.
[b] Obtained from the CIA World Factbook: https://www.cia.gov/the-world-factbook/countries/.
[c] Obtained from the World Bank's databank: https://data.worldbank.org/indicator/.
[d] Obtained from the ILO's 2023 ILOSTAT website (https://ilostat.ilo.org/topics/informality/#) or the ILO's 2018 report on Women and men in the informal economy: A statistical picture (https://www.ilo.org/publications/women-and-men-informal-economy-statistical-picture-third-edition).
[e] Obtained from the 2024 Statistical Review of World Energy: https://ourworldindata.org/energy-mix.

but these will mostly be lower-skilled jobs in the distribution, maintenance, and disassembly of technology. Increased technology adoption also results in greater energy consumption (Cohen, 2024). Technology adoption is therefore hampered in countries which have an insufficient or unreliably energy supply. Countries that depend on fossil fuels for their energy production, will also increasingly contribute to climate change as technology adoption increases, especially if they move to technologies such as artificial intelligence, automation, big data analytics, and robotics which are energy-demanding (Cohen, 2024).

3.4. Climate change

Climate change will be a significant driver of the future of work in most countries. In countries that will be heavily impacted by the consequences of climate change, the future of work will have to encompass disaster preparedness from climate change impacts (e.g., high intensity tropical cyclones and sea-level rises). There will be coastal regions in many other parts of the world that will also need to focus on protective measures or a loss of land. Notably, extreme weather events may impact countries at a distance by disrupting transport routes and supply chains. For many countries there are also various challenges that will need to be addressed for working in more extreme environmental conditions including heat, cold, floods, ice, UV exposure, and changes in the distribution of diseases, disease vectors, and allergens. The future of work in countries that contribute heavily to climate change will also be impacted, as they transition away from fossil fuels (i.e., job losses in fossil fuel extraction, refinement, distribution, and energy production) by inspiring jobs in the green (i.e., renewable energy, waste management, recycling, and sustainable tourism) and blue (i.e., offshore wind energy, seaweed and algae farming, and sustainable fisheries) economies. The countries that will benefit the most in the short-term, will be those countries who already have a high-technology society (e.g., Norway, Spain, or China), although there are examples of low-technology countries rapidly transitioning to low-carbon societies (e.g., Brazil or South Africa).

4. Systems perspective on the future of work

As Bentley et al. (2021) and Salmon and Read (2018) suggested, the four megatrends are interconnected in ways that broaden our understanding of the evolving dynamics of the future of work. Uncovering these relationships required a broader systemic analysis which was aided by constructing a CLD. Fig. 1 shows the CLD interactive dynamics of the four megatrends at a macro-level (from the thematic analysis), representing the key system components and their interactions. The CLD is not intended to capture all the possible global causal interactions (that would be impossibly complex to unravel and represent), but rather the primary interactions emerging from the thematic analysis.

Given the E/HF perspective the CLD obviously highlights the centrality of humans (i.e., skills availability and any re-skilling requirements) and technology introduction within the broader future environment (i.e., especially climate change, labour migration, and the two types of informality). Following the causal loops in Fig. 1 it is evident that technology introduction is always a stop-gap measure and not a final solution. Technology introduction is always dependent on skills availability, skills development, and re-skilling initiatives (e.g., for the development, construction, implementation, integration, use, and maintenance of technology). In addition, multiple "external" forces will influence skills availability such as migration patterns, the strength of education/training and healthcare systems, as well as numerous cultural, political, and economic factors that are not all captured in Fig. 1.

Fig. 1 helps identify several loops that require E/HF attention. The reinforcing loop between the introduction of technology and climate change impacts (R1) is one such example. More advanced technology requires more energy (Cohen, 2024), which drives further carbon emissions (when fossil fuels are the energy source), which is often addressed by implementing more energy-intensive technology. The more sustainable path is a balancing loop towards renewable energy production which reduces climate change impacts (B1), but that trajectory is by no means certain. Another reinforcing pattern is evident between technology introduction and re-skilling requirements (R2). The more sophisticated the technology, the higher the re-skilling level required to design, build, sell, implement, and maintain that technology. This benefits countries that already have good skills availability or good

