European Journal of Sustainable Development (2025), **14**, 4, 139-156 ISSN: 2239-5938
Doi: 10.14207/ejsd.2025.v14n4p139

Analysis of Work-Life Balance in European Union Countries: The Impact of Technological Progress and Digitalization

By Rasa Balvociute[1] and Ligita Salkauskiene[2]

ABSTRACT:
The 2030 Agenda for Sustainable Development, approved by the United Nations, includes two important goals related to work-life balance: ensuring healthy lives for everyone and promoting sustainable economic growth. A key part of sustainable economic growth is providing full, productive jobs with good working conditions. Recent research shows that work-life balance has several critical issues. Long working hours and heavy workloads are major concerns that harm both physical and mental health. Poor work-life balance can lead to stress, burnout and lower productivity. It's important to maintain a good work-life balance not just for employees' health, but also for the success of organizations. Companies that support work-life balance have more engaged employees, greater loyalty and lower turnover rates. The rapid growth of technology in the workplace, at home and in public life affects how employees balance work-life time. Cultural differences, economic conditions and social policies impact work-life. This study aims to improve the understanding of work-life balance in EU countries as technology advances. It will identify key factors influencing this balance and explore future trends. The research uses EUROSTAT data to look at work-life balance across 27 EU countries from 2005 to 2023, utilizing regression analysis models for panel data.

Keywords: work-life balance, technological progress, digitalization, healthy life

1. Introduction

Work-life balance (WLB) is essential for sustainability, promoting a harmonious integration of professional and personal responsibilities that enhances well-being and organizational resilience. It has gained importance in achieving social sustainability, particularly in line with the United Nations' Sustainable Development Goals (SDGs), such as SDG 8 (decent work) and SDG 12 (responsible consumption) (United Nations, 2015). Despite the recent surge of research in this field, much of it predominantly addresses issues at the company level. The systematic review by Thilagavathy & Geetha (2023) highlights a significant gap in understanding the effects of technological advancements, such as remote work technologies and automation, on WLB. A more recent study by Stephen et al. (2024) expands the conversation to examine broader societal implications, including how digitalization influences employment patterns and public health policies across various countries.

Studying WLB across countries with different levels of technological advancement is essential for understanding how technology influences human well-being. In highly advanced countries, technology often facilitates flexible work arrangements, such

| [1]Siauliai University of Applied Science, Lithuania
[2] Siauliai University of Applied Science, Lithuania

as remote work; however, it can also blur the lines between work and personal life. In contrast, countries with less technological progress may face challenges like limited access to digital tools, longer working hours, or more rigid work environments.

Cultural norms significantly shape how people in different European societies perceive the balance between work and personal life, extending beyond technology. In Nordic countries like Sweden and Denmark, this balance is viewed as a social responsibility, supported by generous parental leave and acceptance of digital flexibility. In contrast, Germany and the Netherlands emphasize individual rights, promoting flexible work models for productivity and well-being. Southern European nations, such as Spain and Italy, integrate leisure into daily life, valuing social interaction over strict productivity. Meanwhile, Eastern European societies often adhere to traditional, hierarchical work values, which can hinder the adoption of digital flexibility (Ibanez et al., 2021). National values, such as individualism and uncertainty avoidance, influence whether digital tools for flexible work are embraced. Countries that adapt easily to change see digital flexibility as sustainable, while those with a strong aversion to uncertainty may prefer rigid schedules.

In the EU, digital flexibility varies widely. Scandinavian countries have integrated it into public services and education, while Central and Eastern Europe face challenges like infrastructure gaps and cultural resistance. For instance, Lithuania advances in digital education but struggles with regional disparities affecting access.

Overall, cultural frameworks are crucial in shaping work-life dynamics and the integration of digital solutions.

The varying levels of technological advancement often align with distinct cultural norms regarding work and life priorities. For instance, some advanced nations prioritize reduced work hours, while others may emphasize productivity over leisure time. Economic disparities between countries can further complicate the challenges associated with achieving a WLB, depending on the resources available and societal expectations.

Long-term research examining the interaction between technological advances and WLB at the country level is crucial for understanding how digitalization, automation, and remote work influence labor markets and overall societal well-being. Studies indicate that technology affects WLB by enhancing flexibility, job satisfaction, and stress management; however, it also raises concerns regarding digital overload and the blurring of boundaries between work and personal life (Nam, 2014). Research has demonstrated that while technological interventions can streamline tasks, they may also lead to work-life conflicts and mental health challenges. Additionally, the risks posed by rapidly changing knowledge, such as outdated technologies and cyber threats, influence the relationship between WLB and work performance. This highlights the necessity for policies that address these evolving issues (Borgia et al., 2022). By analyzing these trends over time, policymakers can formulate regulations that foster healthy work environments, such as limiting after-hours digital communication and supporting flexible work arrangements. Ongoing research is essential to ensure that technological progress aligns with workforce sustainability and global health priorities.

This study aims to explore the relationship between technological progress and WLB, specifically focusing on how different work-related factors impact health outcomes in countries with varying levels of technological advancement. By comparing nations where technological progress is either above or below the EU-27 average, the research seeks to identify patterns in the effects of typical weekly work hours, irregular work schedules (such as long shifts, night shifts, and remote work), and material deprivation on healthy life years and self-perceived health expectancy.

The findings aim to provide insights into how technological advancements shape workforce sustainability, affecting both objective health indicators and subjective well-being. Additionally, the study seeks to highlight socio-economic disparities between different country groups, demonstrating the roles of infrastructure, policy interventions, and workplace conditions in mitigating work-related stress and its long-term impacts on public health. By identifying these trends, the research contributes to the ongoing discussion about creating effective policies that balance productivity with employee well-being in the labor market.

2. Theoretical Background

Work-life Balance and Technological Progress Interaction in the Context of Sustainable Development

Research on WLB over the past twenty-five years has revealed significant insights into its impact on employees, organizations, and society. Studies have consistently shown that achieving WLB contributes to improved mental health and job satisfaction. For instance, a systematic review highlighted that flexible work arrangements are a key factor in enhancing WLB (Thilagavathy & Geetha, 2023). Empirical research has also emphasized the role of technology in both facilitating and hindering WLB. While remote work options have enabled employees to better manage their personal and professional lives, the constant connectivity has blurred boundaries, leading to potential burnout (Wong, Teh, & Chan, 2023). The COVID-19 pandemic brought WLB into sharper focus, as irregular, remote work became the norm, prompting organizations to rethink their policies. Research highlights the importance of WLB in promoting a sustainable workforce and promoting employee well-being (Sánchez-Hernández et al., 2019). It encourages organizations to adopt a holistic approach that considers individual needs, technological advances and cultural context.

