GREEN HUMAN CAPITAL AND SUSTAINABLE HEALTHCARE: EVIDENCE FROM ROMANIA (2014–2024)

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ABSTRACT: *This paper examines green human capital as a determinant of sustainable healthcare in Romania during 2014-2024. Green human capital is understood as the combination of professional, digital and sustainability-related competencies that enables health workers and organisations to provide effective care while improving resilience and reducing environmental pressures. The study integrates health-economics and labour-market perspectives and uses secondary evidence from Eurostat, OECD, the European Commission and the World Health Organization. A descriptive and comparative design is employed to assess workforce capacity, health financing, professional development, digital readiness and the emerging role of green skills. The evidence indicates substantial quantitative progress in physician density, but persistent shortages, territorial imbalances, migration pressures and comparatively low health expenditure continue to constrain system performance. In 2021 Romania recorded 3.5 practising doctors and 8.0 nurses per 1,000 population, compared with EU averages of 4.1 and 8.5. In 2023 health expenditure represented 5.8% of GDP, compared with 10.0% in the EU. These gaps suggest that workforce expansion alone is insufficient. Sustainable healthcare requires continuous professional development, digital capabilities and explicit climate-health competencies embedded in education, organisational practice and workforce planning. The paper concludes that green human capital should be treated as a strategic health-system investment connecting workforce resilience, efficiency, digital transformation and environmental sustainability.*

Keywords: *health economics; human capital; green skills; healthcare workforce; sustainability; Romania; labour market; health systems*

JEL classification: *I11; I15; I18; J24; Q56*

1. INTRODUCTION

Health systems are increasingly recognised not only as providers of medical care but also as major employers, investors and users of energy, materials, pharmaceuticals and technology. At the same time, climate change is creating new health risks and increasing

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pressure on already constrained health systems. The World Health Organization (WHO, 2020) therefore frames climate-resilient and environmentally sustainable healthcare facilities around four interconnected requirements: the health workforce; water, sanitation and healthcare waste; sustainable energy; and infrastructure, technologies and products. This perspective places human capital at the centre of the transition because infrastructure and technology cannot generate sustained improvements without a workforce able to use them effectively.

The concept of green human capital extends conventional human-capital theory by incorporating environmental literacy, resource-efficiency competencies, climate-risk awareness and the ability to adopt low-carbon practices. In healthcare, these competencies intersect with digital skills and traditional clinical knowledge. Recent European evidence emphasises that a climate-smart health workforce requires capabilities for adaptation, mitigation, organisational change and communication, while green-skills education and training remain at an early stage across Europe (Schmidt et al., 2025).

Romania provides a relevant case because workforce expansion has occurred alongside persistent structural weaknesses. The attached manuscript identifies shortages, migration, uneven regional distribution and limited integration of green competencies as central challenges to sustainable workforce formation. The same manuscript defines green human capital in healthcare through environmental awareness, resource efficiency and sustainable practices in professional education and training.

The empirical problem is therefore not simply whether Romania has more healthcare professionals than a decade ago, but whether the workforce possesses the capabilities and institutional conditions required to translate quantitative expansion into accessible, efficient and sustainable care. The 2023 Country Health Profile reported 3.5 practising doctors and 8.0 nurses per 1,000 population in 2021, both below EU averages, while the 2025 profile shows that health spending in 2023 remained the lowest in the EU at EUR 1,800 per capita in purchasing-power terms and 5.8% of GDP (OECD/European Observatory, 2023, 2025).

Against this background, the paper analyses the evolution of health-sector human capital in Romania over 2014-2024 and assesses its relevance for sustainable healthcare. It addresses four research questions: (RQ1) How has Romania's healthcare workforce capacity evolved? (RQ2) Which structural constraints limit the conversion of workforce growth into health-system performance? (RQ3) How should digital and green competencies be incorporated into the concept of health-sector human capital? (RQ4) What policy measures could strengthen workforce resilience and the sustainability of healthcare delivery?

The contribution of the paper lies in connecting health economics, labour-market analysis and sustainability. Rather than treating green skills as an isolated environmental topic, the study interprets them as part of a broader bundle of competencies that can affect resource use, organisational efficiency, service resilience and the capacity to adopt digital and low-carbon technologies.

2. LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

Human capital is a core determinant of health-system capacity because healthcare production is highly skill-intensive. The quantity, distribution and quality of physicians, nurses and other health professionals affect access, waiting times, continuity of care and the ability of systems to respond to demographic and epidemiological change. OECD and European Observatory assessments consistently emphasise that workforce planning must address not only headcounts but also skill mix, territorial distribution, working conditions and retention.

Sustainable healthcare adds a further competency dimension. WHO (2020) argues that environmentally sustainable facilities require workforce involvement in energy, waste, water, infrastructure and procurement practices. More recent European work defines a climate-smart

workforce through three capacities: workforce capability to respond to climate-related health risks, organisational capacity to implement low-carbon and resilient practice, and communication capacity to explain climate-health risks (Schmidt et al., 2025).

Green skills in healthcare include climate-health literacy, sustainable clinical practice, resource stewardship, waste reduction, sustainable procurement and the ability to participate in organisational decarbonisation. These competencies are not substitutes for clinical skills. They complement them by changing how services are designed and delivered. WHO's climate-change and health training programme similarly includes risk assessment, greenhouse-gas accounting, adaptation and mitigation planning, and climate-informed decision-making (WHO, 2026).

Digital capabilities are closely related to this transition. Telemedicine, electronic records, clinical data management, artificial intelligence and digital logistics can reduce unnecessary travel, support prevention and improve resource allocation, but they also require new skills and governance. Recent BeWell evidence identifies digital skills, green skills and emerging professional profiles as priority areas for health and care workforce education, and reports uneven provision of green-skills training across Europe (European Observatory on Health Systems and Policies, 2025a, 2025b).

For Romania, the conceptual framework must also account for migration and financing. Training additional professionals generates limited domestic returns if retention is weak or if staffing is geographically concentrated. Likewise, limited financing can constrain salaries, working conditions, continuous professional development and the adoption of sustainable technologies. Green human capital should therefore be understood as an interaction between workforce quantity, skill quality, organisational capacity and system resources.

Three research expectations follow.

H1: higher healthcare workforce capacity should be associated descriptively with stronger system capacity, but its effect is conditioned by distribution and retention.

H2: continuous training and digital readiness should increase the adaptability and effective use of human capital.

H3: explicit green competencies should become increasingly relevant to healthcare resilience and efficiency as climate and sustainability requirements are incorporated into health-system management.

3. DATA AND METHODOLOGY

This study adopts a descriptive and comparative research design to examine the role of green human capital in the development of sustainable healthcare in Romania. The methodological approach combines quantitative indicators of healthcare workforce capacity and financing with qualitative evidence concerning professional development, digital readiness, sustainability competencies, workforce retention and territorial distribution. This mixed analytical perspective is appropriate because green human capital in healthcare cannot be adequately captured by a single statistical indicator. Rather, it reflects the interaction between the quantity of available human resources, the quality and adaptability of professional competencies, and the institutional conditions that determine how effectively these resources are deployed.

The empirical analysis is based exclusively on secondary data obtained from internationally recognised institutional sources, primarily Eurostat, the Organisation for Economic Co-operation and Development (OECD), the European Observatory on Health Systems and Policies, the European Commission and the World Health Organization (WHO). Priority is given to harmonised indicators and official country-level assessments in order to ensure comparability, transparency and methodological consistency. OECD and European

Observatory data are used mainly to evaluate healthcare workforce density and health expenditure, while European Commission reports provide complementary evidence regarding workforce shortages, professional mobility, digitalisation and health-system reforms. WHO publications are used to operationalise the emerging sustainability and climate-health dimensions of healthcare competencies (OECD/European Observatory on Health Systems and Policies, 2023, 2025; WHO, 2020, 2026).

The general analytical period covers 2014–2024, corresponding to a decade characterised by significant changes in European healthcare systems, including demographic pressures, increasing workforce mobility, accelerated digitalisation, the COVID-19 pandemic and the growing integration of environmental sustainability into health policy. However, not all indicators are available as complete annual series for the entire period. Healthcare workforce statistics, expenditure indicators, digital-health measures and sustainability-related competencies are published according to different reporting schedules and methodological frameworks. Consequently, the analysis uses the latest comparable observation available for each indicator, while longer-term evidence is employed whenever consistent historical information exists. Missing observations are not interpolated, since artificial completion of the series could create an unjustified impression of statistical precision.