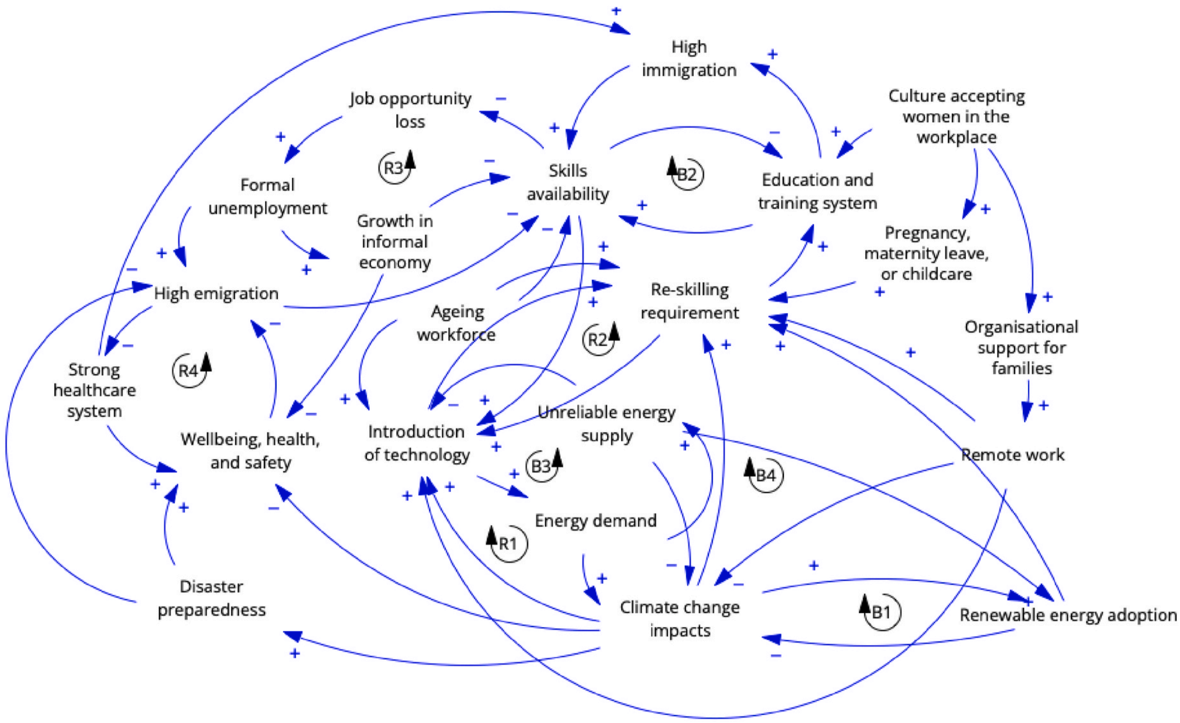

Fig. 1. CLD of the future of work macro-system primary interactions.

quality and responsive education and training infrastructure. However, where there are insufficient skills, countries with high-technology try to fill the gap through increasingly high-technology solutions. Without further importation of skilled labour, technology introduction to replace labour is a risky strategy. This feeds into another balancing loop between education and training systems and skills availability (B2). In another reinforcing loop, in low skill contexts (stemming from non-viable or low-quality education and training infrastructure) there is an increased likelihood that people will be forced into unemployment, the informal sector, or emigration (R3). Finally, climate change impacts will result in decreased health, wellbeing, and safety for all workers, but will have a disproportionate effect on workers in the informal economy who are more likely to engage in manual labour outdoors, or without protective technology and infrastructure, and in contexts with poor healthcare systems (R4).