Overall, the body of research underscores the importance of WLB in fostering a sustainable workforce and promoting employee well-being. It calls for organizations to adopt holistic approaches that consider individual needs, technological advancements, and cultural contexts.

WLB benefits individuals by fostering healthier workforces and reducing societal costs related to burnout (Maslach & Leiter, 2016). Factors influencing WLB include flexible work arrangements, supportive leadership, and wellness programs at the organisational level. Societal support, such as equitable parental leave and affordable childcare, is crucial. While technology can enhance flexibility through remote work, it may also promote an "always-on" culture that threatens sustainability. Additionally, economic stability supports WLB by providing access to necessary resources. Research by Kruyen, André, & Heijden (2024) highlights the positive impact of integrating work-life balance into sustainability strategies. This approach not only enhances employee satisfaction but also promotes long-term societal well-being. By aligning personal fulfilment with

© 2025 The Authors. Journal Compilation © 2025 European Center of Sustainable Development.

ecological and social objectives, organizations can create a more harmonious and productive workplace.

WLB has traditionally been studied at the individual and organizational levels, leaving a gap in understanding broader determinants shaped by technological progress. Rapid digitalization has transformed how people work, introducing remote work and flexible schedules but also creating challenges like constant connectivity and blurred boundaries (Pichler, 2009; Thilagavathy & Geetha, 2023). Despite these changes, little research addresses how technological advancements influence WLB within the framework of sustainable societal development. Sustainable development requires a balance between economic productivity, social equity, and environmental well-being, making it essential to integrate WLB into this context. Exploring how evolving technology intersects with sustainability principles can reveal strategies to foster healthier work-life dynamics. This highlights the need for a comprehensive understanding of WLB that bridges technology, social sustainability, and evolving work environments.

Technological progress has greatly influenced healthy life years (HLY) by enhancing living conditions, accessibility, and overall well-being. Innovations in environmental monitoring and pollution control have improved air and water quality, which directly impacts public health. Advances in transportation and urban planning have lowered accident rates and encouraged active lifestyles by creating better infrastructure, such as bike lanes and pedestrian-friendly spaces.

Digital technologies, including wearable devices and health apps, empower individuals to monitor their health and adopt preventive measures. Furthermore, automation and artificial intelligence have optimized various industries, reducing workplace hazards and physical strain (Kasoju, Remya, Sasi et al., 2023). As identified by Raghupathi V. & Raghupathi, W. (2020), educational technology has also contributed to increasing awareness of healthy behaviours and providing access to health-related information.

However, the benefits of technological progress are not evenly distributed. Disparities in access to technology can worsen health inequalities. Weiss and Eikemo's (2020) research emphasizes the importance of integrating technological advancements with equitable policies to enhance their positive impact on HLY.

The Main Science and Technology Indicators (MSTI) and the Digital Economy and Society Index (DESI) (EUROPEAN COMMISSION, 2023) are instrumental in offering a nuanced perspective on a country's technological advancement. MSTI highlights the foundational elements critical to fostering innovation, including investment in research and development (R&D), the availability of a skilled workforce in science and technology, and innovation outputs as indicated by patent filings. A robust commitment to R&D and a well-trained workforce signify a nation’s determination to nurture innovation and technological growth. Patent data not only serves as a tangible measure of innovation but also underscores a country’s capacity to develop and protect new technologies. Conversely, DESI focuses on the practical implementation and societal impact of digital technologies. It examines key factors such as connectivity, digital skills, internet usage, business digitalization, and the accessibility of digital public services. By assessing these elements, DESI provides valuable insights into how effectively a country leverages digital tools to enhance its economic and social infrastructure. Strong connectivity and the advancement of digital skills are essential for empowering the population to engage fully with digital technologies. Moreover, the integration of these technologies into businesses and public services exemplifies their role in daily life.

Together, MSTI and DESI present a comprehensive overview of a country's technological progress, enabling policymakers and stakeholders to identify strengths and areas for improvement as they work toward a more innovative and digitally adept future.

3. Methods

The research was carried out in two stages:

Stage 1: Clustering of EU countries by technological progress

The first stage of the analysis involved classifying 24 European Union countries into three groups based on their level of technical progress, excluding Croatia, Cyprus, and Malta due to insufficient data. The variables used for clustering included GDP per capita allocated to technical progress and the number of researchers per population, as well as digitalization indicators (DESI).

A hierarchical clustering approach was employed to identify homogeneous groups of countries. A between-group linkage method was applied to compute the similarity between clusters, and the squared Euclidean distance was chosen as the distance measure for clustering. Clusters were formed based on the relative similarities in the technical progress indicators. The number of clusters was determined using dendrograms (see Figure 1) while balancing interpretability with statistical rigour. This process resulted in identifying three distinct groups of countries, each representing a unique level of technical progress within the EU.

© 2025 The Authors. Journal Compilation © 2025 European Center of Sustainable Development.