3.1. Conceptualisation and selection of indicators

The methodological framework conceptualises green human capital in healthcare as a multidimensional construct. Conventional human-capital approaches generally emphasise education, professional qualifications, experience and skills. In the context of sustainable healthcare, however, this definition needs to be extended to incorporate competencies associated with climate-related health risks, resource efficiency, environmentally sustainable clinical practice, digital technologies and organisational adaptability. WHO (2020) emphasises that climate-resilient and environmentally sustainable healthcare systems require not only appropriate infrastructure and technologies but also a workforce capable of integrating sustainability considerations into routine health-service delivery.

Accordingly, the indicators included in the study are organised into several interconnected analytical dimensions. Workforce capacity represents the quantitative foundation of health human capital and is measured primarily through the number of practising physicians and nurses per 1,000 inhabitants. These indicators provide information about the availability of core healthcare professionals and allow Romania's position to be compared with broader European benchmarks.

The second dimension concerns health-system financing, measured through current health expenditure as a percentage of GDP and expenditure per capita adjusted for purchasing-power differences. Financing is treated as a conditioning variable rather than as a direct component of green human capital. Adequate financial resources influence recruitment, remuneration, working conditions, professional development and the adoption of digital and sustainable technologies. Consequently, workforce competencies cannot be evaluated independently of the institutional capacity to finance and utilise them effectively.

Another dimension addresses workforce retention and territorial distribution. Aggregate workforce density can conceal substantial inequalities between regions and between urban and rural areas. Similarly, an increase in the number of trained professionals does not necessarily translate into greater domestic healthcare capacity when migration or professional exit remains significant. Evidence concerning mobility, shortages and geographical disparities is therefore incorporated into the interpretation of the quantitative indicators.

The qualitative component of human capital is captured through evidence on continuous professional development, digital readiness and sustainability-related

competencies. Continuous learning is particularly important in healthcare because technological change, new treatment methods, digital health systems and emerging climate-related risks continuously modify competency requirements. Digital readiness includes capabilities associated with electronic health records, telemedicine, health-data management and other digital technologies. Green competencies include climate-health literacy, sustainable resource use, waste reduction, environmentally responsible procurement and participation in organisational decarbonisation and resilience strategies (WHO, 2020, 2026).

These dimensions are summarised in Table 1.

Table 1. Analytical dimensions, indicators and data sources

Dimension	Indicator / evidence	Reference period
Workforce capacity	Practising physicians per 1,000 population	mid-2010s to 2021/2023
Workforce capacity	Nurses per 1,000 population	mid-2010s to 2021
Financing	Current health expenditure (% GDP; PPS per capita)	2021–2023
Retention & distribution	Migration and territorial shortages	2014–2024 evidence
Human-capital quality	Continuous professional development and training	2014–2024 evidence
Green human capital	Climate-health, sustainability and resource-efficiency competencies	Current policy framework
Digital readiness	Digital-health and data competencies	Current policy framework

Source: Author's synthesis based on OECD/European Observatory on Health Systems and Policies (2023, 2025), WHO (2020, 2026) and European Observatory on Health Systems and Policies (2025a, 2025b).

Note**:** Reference years differ by indicator. The analysis uses the latest comparable observations available and does not interpolate missing annual data.

Table 1 demonstrates that the empirical framework deliberately combines stock, quality and contextual indicators. Physician and nurse densities approximate the quantitative stock of healthcare human capital, whereas continuous training, digital capabilities and sustainability competencies reflect its qualitative development and adaptability. Financing, migration and territorial distribution are incorporated because they determine the extent to which the existing stock of human capital can be retained, geographically allocated and transformed into effective healthcare services.

3.2. Analytical methods

The empirical analysis employs three complementary methods: benchmark comparison, relative-gap analysis and qualitative triangulation. Benchmarking is used to compare Romanian healthcare indicators with corresponding EU values wherever comparable data are available. This approach makes it possible to distinguish domestic improvement from relative convergence. An indicator may improve in Romania while the gap with the EU remains substantial if European performance develops at a similar or faster rate.