Remote work operates in multiple loops including requiring

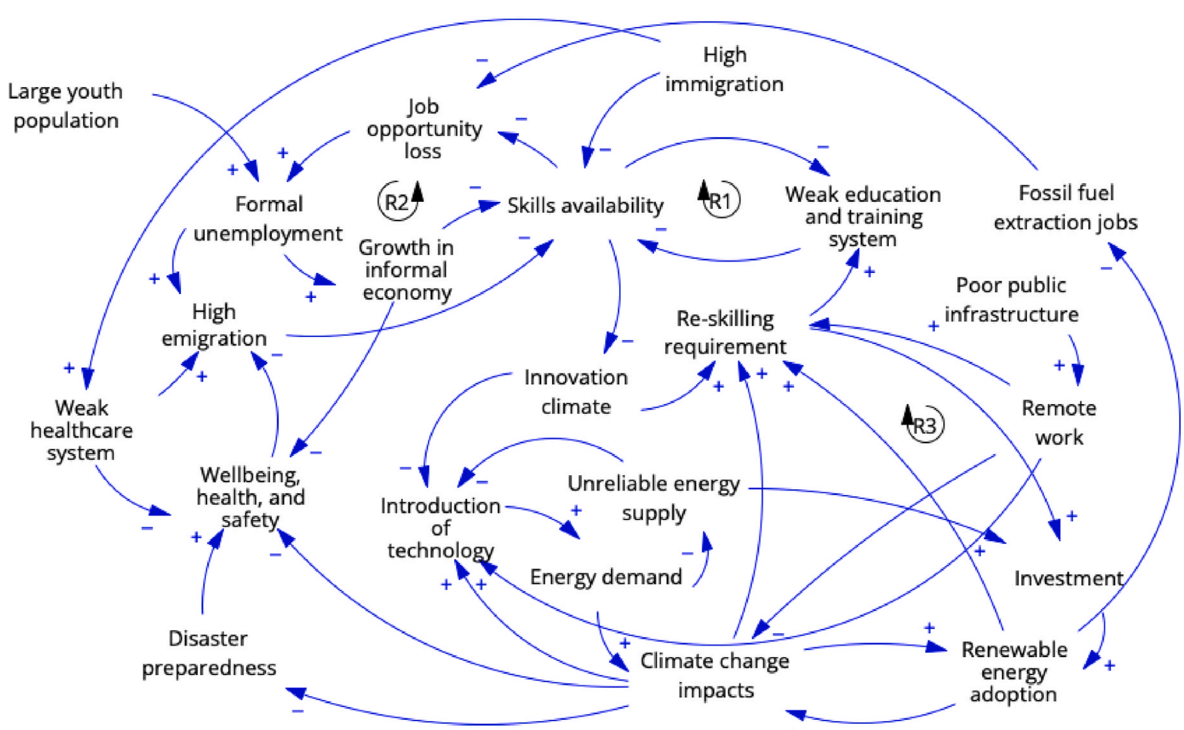

Fig. 2. CLD of the future of work for South Africa.

increasingly sophisticated technology which contributes to climate change, and re-skilling. However, remote work also contributes to reducing climate change impacts (through reduced travel requirements) and to the possibility of improved gender equalisation in the workforce. In another example related to the loops between technology and climate change impacts, there is a balancing loop where a less reliable energy supply drives lower technology adoption, and therefore lower energy demands (B3). An unreliable energy supply might also be mitigated through greater renewable energy adoption which would also reduce the negative climate change impacts and form another balancing loop with technology adoption (B4).

4.1. National-level systems

Fig. 1 provides a high-level overview of the interactions at the global level, but we also wanted to investigate whether the CLD analysis for a specific country adds additional context and value. An example of the national-level system dynamics for South Africa is shown in Fig. 2. The CLD analysis at this level loses some (but not all) of the global interactions, but new observations become evident with the introduction of country-specific factors. In South Africa the future of work is characterised by more younger people looking to enter the workforce rather than an ageing population, and remote work is driven by failing public infrastructure rather than by gender equalisation. It is evident that some relationships between system components might also be reversed. For example, in South Africa the high rate of immigration is mainly from low-skilled workers who place a significant burden on an already constrained education and training infrastructure, creating a reinforcing loop that exacerbates the existing skill deficit (due to a weak education/training system) rather than ameliorating the skills deficits (R1). This adds impetus to the other reinforcing loop that leads to job opportunity loss, unemployment, and growth in the informal economy (R2). In addition, high immigration weakens an already weak healthcare system which contributes to poorer health, wellbeing, and safety. Nevertheless, the CLD shows one area of potential growth where E/HF can play a role. The unreliable energy supply is currently driving significant investment in renewable energy systems (R3). However, this development needs to be supported with re-skilling to support the investment for the installation and maintenance of renewable energy.

There are some caveats at the national level. There may still be considerable variations within a country. In fact, some countries are characterised by large variability (e.g., Brazil, Colombia, and South Africa) as evidenced by their high Gini coefficient (see Table 4). It is possible that further observations might become apparent if the CLD analysis is carried out at an even finer-grained intra-national level. Further, there isn't necessarily a single discernible trajectory towards the future. There are likely to be many possible trajectories. For example, current and emerging political decisions and policies, make some trajectories more likely.