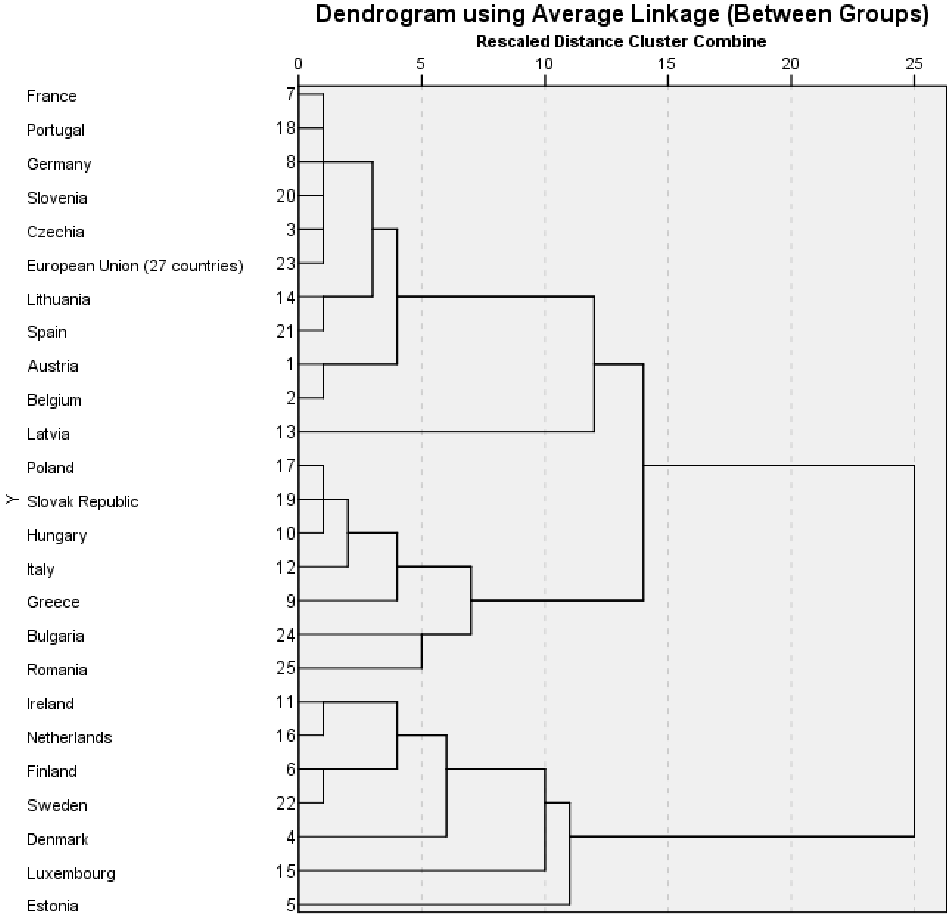

Figure 1: Clusters of EU countries according to technical progress (GDP per capita devoted to technical progress and number of researchers) and digitalisation (DESI) indicators.
Data source: EUROSTAT (2025). Main Science and Technology Indicators (MSTI database)

The study identified three groups of countries based on their level of technological advancement:
1) countries with the highest technological progress (CHTP) – Ireland, Netherlands, Finland, Sweden, Denmark, Luxembourg, Estonia. This group shows a moderate level of homogeneity. Some countries, like Finland, Sweden, and Denmark, are more closely clustered, indicating strong similarities. Others, such as Ireland and the Netherlands, are positioned slightly further apart, suggesting some distinctions within the cluster.
2) countries with medium technological progress close to the EU-27 average (CMTP) – France, Portugal, Germany, Slovenia, the Czech Republic, Lithuania, Spain, Austria, Belgium, and Latvia. This group is less homogeneous, with longer branch lengths and more dispersion in the clustering. The variation within this group suggests that a wider range of differences in classification parameters was used.

3) countries with lower technological progress than the EU-27 average (CLTP) – Poland, Slovak Republic, Hungary, Italy, Greece, Bulgaria, and Romania. This group is relatively homogeneous, as the countries are closely clustered with shorter branch lengths, indicating smaller rescaled distances.

Stage 2: Panel data regression analysis

The second stage of the study focused on analyzing the complex relationships between health outcomes and working patterns, using a comprehensive panel dataset that spans the years 2004 to 2023. The dependent variables examined were Healthy Life Expectancy Based on Self-Perceived Health (HLE) and HLY. To explore the potential influences on these health outcomes, a range of independent variables was selected, including the usual weekly hours worked in the main job, actual weekly hours worked in the main job, health spending per capita, the proportion of employment involving long hours, employment at night, and employment from home (see Table 1).

Table 1: Selected variables description

Healthy Life Expectancy Based on Self-Perceived Health (HLE)	This indicator is derived from individuals' subjective assessments of their general health status. It relies on survey data where respondents rate their health as very good, good, fair, bad, or very bad. The measure reflects perceived health quality but may be influenced by cultural, social, or personal biases in self-reporting. EUROSTAT (2025a)
Healthy Life Years (HLY)	Also known as disability-free life expectancy, this indicator is based on objective data about activity limitations and disabilities. It combines mortality data with the prevalence of health conditions that limit daily activities, offering a more standardized measure of the years a person is expected to live without significant health-related restrictions. EUROSTAT (2025b)
Number of usual weekly hours of work in main job (whf)	The average number of usual weekly hours worked in the main job refers to the typical hours a person works per week in their primary employment over an extended period. This includes all hours worked, whether paid or unpaid, such as overtime, but excludes commuting time, meal breaks, and non-job-related training. It represents the mode of hours worked, meaning it reflects the most frequently occurring number of hours. EUROSTAT (2025c)
Number of actual weekly hours of work in main job (wha)	The average number of actual weekly hours of work in the main job is the total hours a person spends on work activities during the reference week. EUROSTAT (2025d)
Health spending (hs)	Health spending per capita is the total amount spent on health care services and goods per person in a given year, expressed in US dollars. This measure includes both public and private expenditures on health, adjusted for differences in purchasing power across countries. It provides a way to compare health care spending levels between countries and over time, reflecting the resources allocated to health care systems. OECD Data (2023)
Long working hours (lh)	Long working hours, defined as working 49 hours or more per week, represent the long working percentage of the total employment in the main job. EUROSTAT (2025e)

© 2025 The Authors. Journal Compilation © 2025 European Center of Sustainable Development.

Persons working at nights (nh)	Employed persons working at night as a percentage of the total employment is employment during the hours typically considered nighttime, often defined as between 10 PM and 6 AM. EUROSTAT (2025f)
Percentage of employed adults working at home (hw)	The percentage of employed adults working at home is the share of employed individuals who perform their work from home, either partially or fully, during a reference period. EUROSTAT (2025g)
Severe material deprivation rate (smd)	The percentage of the population unable to afford a set number of essential items or services, such as adequate heating, a meal with meat or its equivalent every other day, or unexpected financial expenses. This rate is analyzed by income quintile and household type to understand disparities across different economic and social groups. EUROSTAT (2025h)

The study utilized a panel data approach to investigate the direct relationships between independent variables: specifically, health spending, weekly working hours, night shifts, long work hours, remote working hours, and the severe material deprivation rate, and dependent variables that characterize WLB, namely health life expectancy (HLE) and HLY. The methodological framework was based on longitudinal data analysis to capture the temporal dynamics and causal associations among these variables across three countries.

A long-term panel data analysis was conducted to examine the direct effects of health spending and various work-hour parameters on HLE and HLY. Ordinary least squares and fixed-effects models were utilized to account for country-specific differences, ensuring that unobserved individual factors did not distort the results (Baltagi, 2021). The dataset was tested for autocorrelation and heteroskedasticity, and necessary adjustments were made to enhance the robustness of the model. To address endogeneity concerns, lagged variables were incorporated where appropriate to capture the delayed impact of health costs on WLB measures.

