# Digital Health, Workforce Well-being and Regional Competitiveness in the European Union: Evidence from a Multi-Indicator Cluster Analysis

Dawid Majcherek[1]

[1]SGH Warsaw School of Economics

Correspondence: Dawid Majcherek, dmajche@sgh.waw.pl

## Abstract:

Digital transformation, demographic ageing and rising mental-health needs are reshaping labour markets across the European Union (EU), accentuating long-standing disparities in workforce well-being and territorial competitiveness. While previous research has separately examined health, productivity and innovation capacity, evidence linking these domains in a coordinated, cross-country EU framework remains limited. This study addresses this gap by integrating indicators of population health and physical activity, labour productivity and sickness absence, and competitiveness and digital readiness. Using harmonised EU-27 data and an unsupervised k-means clustering approach, four distinct country configurations were identified.

Cluster 1 combines high healthy life expectancy, the highest levels of physical activity, strong labour productivity and leading performance in the Global Competitiveness Index and DESI, illustrating how mature digital ecosystems and preventive health systems facilitate the effective conversion of health capital into economic performance. Cluster 2 also exhibits excellent health outcomes but only moderate activity levels and digital readiness, suggesting unrealised productivity potential. Cluster 3-largely Central and Eastern Europe-shows the lowest health indicators and weak digital foundations, yet records the highest measured productivity and lowest sickness absence, raising concerns about sustainability and measurement differences. Cluster 4 lags across nearly all dimensions, reflecting deep structural constraints.

The results demonstrate that similar health levels do not translate into comparable productivity or competitiveness across the EU. Digital readiness, institutional design and workplace

environments significantly mediate the health–productivity link. The study highlights the need for cluster-tailored policies integrating digitalisation, prevention and occupational health to reduce territorial inequalities and strengthen the EU's long-term resilience and competitiveness.

## Background and motivation

In the European Union (EU), demographic ageing, chronic disease burdens, rising mental-health needs and uneven digital transformation have been reshaping labour markets and territorial competitiveness. Empirical work has shown that population health strongly influences labour-market outcomes and productivity, making health a core component of economic performance (OECD, 2019). Lifestyle and workplace factors such as physical inactivity, obesity and mental-health conditions have been linked to absenteeism and presenteeism, with substantial productivity losses (Burton, Edington, & Schultz, 2021). Although health and competitiveness have often been analysed in parallel, the empirical linkage between workforce health, digital readiness and productivity at the scale of the EU with twenty-seven Member States (EU-27) has remained under-specified. An integrated perspective was therefore adopted, combining population-level health outcomes and behaviours with indicators of productivity and international competitiveness. The contribution has been framed to align with the European Regional Science Association (ERSA) 2026 Congress focus on regional responses in a transition era and with Special Sessions addressing territorial disparities, digital diffusion and human capital.

## Objectives

Three questions were examined. First, it was assessed whether EU-27 countries can be grouped into coherent clusters based on a multi-domain profile that spans workforce health and lifestyle, labour productivity and absence, and competitiveness. Second, it was analysed what patterns link workers' health and behaviour to productivity and competitiveness across clusters. Third, it was explored whether similar health outcomes translate into similar productivity or competitiveness, or whether the conversion of health capital is conditioned by digital readiness and institutional context.

## Data and indicators

A compact dataset was assembled from established sources. Overall population health was captured by Health-Adjusted Life Expectancy (HALE), while behavioural health capital was proxied by the share of people regularly engaging in non-work-related physical activity. Productivity was reflected by labour productivity per hour worked and by absence from work due to personal health problems. Competitiveness was represented by the Global Competitiveness Index (GCI) and the Digital Economy and Society Index (DESI), which summarise institutional quality, innovation and digital diffusion. All indicators were harmonised and standardised prior to analysis. Indicator choice followed prior evidence on health–productivity links and on the role of digital adoption in enabling innovation and knowledge flows.

## Methods

Unsupervised learning was employed to reveal regularities beyond simple bivariate comparisons. Specifically, k-means clustering was applied to the standardised variables (Hartigan et al., 1979). The number of clusters was selected via the Elbow criterion, the Silhouette coefficient and the Gap Statistic, which converged on a four-cluster solution. Multiple random initialisations were used to limit sensitivity to starting values. Post-clustering, clusters were profiled by domain (health and behaviour, productivity, competitiveness and digital readiness) and interpreted using literature on absenteeism, presenteeism, prevention and the role of digital infrastructure and skills.

## Results

Table 1. EU-27 country clusters based on health profiles, labor productivity, and competitiveness levels.

| Measure | Variable | Cluster 1 | Cluster 2 | Cluster 3 | Cluster 4 |
|---|---|---|---|---|---|
| Health | HALE | 70,13 | 70,16 | 64,77 | 68,70 |
| Health | Sport | 64,91 | 39,76 | 31,03 | 29,33 |

| | | | | | |
|---|---|---|---|---|---|
| Productivity | Sickness Absence | 49,9% | 31,5% | 20,5% | 16,7% |
| Productivity | Labour productivity | 107,1% | 103,8% | 115,5% | 99,9% |
| Competitiveness | DESI | 51,57 | 44,43 | 37,46 | 33,31 |
| Competitiveness | GCI | 79,45 | 73,03 | 67,45 | 63,64 |

Source: Own elaboration.