5. Discussion: E/HF and the future of work

5.1. Systems-thinking and E/HF contributions

Several recent reviews have already made suggestions about E/HF's role in addressing the future of work (Bentley et al., 2021), or specific aspects such as ageing (Bentley et al., 2023), artificial intelligence (Grote, 2023), automated driving (Navarro, 2019), global challenges (Thatcher et al., 2018), human-artificial intelligence teaming (Endsley, 2023), and sustainability (Bolis et al., 2023). It is not the purpose to repeat or critically evaluate these previous suggestions. A summary of these suggestions, augmented by our analysis, is provided in Table 5. Instead, we suggest that a CLD systems analysis helps an E/HF team decide which of these aspects to focus on for their region or country. It must be acknowledged that some aspects revealed by the CLDs are beyond the scope of E/HF to reasonably address in the short term (e.g., migratory patterns, high rates of unemployment, or the state of healthcare or education infrastructure), but one can still use a systems understanding to uncover the emergent issues that arise from these aspects, in order to identify leverage points where E/HF might be most effective.

This work shows that E/HF, as a systems discipline, can play an influential role in helping transdisciplinary teams create the systems understanding to establish which future of work problems require attention and which policies to develop. CLDs were a simple and parsimonious method of characterising the complexity amongst the diverse contributors, but there are other systems methods that can be explored such as the Systems-Theoretic Accident Model and Processes (STAMP) (Leveson, 2004) or Cognitive Work Analysis (CWA) (Naikar, 2017). The global systems perspective is also valuable for the global E/HF community involved in this work to understand how to support good E/HF across global commodity chains. Currently wealthier nations rely on a net appropriation of labour and resources from the rest of the world to support their lifestyles (Hickel et al., 2024), but this approach is increasingly unsustainable, and E/HF interventions are therefore required across the supply chain (Fischer et al., 2021).

Table 5
Areas of E/HF focus by megatrend.

Labour-market supply	Technology	Informalisation	Climate change
• Skills development initiatives • Workplace accommodations for ageing, families, etc. • Work schedule design for ageing, families, etc. • Supportive technologies for ageing, families, etc. (e.g., gerontechnology; exoskeletons, neuroaugmentation) • Cultural integration initiatives • Decent work E/HF across supply chains[a] • Cross-cultural considerations in system design	• Preventing harm to humans from smart technologies • Improving lived experience with technologies • Reducing work intensification • Making smart technologies operation transparent • Inserting E/HF early in the technology design process • Perception of E/HF as a barrier to innovation[a] • Human-technology teaming • Telehealth systems • New methods of function allocation (especially for decision making and responsibility) for joint cognitive systems	• Low-cost solutions[a] • Labour protections for all informal work[a] • Remote-working and collaborative tools • Managing remote work • E/HF at a distance • E/HF for multiple holders of the same job • E/HF problems associated with casualisation and informal sector • Psychosocial risks of remote work • Design of activity-based work • Design of networking and collaborative tools.	• Work under heat conditions • Work with extended UV exposure • Work in extreme events • Design of work for disaster preparedness[a] • Design of early warning systems • Organisational contingency plans • Improve climate change communication • Design work for resource efficiency • Design for effective recycling, re-use, and disposal • Design of green jobs • Disaster ergonomics[a] • Green ergonomics

[a] New areas of E/HF contributions emerging from the thematic analysis and CLD.

Worldwide there are more than 2 billion workers (60 % of the "employed" population) identified as informal workers (ILO, 2023). True transformation for informality requires E/HF to have a broader definition of a "worker" to include the wide variety of informal contexts such as work in family contexts, care-work, and volunteering. Many E/HF tools already exist to characterise these work conditions, but the enormous variety of types of work, workers, and workplaces will produce challenges for E/HF professionals. E/HF work in the informal economy will demand low-cost solutions (Thatcher and Todd, 2019) and for the E/HF professional there are poor prospects to earn considerable profits. However, without E/HF's involvement in the informal economy, we risk becoming a discipline concerned predominantly with designing work for the elites. The CLD analysis shows that informality has both positive and negative aspects, and that the reasons for informality are globally linked. All forms of informal work and alternative work situations will therefore require E/HF involvement in the development of international and local labour protections that are situation-appropriate while also enabling worker's flexibility to attend to other life tasks (Golman and Ernst, 2022; ILO, 2021, 2021).

As others in the E/HF discipline have already noted (Endsley, 2023; Navarro, 2019; Salmon et al., 2025), increasingly "smart" technology requires E/HF to design more appropriate human-technology teaming that makes decision-making more transparent, while also reducing cognitive disengagement, trust, and the out-of-loop phenomenon. Given that developers of "smart" technology don't have human-technology teaming as a central goal, E/HF needs to find a way to meaningfully insert themselves into these technology development processes (Grote, 2023; Salmon et al., 2019). Our analysis showed that in some countries E/HF was associated with the safety and human resources professions that were perceived to be barriers to technological innovation. These professions are perceived to restrict the pace and types of possible innovations and E/HF will need to respond to this perception.