Following the panel data analysis, correlation analysis was carried out between HLE and health spending, which emerged as the most significant determinant from the previous stage. Pearson's correlation coefficient was used to quantify the strength of the association. Significance levels were evaluated to statistically validate the results (Gujarati & Porter, 2021). The analysis also included an investigation of multicollinearity among independent variables to ensure reliable parameter estimation.

The final step of the study involved conducting a sensitivity analysis on panel data to evaluate how changes in independent variables influenced the dependent variables. Fixed-effects models and dynamic panel estimation techniques, including the Generalized Method of Moments (GMM), were used to analyze the effects of changing work conditions on HLE and HLY. Variance decomposition methods were also used to determine the relative contribution of each independent variable to the overall changes in WLB indicators.

For each dependent variable, the regression model can be expressed as:

$$Y_{it} = \beta_0 + \beta_1\, whf_{it} + \beta_2\, wha_{it} + \beta_3\, hs_{it} + \beta_4\, lh_{it} + \beta_5\, nh_{it} + \beta_6\, hw_{it} + \alpha_i + \varepsilon_{it}$$

Where:

- Y_{it} represents the dependent variable (HLE_{it} or HLY_{it} for entity i (e.g., country) at time t.
- β_0 is the intercept term.
- $\beta_1, \beta_2, \ldots, \beta_6$ are the coefficients of the independent variables.
- α_i represents the time-invariant fixed effects unique to each entity i (capturing unobserved heterogeneity).
- ε_{it} is the error term.

To evaluate how changes in the independent variables influence changes in the dependent variables between 2004 and 2023, a differenced regression model is used:

$$\Delta Y_{it} = \beta_1 \Delta \, whf_{it} + \beta_2 \Delta \, wha_{it} + \beta_3 \Delta \, hs_{it} + \beta_4 \Delta \, lh_{it} + \beta_5 \Delta \, nh_{it} + \beta_6 \Delta \, hw_{it} + \Delta\varepsilon_{it}$$

Where:

- $\Delta Y_{it} = Y_{it} - Y_{i(t-1)}$: represents the change in the dependent variable (HLE_{it} or HLY_{it}) between time t and t−1.
- Δwhf_{it}, $\Delta wha_{it}, \ldots, \Delta hw_{it}$: changes in the independent variables over time.
- $\Delta\varepsilon_{it}$: change in the error term.

The analysis employed three distinct regression models and several of their modifications. The first model was the Ordinary Least Squares (OLS) regression, which allowed for an initial exploration of the linear relationships between the variables. The second model, the Fixed Effects Model (FEM), was used to account for unobserved, time-invariant differences across countries. Additionally, a dynamic panel model was applied because the initial analysis revealed that previous values of the dependent variable influence current results; dynamic panel models effectively capture these lagged effects.
To determine the appropriateness of the FEM over the Random Effects Model (REM), the Hausman test was conducted. Error diagnostics were crucial in ensuring the robustness of the models. Residual diagnostics were performed to identify heteroskedasticity, which was addressed by using robust standard errors. Serial correlation was examined using panel-specific methods, and multicollinearity was assessed through the calculation of Variance Inflation Factors (VIF).

For data processing and analysis, the study relied on the GRETL software package. This software was instrumental in tasks ranging from data preprocessing, such as handling missing values and scaling variables, to conducting regression analyses. GRETL was also utilized to perform diagnostic tests, ensuring that the models' assumptions were met and enhancing the reliability of the findings.

To further ensure the robustness of the results, sensitivity analyses were conducted. This involved testing alternative variables' specifications and analysing data subsets. The final results were carefully interpreted, with attention to the statistical significance, direction, and magnitude of the observed relationships.

Through this integrated approach, combining clustering and regression analysis, the study provided a nuanced understanding of how variations in working patterns and technological progress influenced health outcomes over nearly two decades. In the context of this study, the clustering of countries based on their level of technical progress (Stage 1) establishes a foundation for investigating how work-life balance influences health outcomes across varying levels of technological development. It is hypothesized that countries with higher levels of technical progress, characterized by greater investments in

© 2025 The Authors. Journal Compilation © 2025 European Center of Sustainable Development.

digitalization, research, and technical innovation, may exhibit distinctive patterns in work-life balance, such as a higher prevalence of flexible working arrangements (e.g., working from home) and reduced night shifts. These differences could mediate the relationships examined in the panel data regression analysis (Stage 2), where variables like weekly working hours and long working hours employment are expected to have varying effects on HLE and HLY depending on the level of technical progress. This hypothesis is central to interpreting regression results, as it suggests that technical progress moderates the impact of work-life balance indicators on health outcomes, highlighting potential disparities between the identified clusters of countries.

4. Results

Research consistently highlights the significant impact of health spending on HLY and HLE based on self-perceived health. The study conducted in OECD countries (Aytemiz et al., 2024) demonstrates that increased health expenditures are positively correlated with longer HLY, emphasizing the importance of the efficient allocation of resources. For instance, higher spending on preventive care and chronic disease management has been linked to improved self-reported health outcomes. However, in high-income countries, diminishing returns are observed, where additional spending results in smaller gains in HLY.

The Sullivan method, which is widely used to calculate HLE, integrates mortality data with self-reported health status, offering a more nuanced understanding of health outcomes (EUROSTAT, 2025a). Research by Aytemiz et al. (2024) also underscores the significance of socioeconomic factors, such as education and income, in enhancing the benefits of health spending. Furthermore, disparities in HLY across regions highlight the necessity for equitable health policies. Studies (Răileanu Szeles, 2018; Ashton et al., 2020) suggest that public health investments, particularly in underfunded areas, can considerably improve self-perceived health.

Table 2: Ordinary Least Squares regressions examining the effects of working hours and health spending on HLY and HLE across different groups of countries with varying technological progress

	Countries with higher technological progress		Countries with middle technological progress		Countries with lower technological progress	
	(1) H_life_y	(2) H_life_exp	(3) H_life_y	(4) H_life_exp	(5) H_life_y	(6) H_life_exp
work_h_full	0.554 (0.487)	0.164 (0.24)	- 0.224 (0.532)	0.125 (0.273)	0.079 (0.623)	0.111** (0.011)
work_h_act	0.363 (0.13)	0.026 (0.614)	0.07 (0.465)	- 0.12** (0.05)	- 0.1 (0.4)	0.055 (0.333)
Healthspen	0.0003 (0.459)	9.338e-05 (0.447)	0.0005** (0.049)	- 0.0003** (0.012)	0.00095** (0.037)	0.00054* (0.083)
Health_life_y_3	0.773*** (0.0003)	0.88*** (1.39e-06)	0.67*** (0.003)	0.97*** (5.11e-012)	0.79*** (0.0003)	0.819*** (1.09e-07)

Obs.	119	119	170	170	119	119
Adj. R-sq.	0.7	0.93	0.55	0.96	0.825	0.943
DW	0.62	0.57	0.75	0.81	0.69	0.7

** $p < 0.10$. ** $p < 0.05$. *** $p < 0.01$.*

Source: elaborated by the authors based on the EUROSTAT, OECD data and the GRETL software.