Four distinct configurations were identified within the EU-27. Cluster 1 combined high HALE with the highest prevalence of regular physical activity, strong labour productivity, relatively elevated sickness absence and the highest scores on both GCI and DESI. This configuration was interpreted as reflecting effective social insurance, robust preventive care and mature innovation–digital ecosystems that help convert health and skills into competitive advantage. Cluster 2 displayed the highest HALE but only moderate physical activity. Productivity and competitiveness were solid yet below the frontier set by Cluster 1, suggesting that excellent health stock does not automatically yield maximum productivity when behavioural intensity and digital diffusion are not equally advanced. Cluster 3, concentrated in Central and Eastern Europe (CEE), exhibited the lowest HALE and low physical activity alongside the highest measured labour productivity and the lowest sickness absence, but with the weakest or only moderate scores on GCI and DESI. This pattern indicated a possible decoupling of measured productivity from underlying health and digital foundations and raised questions about sustainability. Cluster 4 showed mid-range HALE, the lowest physical activity and productivity, and the weakest performance on competitiveness and digital indicators, pointing to foundational constraints.

The cluster structure revealed that similar levels of population health do not guarantee similar productivity or competitiveness. The conversion of health capital into economic performance appeared to be strongly conditioned by digital readiness and institutional design. In Cluster 1, high digital diffusion and innovation capacity were aligned with strong preventive and occupational systems, enabling high value creation even with more frequent reporting of sickness absence. In Cluster 2, the gap between excellent health stock and only moderate activity intensity suggested that health behaviours and workplace environments still delimit the productivity return on health.

In Cluster 3, the coexistence of weak health and digital indicators with high measured productivity implied reliance on work intensity, sectoral composition and possible reporting differences. Without systematic investments in prevention, Occupational Safety and Health (OSH) and digital catch-up, such gains may be difficult to sustain. Cluster 4 appeared to face basic constraints in both behavioural health and digital foundations.

## Policy implications

Cluster-sensitive priorities were proposed. For Cluster 1, absenteeism should be managed through early Return-to-Work (RTW) pathways and mental-health support without eroding protection, while next-generation digital health-interoperability, real-world data and Artificial Intelligence (AI) for risk prediction-could be scaled to push the productivity frontier. For Cluster 2, greater emphasis on vigorous activity and evidence-based Workplace Physical Activity interventions (WPPAs), embedded within comprehensive workplace design and supported by digital tools, could unlock remaining productivity potential; complementary digital-skills programmes for small and medium-sized enterprises would accelerate diffusion. For Cluster 3, priorities include strengthening prevention and primary care, expanding OSH capacity and accelerating digital infrastructure and skills to reconnect productivity with sustainable health and innovation foundations; improvements in administrative and statistical systems would reduce under-reporting and enhance comparability. For Cluster 4, foundational investments in broadband, e-government and e-health, coupled with population-wide activity programmes and sectoral diversification aligned with local capabilities, were identified as prerequisites for breaking low-productivity equilibria. At the EU level, cohesion instruments and Research and Innovation Strategies for Smart Specialisation (RIS3) should integrate health and digital objectives with measurable productivity targets.

## Robustness and limitations

The analysis was conducted at the national level, which conceals within-country heterogeneity. Nevertheless, national health, social insurance and digital frameworks define constraints and incentives within which regions operate; the revealed cluster structure therefore retains regional policy salience. Causal identification was not pursued, and differences in measurement of productivity and sickness absence cannot be ruled out. Future work should use panel designs, NUTS-2 regional data and firm-level metrics to track how workplace design, technology adoption

and management quality mediate the health–productivity link. Sensitivity checks using alternative indicators of innovation and digital intensity-such as research and development effort, patenting or cloud uptake-would further test cluster stability.

## Conclusion

Comparable health levels across EU-27 countries do not automatically translate into comparable productivity or competitiveness. The capacity to transform health capital into durable economic advantage is strongly shaped by digital readiness, institutional architecture and the quality of workplace environments. Where digital and innovation systems are mature and prevention is embedded, health and skills are more readily converted into productivity. Where digital diffusion is limited and prevention is weak, reliance on intensity rather than innovation is more likely. Policies that jointly advance digital transformation and population and workplace health-tailored to cluster-specific constraints and opportunities-offer a credible pathway to strengthen Europe's territorial resilience and competitiveness.

## References (APA)


Burton, W. N., Edington, D. W., & Schultz, A. B. (2021). Lifestyle medicine and worker productivity. American Journal of Lifestyle Medicine, 15(2), 136–139.

OECD. (2019). Health for Everyone? Social Inequalities in Health and Health Systems. OECD Publishing.

European Commission. (2022). Digital Economy and Society Index (DESI) – 2022 edition.

Eurostat. (2022). Physical activity (HLTH_EHIS_PE3I).

Eurostat. (2022). Absence from work due to personal health problems (HLTH_EHIS_AW1E).

Eurostat. (2025). Labour productivity per hour worked (TIPSNA70).

Hartigan, J. A., & Wong, M. A. (1979). Algorithm AS 136: A K-Means clustering algorithm. Journal of the Royal Statistical Society: Series C (Applied Statistics), 28(1), 100–108.

Kodinariya, T., & Makwana, P. (2013). Review on determining the number of clusters in K-means clustering. International Journal of Advance Research in Computer Science and Management Studies, 1, 90–95.

World Economic Forum. (2018). The Global Competitiveness Report 2018.

World Health Organization. (2019). Global Health Observatory (GHO): Healthy life expectancy (HALE).