E/HF is currently unprepared to address the impacts of climate change on workers and to help ameliorate other resource shortages (Bolis et al., 2023). The CLD analysis shows that without adequate supportive services, such as healthcare systems, climate change will also likely exacerbate existing migratory patterns to higher latitudes and other areas less affected by heat and drought. Ironically, the E/HF lessons learned from work under heat conditions from tropical and desert countries might prove valuable knowledge transfer to countries at higher latitudes. The CLD analysis also shows the need for improved disaster preparedness from the greater likelihood of extreme weather events. Some of this work has already begun in the E/HF field with the introduction of "disaster ergonomics" (Sasangohar et al., 2020). In relation to more efficient and effective use of available resources, green ergonomics (Thatcher, 2013) is already playing a role, but more concerted attention is required to facilitate a sustainable future.

5.2. Study limitations and systems analysis recommendations

A problem that plagued the research team throughout this research was the temporal and geographical qualities of the future. We partially address the geographical issue by demonstrating how the future of work differs and interacts between countries and regions of the world. Moreover, through a systems analysis linked to the future of work it is possible to construct a clearer picture using E/HF systems methods to identify new opportunities. However, the future timespan remains unclear. Autobiographical thinking was encouraged to capture the drivers in the near-term (five to ten years). However, predictions were based on currently emerging technologies, not on technologies which have yet to be developed or even imagined. Making predictions further into the future becomes even more difficult. The future of work is therefore a continual, unfolding, dynamic process which requires regular systemic analysis. For example, an event such as the COVID-19 pandemic, was predictable (i.e., one could predict with reasonable certainty that a global pandemic would arrive at some point), but not the exact time, the nature or severity of the pandemic, nor the specific impact it would have on society and work. Yet, the COVID-19 pandemic had a profound impact on work by accelerating the adoption of flexible and remote working activities (Sigahi et al., 2021) while slowing the development of the green and blue economies. It is not possible to predict what impact current and emergent wars, political decisions, future pandemics, natural disasters, or economic shocks will have on shaping the future of work over longer time scales.

This work does not include extensive recommendations or a plan with regards to specific E/HF interventions. Intervention details can be found in more specific reviews (e.g., Bentley et al., 2021, 2023; Bolis et al., 2023; Endsley, 2023; Grote, 2023). We also do not claim that this work presents a complete global picture of the future of work. It presents a limited number of voices which might represent biases in the issues they chose to foreground. We tried to overcome this bias by having more than one person representing each country or region, but there are still gaps that might help refine the models. The purpose of this work was to demonstrate that collaborative E/HF systems thinking can add value, not to argue that our analysis (or indeed, any analysis) is complete. The CLD models are limited in that only the inputs of E/HF researchers and practitioners were used to derive the core components and interactions. There were no experts in economics, politics, law, public health, ecology, or climate science. Such a transdisciplinary approach to understanding the future of work is encouraged but will require significant resources to assemble and E/HF systems analysis tools to make sense of the complexity. It is also limited by the fact that E/HF (and its range of contributions) is not universally understood across all countries. In some countries E/HF has a unique identity as a recognised profession whereas in other countries E/HF might be part of engineering, health science, or psychology degrees. This might broaden or narrow the scope of possible intervention areas. There are other methods such as scenario-based design (using the types of systems thinking we have emphasised here), brainstorming, anticipatory-thinking, or personas that may also help E/HF practitioners plan for these emerging situations (Lopez-Bagousse et al., 2024). This analysis provides a systems method that can be applied in multiple contexts at the national, regional, and global levels. Despite the obvious benefits of including E/HF early in design process that the discipline remains largely reactionary. It is hoped that forward-thinking global systems analysis process might show the value for including E/HF as part of the initial design-thinking.

6. Conclusions

It is anticipated that the global-scale systems analysis presented in this work will be unsettling to many in E/HF. However, Davis et al. (2014) put forward a call for bravery in advancing socio-technical systems thinking, emphasising the need for a wider range of applications for our discipline. Barcellini et al. (2025) also articulated the discomforting reality that E/HF must embrace its expansion into the political and economic levels if it is to continue its developmental pathway. Understanding the challenges for the future of work, even from an E/HF perspective, cannot be achieved without a recognition of these larger, global forces driving changes to the way work is carried out. It is at this juncture where E/HF can play an important linking role as systems analysts with knowledge of people, work, and the technological and environmental systems with which they interact. To get a more complete picture, transdisciplinary knowledge creation will be necessary. This work provides an attempt to put Davis et al.'s (2014) call for bravery into action through highlighting some of the crucial intersections between four megatrends for the future of work relevant for E/HF. Finally, authors such as Lange-Morales et al. (2014) and Read et al. (2018), highlight the need for a values-driven E/HF discipline. The values outlined in Lange-Morales et al. (2014) delineate the approach E/HF must take to contribute in a meaningful way to a sustainable and just future of work, regardless of how external forces drive this evolution.