OLS regression analysis indicated (see Table 2) statistically significant relationships between HLY and HLE with health spending, as well as usual and/or actual working hours per week. No significant relationship was observed with the other independent variables. Across all country groups, past values of HLY and HLE are highly significant, indicating a strong path dependence. This means that current health outcomes are largely influenced by previous conditions. The adjusted R^2 values range from 0.55 to 0.96, demonstrating good explanatory power, with middle-progress countries showing the strongest model fit at 0.96 for HLE. The Durbin-Watson (DW) values range from 0.57 to 0.81, suggesting moderate autocorrelation. This autocorrelation was not eliminated even after including lagged variables in the model, which may indicate the need for further diagnostic testing.

The analysis underscores the significant role that technological progress plays in shaping WLB and health outcomes. In countries with above-average technological advancement, health investments do not markedly influence life expectancy. This suggests that established healthcare systems already create a strong foundation for overall well-being. However, the effects of working conditions are more intricate; while an increase in working hours may modestly contribute to improved life expectancy, the evidence supporting this link remains limited.

In nations with moderate technological development, actual work hours hurt self-perceived life expectancy, likely due to workplace stress or less favourable working environments. Health spending reveals mixed outcomes; while such investments can enhance the number of healthy life years, they do not necessarily improve individuals' perceptions of their health, indicating possible inefficiencies in healthcare resource allocation. The enduring influence of past health conditions remains a strong predictor, emphasizing the long-term effects of previous health status on current life expectancy.

Conversely, lower-tech countries experience the greatest benefits from heightened health investments, which lead to significant improvements in both healthy life years and self-perceived health expectancy. Notably, in these regions, higher usual working hours are associated with better self-perceived health, potentially linked to employment stability. However, actual working hours do not demonstrate strong effects, suggesting that broader economic factors may modulate work-related health outcomes.

Overall, models for self-perceived health expectancy exhibit greater explanatory power across various country groups. This indicates that Subjective health measures are more directly responsive to policy changes than objective life expectancy figures. These findings highlight the need for context-specific interventions to enhance health outcomes, necessitating tailored strategies based on each country's level of technological advancement.

© 2025 The Authors. Journal Compilation © 2025 European Center of Sustainable Development.

The findings of this study confirm that health spending significantly influences HLY and HLE, especially in countries with moderate and low levels of technological advancement. Consistent with Aytemiz et al. (2024), the results emphasize that strategic investments, particularly in preventive care and chronic disease management, can greatly improve self-perceived health outcomes. However, in high-tech countries, the diminishing returns of additional health expenditure indicate that wellness improvements tend to plateau once a threshold of spending efficiency is achieved. This challenges existing WLB models that equate increased resources with enhancements in quality of life. These observations call for a reexamination of WLB theories, stressing the importance of incorporating structural factors like socioeconomic disparities and regional inequalities. By doing so, WLB models can evolve into a more equitable framework that acknowledges how institutional context and public health equity profoundly shape individuals' experiences of balance, beyond merely individual choices.

Figure 1 illustrates the correlation between healthcare spending and healthy life expectancy across three groups of countries.

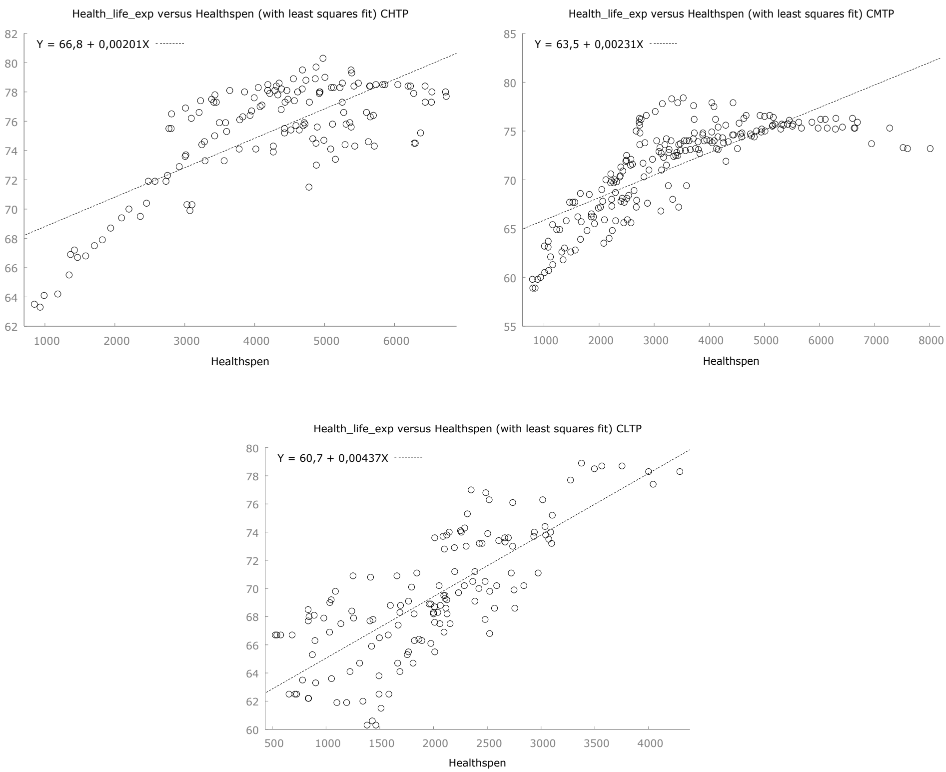

Figure 2: Correlation between healthcare spending (in USA dollars) and healthy life expectancy in higher (CHTP), middle (CMTP), and lower (CLTP) tech countries groups. Scatterplots of healthcare spending vs. healthy life expectancy across technology tiers (correlation coefficients: 0.747, 0.7636, 0.778)
Data source: elaborated by the authors based on EUROSTAT (2025a) and OECD Data (2023)

The correlation coefficients demonstrate a strong positive relationship between health care spending and healthy life expectancy across all categories of countries (see Figure 2). Notably, this correlation is slightly higher in medium- and low-tech countries. This suggests that health care spending may have a more significant impact on healthy life expectancy in these regions, likely due to differences in baseline health care infrastructure and efficiency.