CRediT authorship contribution statement

Andrew Thatcher: Writing – review & editing, Writing – original draft, Visualization, Validation, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Augustine Appah Acquah:** Writing – review & editing, Writing – original draft, Validation, Investigation, Formal analysis, Conceptualization. **Agnès Aublet-Cuvelier:** Writing – review & editing, Writing – original draft, Validation, Investigation, Formal analysis, Conceptualization. **Rob Becker:** Writing – review & editing, Writing – original draft, Validation, Investigation, Formal analysis, Conceptualization. **Tim Bentley:** Writing – review & editing, Writing – original draft, Validation, Investigation, Formal analysis, Conceptualization. **Maria Elena Boatca:** Writing – review & editing, Writing – original draft, Validation, Investigation, Formal analysis, Conceptualization. **Daniel Braatz:** Writing – review & editing, Writing – original draft, Validation, Investigation, Formal analysis, Conceptualization. **Hong-In Cheng:** Writing – review & editing, Writing – original draft, Validation, Investigation, Formal analysis, Conceptualization. **Fabien Coutarel:** Writing – review & editing, Writing – original draft, Validation, Investigation, Formal analysis, Conceptualization. **Somnath Gangopadhyay:** Writing – review & editing, Writing – original draft, Validation, Investigation, Formal analysis, Conceptualization. **Nicola Green:** Writing – review & editing, Writing – original draft, Validation, Investigation, Formal analysis, Conceptualization. **Nigel Heaton:** Writing – review & editing, Writing – original draft, Validation, Investigation, Formal analysis, Conceptualization. **Hongwei Hsiao:** Writing – review & editing, Writing – original draft, Validation, Investigation, Formal analysis, Conceptualization. **Liang Ma:** Writing – review & editing, Writing – original draft, Validation, Investigation, Formal analysis, Conceptualization. **Masaaki Mochimaru:** Writing – review & editing, Writing – original draft, Validation, Investigation, Formal analysis, Conceptualization. **Beata Mrugalska:** Writing – review & editing, Writing – original draft, Validation, Investigation, Formal analysis, Conceptualization. **Verena Nitsch:** Writing – review & editing, Writing – original draft, Validation, Investigation, Formal analysis, Conceptualization. **Paulo Antonio Barros Oliveira:** Writing – review & editing, Writing – original draft, Validation, Investigation, Formal analysis, Conceptualization. **Taezoon Park:** Writing – review & editing, Writing – original draft, Validation, Investigation, Formal analysis, Conceptualization. **Arto Reiman:** Writing – review & editing, Writing – original draft, Validation, Investigation, Formal analysis, Conceptualization. **Yordán Rodriguez:** Writing – review & editing, Writing – original draft, Validation, Investigation, Formal analysis, Conceptualization. **Gary Roth:** Writing – review & editing, Writing – original draft, Validation, Investigation, Formal analysis, Conceptualization. **Urmi Ravindra Salve:** Writing – review & editing, Writing – original draft, Validation, Investigation, Formal analysis, Conceptualization. **Rosemary Seva:** Writing – review & editing, Writing – original draft, Validation, Investigation, Formal analysis, Conceptualization. **Anita Tisch:** Writing – review & editing, Writing – original draft, Validation, Investigation, Formal analysis, Conceptualization. **Andrew Todd:** Writing – review & editing, Writing – original draft, Validation, Investigation, Formal analysis, Conceptualization. **Yaniel Torres:** Writing – review & editing, Writing – original draft, Validation, Investigation, Formal analysis, Conceptualization. **Yoshiko Yagi:** Writing – review & editing, Writing – original draft, Validation, Investigation, Formal analysis, Conceptualization. **Shanqing Yin:** Writing – review & editing, Writing – original draft, Validation, Investigation, Formal analysis, Conceptualization. **Wei Zhang:** Writing – review & editing, Writing – original draft, Validation, Investigation, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: The majority of authors declare that they have no known completing interests that would influence the work reported in this paper. Two of the authors, Tim Bentley and Hongwei Hsiao, are members of the Editorial Board, but have not been involved in the editorial review or decision making on the review of this paper. One author, Gary Roth, is employed by the US Government in the CDC and has obtained permission to be an author on this paper.