For instance, technological advancements in medicine and health care enhance the relationship between healthcare spending and healthy life expectancy through improvements in efficiency, cost reductions, and better preventive care. Advanced medical technologies facilitate more accurate diagnostics, more effective treatments, and optimized allocation of healthcare resources.

Additionally, the reduction in costs resulting from automation, AI-driven diagnostics, and telemedicine increases accessibility and ensures that resources are utilized effectively. Personalized medicine, which is made possible by genetic analysis and lifestyle assessments, enhances treatment effectiveness and ultimately extends healthy life expectancy. Preventive care also benefits from wearable health devices and predictive analytics, which help detect diseases earlier and reduce the need for expensive interventions. Improvements in accessibility through digital health solutions and mobile clinics ensure broader coverage and better health outcomes for the population. In contrast, high-tech countries may experience diminishing returns on healthcare spending, as their already advanced healthcare infrastructure makes additional investment less impactful compared to lower-tech countries.

Table 3: Fixed effects (1, 2, 3, 4 models) and 1-step dynamic panel (5, 6 models) regressions on the impact of working hours, health spending and severe material deprivation on HLY and HLE in different technological progress countries groups:

	Countries with higher technological progress		Countries with middle technological progress		Countries with lower technological progress	
	(1) ldH_life_y	(2) ldH_life_exp	(3) ldH_life_y	(4) ldH_life_exp	(5) ldH_life_y	(6) ldH_life_exp
ld_work_h_full	- 1.1** (0.018)	- 0.126 (0.302)	0.437 (0.541)	0.143 (0.422)	- 0.456 (0.448)	- 0.057 (0,844)
ld_work_h_act	0.064 (0.815)	- 0.0418 (0.361)	0.07 (0.465)	- 0.12** (0.05)	- 0.258** (0.029)	- 0.012 (0.839)
ld_Healthspen	- 0.019 (0.424)	- 0.005 (0.618)	0.024 (0.552)	- 0,037** (0.038)	- 0.033 (0.229)	- 0.004 (0.757)
d_Long_w_h	- 0.006 (0.192)	0.0018*** (2.48e-05)	- 0.001 (0.864)	0.0016*** (0.002)	- 0.0023 (0.285)	0.002 (0.209)
d_Night_w_h	0.007*** (0.005)	0.0027*** (0.0003)	0.001 (0.86)	- 0.001 (0.367)	- 0.006*** (0.032)	0.001 (0.137)
d_Work_home_h	- 0.0009 (0.341)	- 0.00027 (0.175)	- 0.0001 (0.936)	- 2.014e-05 (0.975)	-3.74e-05 (0.979)	- 0.002*** (0.0001)
d_Sev_mat_dep	0.0003 (0.596)	- 6.384e-05 (0.739)	- 0.0002 (0.597)	- 0.0003*** (0.0002)	0.001*** (0.0002)	0.0001 (0.224)
ld_Health_(-1)					- 0.056 (0.403)	- 0.02 (0.775)

© 2025 The Authors. Journal Compilation © 2025 European Center of Sustainable Development.

Obs.	133	133	190	190	119	119
Within R-sq. for (1),(2),(3),(4)mod.	0.24	0.3509	0.087	0.278		
Sargan test for (5), (6) mod.					Chi-sq.(17) = 19.8 [0.28]	Chi-sq.(17) = 27.4 [0.05]
DW for (1), (2), (3),(4) mod.	1.897	1.89	1.82	2.26		
Wald (joint) test					Chi-sq.(5) =14[0.016]	Chi-sq.(5) =4.9[0.423]
Wald (time dumm.) for (5), (6) mod.					Chi-sq. (17)=102 [0.000]	Chi-sq.(16) = 178.0 [0.000]

** $p < 0.10$. ** $p < 0.05$. *** $p < 0.01$.*
Source: elaborated by the authors based on the EUROSTAT, OECD data and the GRETL software.

Countries with high technological progress (Models 1 and 2):

Changes of usual weekly work hours in the main job (ld_work_h_full) are significant in Model 1 (p = 0.018) with a coefficient of -1.1, indicating that work hours have a strong negative relationship with life expectancy based on years. More work hours significantly reduce healthy life years. Employed persons working at night are highly significant (p = 0.005 in Model 1 and p = 0.0003 in Model 2), with a positive relationship for both dependent variables. This suggests that night work contributes positively in these models, but the underlying cause might need more investigation (perhaps due to better adaptation or healthier workers in advanced tech countries). The positive and significant relationship between life expectancy based on years and long working hours indicates better self-perceived health outcomes. This might reflect a unique scenario in high-tech countries where night and long work hours are tied to highly rewarding or fulfilling jobs, better working conditions, or effective health management practices. Similar results, only regarding employee satisfaction, were obtained by Shin *et al.* (2021). This study explores how long working hours and night shifts influence subjective well-being. It highlights that when task variety and work creativity are high, negative effects are mitigated.

The R-squared is moderate for healthy life years (0.24) and higher for healthy life expectancy based on self-perceived health (0.3509), showing a better explanation of variance in Model 2, suggesting that self-perceived health is more responsive to work-related changes.

Countries with middle technological progress (Models 3 and 4):

Changes of actual weekly hours of work in the main job are significant in Model 4 (p = 0.05), showing a small negative impact on life expectancy based on years. This implies that actual working hours can marginally decrease life expectancy based on self-perception of health in middle-tech countries. Changes in health spending are significant in Model 4 (p = 0.038), but its negative coefficient suggests that higher health spending doesn't necessarily lead to better self-perceived health outcomes in this group. Changes in long working hours are highly significant (p = 0.002 in Model 4) with a positive effect on life expectancy based on self-perception of health. This indicates that longer work hours might contribute positively to self-perceived health - this result is similar to that obtained in high-tech countries, only the effect is somewhat smaller.

Countries with lower technological progress (Models 5 and 6):

Changes in night work hours are significant in Model 5 (p = 0.032), but with a negative coefficient, showing that night work may harm health outcomes in low-tech countries. Working at home was significant in Model 6 (p = 0.0001), with a strong negative coefficient. Remote work seems to negatively affect health outcomes in these countries, possibly due to poor infrastructure or work-life balance issues. This result is the opposite of what is compared in the group of countries with higher technical progress; therefore, it presupposes that technical progress can eliminate or reduce the impact of irregular working hours on healthy life years, while ensuring work-life balance. To better understand these interactions, future research should focus on how telecommuting infrastructure impacts health outcomes. A comparative study examining the health effects of digital literacy, housing conditions, and work autonomy, while including relevant variables in the models, could help explain these differences.

Material deprivation impacts healthy life years and healthy life expectancy differently across countries with low technological progress. It positively influences healthy life years, potentially due to social support systems that extend life despite poorer living conditions. However, it negatively affects healthy life expectancy, as deprivation diminishes individuals' self-perceived health and quality of life. These contrasting effects emphasize the intricate socio-economic dynamics in less technologically advanced countries.

5. Discussion

The impact of work hours varies considerably among different groups of countries. In higher-tech nations, usual work hours are negatively correlated with HLY, while night work hours demonstrate a positive and significant effect on life expectancy. These findings indicate that the labor structure in technologically advanced economies plays a pivotal role in shaping perceived health outcomes. The presence of specialized and rewarding jobs in these areas may help alleviate the negative impacts of extended work hours.

In middle-tech countries, longer actual work hours significantly adversely affect HLY, highlighting the negative consequences of work-related stress and low job satisfaction. While health spending does offer some benefits for HLY, it does not necessarily translate into improved self-perceived health, suggesting potential inefficiencies in healthcare resource allocation. In contrast, in lower-tech countries, increased health investments provide substantial benefits, significantly enhancing both HLY and HLE. Additionally, standard work hours show a positive correlation with health outcomes, likely due to the stability that consistent employment affords, whereas actual working hours exhibit weaker associations.

A key finding across various groups is the influence of technological progress on the relationship between work and health. Countries with advanced technology appear to be more resilient to the adverse effects of irregular work patterns, likely due to their superior healthcare infrastructure, labor protections, and work-life balance policies.

© 2025 The Authors. Journal Compilation © 2025 European Center of Sustainable Development.

Conversely, countries with developing technology experience significant improvements in life expectancy as they increase their investment in healthcare. The correlation analysis between health spending and healthy life expectancy further underscores the importance of allocating healthcare resources in shaping life expectancy outcomes. The strongest correlation coefficients were found in middle- and lower-technology countries, suggesting that investment in healthcare has the most substantial impact in regions with underdeveloped medical infrastructure. These findings align with previous research indicating diminishing returns on health spending in high-income nations.

The role of severe material deprivation as a socio-economic factor in HLY and HLE is both interesting and debatable. In countries with a moderate level of technological progress, severe material deprivation is linked to a decline in healthy life expectancy. This decline may result from increased stress, reduced access to healthcare, and greater economic disparity. In contrast, in countries with lower technological progress, healthy life years appear to increase despite material deprivation. This phenomenon could be attributed to stronger community support, lower expectations, or adaptive lifestyles. Differences in social structures, healthcare availability, and psychological resilience may help explain this contrast.

6. Conclusions and further research

Study emphasizes the important relationship between work-related variables, health outcomes, and technological progress, providing insights into how WLB is influenced across groups of countries with different levels of technological advancement. In countries where technological progress exceeds the EU-27 average, the growth of usual weekly work hours is associated with a significant reduction in healthy life years. This illustrates the difficulty of maintaining optimal health standards in demanding work environments. Interestingly, night shifts and extended hours of work can positively affect self-perceived health, suggesting that rewarding work conditions, effective health management practices, or satisfying job roles can enhance overall well-being. These findings highlight the complex relationship between work schedules and health, influenced by the supportive infrastructures of more advanced nations.

On the other hand, in countries with below-average technological progress, irregular work patterns, such as night shifts and remote work, have adverse effects on health outcomes. These negative impacts are indicative of infrastructural limitations, socio-economic challenges, and a lack of supportive systems to alleviate work-related stress. Interestingly, material deprivation presents contrasting effects: while it may extend healthy life years through potential social safety nets, it also diminishes self-perceived health by lowering living standards and quality of life. These disparities highlight the essential role of technological advancement in alleviating the effects of work conditions on health and in fostering a sustainable work-life balance.

Overall, the study illustrates that while higher technological progress can help mitigate some of the adverse impacts of demanding work conditions, countries with lower levels of progress confront compounded challenges that require targeted policy interventions. Achieving an equitable work-life balance across countries calls for context-specific strategies that take into account the distinct socio-economic and technological realities of each group. Countries with advanced technologies may require stricter work and rest regulations, while those with less technological capacity may need significant investments to improve digital infrastructure and the work environment.

To expand on these findings, future research could consider incorporating additional variables, such as environmental conditions, healthcare quality, and lifestyle factors, to better understand their interactions with work-related variables and health outcomes.

References

Ashton, K., Schröder-Bäck, P., Clemens, T., Dyakova, M., Stielke, A., Bellis, M. A. (2020). The social value of investing in public health across the life course: a systematic scoping review. *BMC Public Health* 20, 597. https://doi.org/10.1186/s12889-020-08685-7

Aytemiz, L., Sart, G., Bayar, Y., Danilina, M., & Sezgin, F. H. (2024). The long-term effect of social, educational, and health expenditures on indicators of life expectancy: An empirical analysis for the OECD countries. *Frontiers in Public Health,* 12. https://doi.org/10.3389/fpubh.2024.1497794

Baltagi, B. (2021). *Econometric Analysis of Panel Data* (6th ed.). Springer.

Barnay, T. (2016). Health, work and working conditions: A review of the European economic literature. *European Journal of Health Economics*, 17(6), 693–709. https://doi.org/10.1007/s10198-015-0715-8

Borgia, M. S., Di Virgilio, F., La Torre, M., & Khan, M. A. (2022). Relationship between Work-Life Balance and Job Performance Moderated by Knowledge Risks: Are Bank Employees Ready? *Sustainability*, 14(9), 5416. https://doi.org/10.3390/su14095416

EUROPEAN COMMISSION (2023). DESI dashboard for the Digital Decade (2023 onwards). DESI dashboard for the Digital Decade (2023 onwards) - Digital Decade DESI visualisation tool

EUROSTAT (2025a). Healthy life expectancy based on self-perceived health (hlth_silc_17). Retrieved March 16, 2025, from https://ec.europa.eu/eurostat/databrowser/view/hlth_silc_17/default/ table?lang=en

EUROSTAT (2025b). Healthy life years statistics (hlth_hlye). Retrieved March 16, 2025, from https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Healthy_life_years_statistics