Appendix 1. Details of the expert team

Contributor name	Position	Role (researcher or practitioner)	Institution, organisation, independent (Country)	Years applying E/HF	Core areas of E/HF (top 3)	Work domain applications of E/HF (top 3)	Frequently applied E/HF methods (top 3)
Augustine Appah Acquah	Lecturer/ Consultant	Practitioner and Researcher	University of Ghana (Ghana)/World Bank Group (West and Central Africa)	Researcher: 7 Practitioner: 2	Environmental E/HF Occupational E/HF Physical E/HF	Healthcare Informal work Mining	Physical evaluation Quantitative methods Work observations methods
Agnès Aublet-Cuvelier	Deputy Scientific Director	Researcher	Institut National de Recherche et de Sécurité (France)	Researcher: 24 Practitioner: 0	Occupational medicine MSDs Prevention	General industry Private companies Services	Qualitative methods Quantitative methods Participatory methods
Rob Becker	Principal Human Factors Consultant	Practitioner	User Centric Design (UK)	Researcher:0 Practitioner: 8	Cybersecurity Digital design & UX Human Machine Interface Design	Aviation Defence General Industry	Contextual Inquiry Low/high fidelity prototyping Stakeholder engagement tools
Tim Bentley	Professor/ Director ECU MARS Centre	Researcher	Edith Cowan University (Australia)	Researcher: 30 Practitioner: 0	Mental health and psychosocial risk Older workers Workplace H&S	HR & management Mining Public sector	Participatory methods Qualitative methods Quantitative methods
Maria Elena Boatca	Assistant professor	Researcher	Politehnica University of Timisoara (Romania)	Researcher: 6 Practitioner: 0	Workplace OHS Workplace wellbeing E/HF risks	Manufacturing	Cost-benefit analysis Qualitative methods Quantitative and observation-based methods

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Contributor name	Position	Role (researcher or practitioner)	Institution, organisation, independent (Country)	Years applying E/HF	Core areas of E/HF (top 3)	Work domain applications of E/HF (top 3)	Frequently applied E/HF methods (top 3)
Daniel Braatz	Associate Professor; Director Innovation Agency	Researcher	Federal University of Sao Carlos (Brazil)	Researcher: 19 Practitioner: 0	Engineering design Participatory E/HF Simulation	General industry Services	Participatory methods Qualitative methods
Hong-In Cheng	Professor	Researcher	Kyungsung University (South Korea)	Researcher: 20 Practitioner: 0	E/HF design OHS Physical E/HF	Manufacturing Policy-making	Qualitative methods Quantitative methods
Fabien Coutarel	Professor	Researcher	Clermont Auvergne University (France)	Researcher: 24 Practitioner: 0	Developmental E/HF Ergonomic intervention assessment Work health & attraction	General industry New technologies	Design methods Participatory methods Qualitative methods
Somnath Gangopadhyay	Professor	Researcher	University of Calcutta (India)	Researcher:30 Practitioner: 0	Health Interventions Physical Ergonomics Productivity	Informal sector Manufacturing	MSD surveys Posture analysis Work analysis
Nicola Green	Lecturer; Consultant	Practitioner and Researcher	Massey University/Ergonomics, Work & Health Ltd (New Zealand)	Researcher: 10 Practitioner: 19	MSDs Psychosocial risk Systems thinking	Education Healthcare Knowledge industries	Biomechanical methods Qualitative methods Systems modelling
Nigel Heaton	Director	Practitioner	Human Applications (UK)	Researcher 10 Practitioner 32	Culture change Health and safety systems Systems E/HF	Expert witness Large distribution companies National Government	Behaviour change tools E/HF audit tools Stakeholder engagement tools
Hongwei Hsiao	Professor	Researcher	Texas A&M University (USA)	Researcher: 38 Practitioner: 6	Human-robot/system Interface Physical E/HF Protective Technology	Construction Public H&S Transportation	Digital modelling Multivariate methods Simulation
Verena Nitsch	Professor, Director	Researcher	Institute of Industrial Engineering/RWTH Aachen University (Germany)	Researcher: 16 Practitioner: 0	Automation Cognitive E/HF Psychological risks	General industry HR Services	Measurements Physiological Qualitative methods Quantitative methods
Liang Ma	Associate Professor	Researcher	Tsinghua University (China)	Researcher: 14 Practitioner: 0	Fatigue modelling and fatigue risk management Human-AI collaboration	Healthcare Manufacturing industry Transportation industry	Fatigue modelling and its validation Field experiment Machine learning
Masaaki Mochimaru	Fellow	Researcher	The National Institute of Advanced Industrial Science and Technology (Japan)	Researcher: 31 Practitioner: 0	Biomechanics Digital human modelling Service engineering	Consumer products Consumer safety Digital service systems	Biomechanical sensing Computer simulation Physiological sensing
Beata Mrugalska	Associate Professor	Researcher	Poznan University of Technology (Poland)	Researcher: 15 Practitioner: 2	Ageing Sustainability E/HF Production systems E/HF	General industry	Interviews Observations Qualitative methods
Taezoon Park	Professor	Researcher	Soongsil University (South Korea)	Researcher: 21 Practitioner: 0	Human error Cognitive E/HF Simulation	Healthcare Robotics Transportation	Machine learning Physiological measurement Quantitative methods
Paulo Antonio Barros Oliveira	Professor	Practitioner and Researcher	Federal University of Rio Grande do Sul (Brazil)	Research: 12 Practitioner: 24	Injury prevention MSDs Occupational health	Food processing Services policy-making	Participatory methods Qualitative methods
Arto Reiman	Adjunct Professor	Researcher	University of Oulu (Finland)	Researcher: 16 Practitioner: 5	Integrated management systems Participatory E/HF Well-being at work	Manufacturing Process industry Transportation	Literature reviews Mixed methods Participatory methods
Yordán Rodríguez	Professor	Practitioner and Researcher	University of Antioquia (Colombia)	Researcher: 18 Practitioner: 10	Healthcare E/HF Macroergonomics Physical E/HF	General industry Services Software interfaces	Design tools Macroergonomic tools Physical evaluation tools
Urmi Ravindra Salve	Associate Professor	Researcher	Indian Institute of Technology Guwahati (India)	Researcher: 20 Practitioner: 0	Cognitive E/HF Occupational Health, Physical E/HF	Design E/HF Health Sciences	Participatory methods Qualitative methods Quantitative methods
Rosemary Seva	Professor	Researcher	De La Salle University (The Philippines)	Researcher: 28 Practitioner: 0	Cognitive E/HF Physical E/HF Systems E/HF	Computing systems Product design Services design	Affective design methods Qualitative methods Usability engineering