EUROSTAT (2025c). The average number of usual weekly hours of work in the main job (lfsa_ewhuis). Retrieved March 18, 2025, from https://ec.europa.eu/eurostat/databrowser/view/lfsa_ewhun2$defaultview/default/table?lang=en

EUROSTAT (2025d). The average number of actual weekly hours of work in the main job (lfsq_ewhais). Retrieved March 18, 2025, from https://ec.europa.eu/eurostat/databrowser/view/lfsq_ewhais/default/table?lang=en

EUROSTAT (2025e). Long working hours in the main job (lfsa_qoe_3a2). Retrieved March 18, 2025, from https://ec.europa.eu/eurostat/databrowser/view/lfsa_qoe_3a2__custom_15374134/ default/table?lang=en

EUROSTAT (2025f). Employed persons working at night as a percentage of the total employment (lfsa_ewpnig). Retrieved March 18, 2025, from https://ec.europa.eu/eurostat/databrowser/view/lfsa_ewpnig/default/table?lang=en

EUROSTAT (2025g). Percentage of employed adults working at home (lfst_hhwahchi). Retrieved March 18, 2025, from https://ec.europa.eu/eurostat/databrowser/view/lfst_hhwahchi/default/table?lang=en

EUROSTAT (2025h). Severe material deprivation rate by income quintile and household type (ilc_mddd13). Retrieved February 3, 2025, from https://ec.europa.eu/eurostat/databrowser/view/ilc_mddd13__custom_8178721/default/table

Gujarati, D. N., & Porter, D. C. (2021). *Basic Econometrics* (6th ed.). McGraw-Hill.

Heller, C., Sperlich, S., Tetzlaff, F. et al. (2022). Living longer, working longer: analysing time trends in working life expectancy in Germany from a health perspective between 2002 and 2018. *Eur J Ageing* 19, 1263–1276. https://doi.org/10.1007/s10433-022-00707-0

Holly, S. & Mohnen, A. (2012). Impact of Working Hours on Work-Life Balance. *SOEPpaper No. 465*, http://dx.doi.org/10.2139/ssrn.2135453

© 2025 The Authors. Journal Compilation © 2025 European Center of Sustainable Development.

Ibanez, Z., Leon, M., Soler, L., & Alvarino, M. (2021). *Fostering work-life balance for precarious workers: Culture and social protection systems in comparative perspective* (EUROSHIP Working Paper No. 5). Oslo Metropolitan University.
https://euroship-research.eu/wp-content/uploads/2021/07/EUROSHIP-Working-Paper-5.pdf

Kasoju, N., Remya, N.S., Sasi, R. et al. Digital health: trends, opportunities and challenges in medical devices, pharma and bio-technology. *CSIT* 11, 11–30 (2023). https://doi.org/10.1007/s40012-023-00380-3

Kruyen, P., André, S., & van der Heijden, B. (2024). *Introduction to Maintaining a Sustainable Work-Life Balance*. In P. Kruynen, S. André, & B. van der Heijden (Eds.), *Maintaining a Sustainable Work-Life Balance: An Interdisciplinary Path to a Better Future* (pp. 2-8). Edward Elgar Publishing Ltd. https://doi.org/10.4337/9781803922348.00010

Maslach, C., & Leiter, M. P. (2016). Understanding the Burnout Experience: Recent Research and Its Implications for Psychiatry. *World Psychiatry*, 15, 103-111.

Nam, T. (2014). Technology Use and Work-Life Balance. *Applied Research Quality Life* 9, 1017–1040. https://doi.org/10.1007/s11482-013-9283-1

OECD. (2022). *Main Science and Technology Indicators (MSTI database)*. OECD Data. Retrieved February 5, 2025, from https://www.oecd.org/en/data/datasets/main-science-and-technology-indicators.html

OECD. (2023). *Health spending (total, per capita, USD)*. OECD Data. Retrieved February 5, 2025, from https://data.oecd.org/healthres/health-spending.htm

Pichler, F. (2009). Determinants of Work-life Balance: Shortcomings in the Contemporary Measurement of WLB in Large-scale Surveys. *Soc Indic Res* 92, 449–469. https://doi.org/10.1007/s11205-008-9297-5

Raghupathi, V. & Raghupathi, W. (2020). The influence of education on health: an empirical assessment of OECD countries for the period 1995–2015. *Arch Public Health* 78, 20. https://doi.org/10.1186/s13690-020-00402-5

Răileanu Szeles, M. (2018). Comparative Examination of Self-Perceived Health and Other Measures of the Quality of Life Across the EU-27. *Soc Indic Res* 137, 391–411. https://doi.org/10.1007/s11205-017-1597-1

Sánchez-Hernández, M. I., González-López, Ó. R., Buenadicha-Mateos, M., & Tato-Jiménez, J. L. (2019). Work-Life Balance in Great Companies and Pending Issues for Engaging New Generations at Work. *International Journal of Environmental Research and Public Health*, 16(24), 5122. https://doi.org/10.3390/ijerph16245122

Shin, M.-G., Kim, Y.-J., Kim, T.-K., & Kang, D. (2021). Effects of Long Working Hours and Night Work on Subjective Well-Being Depending on Work Creativity and Task Variety, and Occupation: The Role of Working-Time Mismatch, Variability, Shift Work, and Autonomy. *International Journal of Environmental Research and Public Health*, 18(12), 6371. https://doi.org/10.3390/ijerph18126371

Stephen, A., Sundari, V. M, Thayumanavar B., Shakya, R. K., & Muthukumar E. (2024). Technology And Its Role In Shaping The Future Of WorkLife Balance. *Educational Administration: Theory and Practice*, 30(5), 1045–1053. https://doi.org/10.53555/kuey.v30i5.3005

Thilagavathy S., & Geetha S.N. (2023). Work-life balance a systematic review. *Journal of Management*, Vol. 20 No. 2, pp. 258-276. https://doi.org/10.1108/XJM-10-2020-0186

United Nations (2015). *Transforming our world: The 2030 agenda for sustainable development. United Nations*. https://sdgs.un.org/2030agenda

Weiss, D., & Eikemo, T.A. (2020). Technological Innovations and Social Inequalities in Global Health. In: Haring, R., Kickbusch, I., Ganten, D., Moeti, M. (eds) *Handbook of Global Health*. Springer, Cham. https://doi.org/10.1007/978-3-030-05325-3_121-1

Wong, K. P., Teh, P.-L., & Chan, A. H. S. (2023). Seeing the Forest and the Trees: A Scoping Review of Empirical Research on Work-Life Balance. *Sustainability*, 15(4), 2875. https://doi.org/10.3390/su15042875