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Contributor name	Position	Role (researcher or practitioner)	Institution, organisation, independent (Country)	Years applying E/HF	Core areas of E/HF (top 3)	Work domain applications of E/HF (top 3)	Frequently applied E/HF methods (top 3)
Andrew Thatcher	Professor	Researcher	University of the Witwatersrand (South Africa)	Researcher: 29 Practitioner: 0	Cognitive E/HF Sustainability E/HF Systems E/HF	Communities design Computing systems Power plants	Participatory methods Qualitative methods Systems tools
Anita Tisch	Professor	Researcher	Institute for Occupational Health/ University Bonn-Rhein-Sieg (Germany)	Researcher: 15 Practitioner: 0	Ethics of digitalisation Occupational health Working conditions	General industry Policy-makers Social Partners	Literature reviews Quantitative methods
Andrew Todd	Senior Lecturer	Researcher	Rhodes University (South Africa)	Researcher: 22 Practitioner: 0	Biomechanics Community E/HF Systems E/HF	Community sport Healthcare Informal economy	Activity analysis Systems tools
Yaniel Torres	Professor	Researcher	University of Antioquia (Colombia)	Researcher: 10 Practitioner: 10	Fatigue risk management Human error Systems E/HF	Aerospace General industry Manufacturing	Fatigue risk indexes SHERPA/HTA STAMP/STPA
Yoshiko Yagi	Executive Officer	Practitioner and Researcher	Itoki Corporation (Japan)	Researcher: 7 Practitioner: 26	Biomechanics Environmental Psychology Well-being at work	Furniture design General industry Workplace	Observational methods Participatory methods Qualitative methods
Shanqing Yin	Human Factors Specialist	Practitioner	Singhealth (Singapore)	Researcher: 0 Practitioner: 12	Cognitive E/HF Macroergonomics	Aviation & transportation Healthcare Process control	Cognitive tools Systems tools
Wei Zhang	Professor	Researcher	Tsinghua University (China)	Researcher: 22 Practitioner: 0	Driving safety Human-AI collaboration	Healthcare Software Transportation	Experimental methods Focus Groups Machine learning methods

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