For indicators expressed in comparable quantitative units, Romania's relative position is calculated as:

$$RP_i=\frac{XRO,i}{XEU,I}\times 100$$

where $X_{RO,i}$ represents the Romanian value of indicator i, and $X_{EU,i}$ represents the corresponding EU benchmark. A value of 100% indicates parity with the European benchmark, while values below 100% indicate a relative performance gap.

Where appropriate, the absolute Romania–EU difference is also considered:

$$G_{api}=X_{EU,i}-X_{RO,i}$$

This measure is particularly useful for workforce-density and expenditure indicators because it preserves the original unit of measurement and therefore provides an intuitive representation of the distance between Romania and the European benchmark.

Percentage changes over time are calculated when sufficiently comparable beginning- and end-period observations are available:

$$\Delta\%=\frac{Xt-X0}{X0}\times 100$$

where X_0 denotes the initial observation and X_t the latest comparable observation. Percentage changes are interpreted cautiously, particularly when initial values are low or when methodological revisions may affect comparability.

The quantitative analysis is complemented by qualitative triangulation of institutional evidence. OECD country profiles, European Commission assessments, European Observatory studies and WHO policy frameworks are used to interpret statistical patterns and identify mechanisms that cannot be directly observed through aggregate indicators. This procedure is especially relevant for migration, continuous professional development, digital competencies and green skills, for which harmonised annual quantitative series remain limited.

3.3. Analytical framework for green human capital

The study assumes that sustainable healthcare performance emerges from an interaction between the stock of healthcare workers and the competencies that determine their capacity to adapt to new technological and environmental requirements. The analytical relationship can be represented conceptually as:

Workforce capacity + professional development + digital competencies + green competencies → adaptive human capital → resilient and sustainable healthcare

This relationship is conditioned by:

financing + retention + territorial distribution + organisational capacity + technology + health policy.

The framework does not assume that an increase in physician or nurse density automatically produces sustainable healthcare outcomes. A country may increase the number of health professionals while continuing to experience regional shortages, migration, inadequate working conditions or insufficient professional development. Similarly, investment in digital or low-carbon infrastructure may produce limited benefits when healthcare professionals do not possess the competencies required to use new technologies effectively.

Green human capital is therefore interpreted as an adaptive capability. Its relevance lies not only in environmental knowledge but also in the ability of healthcare professionals and

organisations to respond to climate-related health risks, reduce unnecessary resource consumption, adopt digital solutions and maintain service continuity under changing conditions. This interpretation is consistent with WHO's approach to climate-resilient and environmentally sustainable healthcare and with recent European discussions concerning the development of green and digital competencies within the health and care workforce (WHO, 2020, 2026; European Observatory on Health Systems and Policies, 2025a, 2025b).

3.4. Methodological limitations

Several limitations must be acknowledged. The most important concerns the absence of a harmonised annual statistical indicator directly measuring green human capital or green skills among Romanian healthcare professionals. Existing international databases provide detailed information on workforce numbers, expenditure and selected digital-health indicators, but sustainability-related professional competencies are generally documented through policy frameworks, surveys or individual projects rather than continuous national statistical series.

For this reason, the paper does not construct an artificial composite green-human-capital index from indicators that differ substantially in definition and coverage. Nor are missing annual observations interpolated. Such procedures could generate apparent quantitative precision without a sufficiently robust empirical foundation.

An other limitation concerns differences in reference years. Workforce statistics often become available with a reporting lag, whereas expenditure and policy information may refer to more recent periods. Comparisons are therefore based on the latest methodologically compatible evidence rather than on the assumption that all indicators refer to exactly the same year.

The last reason, the descriptive design does not permit causal inference. Although relationships between workforce capacity, financing, digital competencies and sustainable healthcare can be theoretically justified, the available dataset is insufficient to establish that changes in one dimension directly cause changes in another. The findings should therefore be interpreted as comparative associations and structural patterns, not as estimated causal effects.

Consequently, no regression results are reported. An econometric extension would require a substantially larger dataset, potentially combining multi-country panel data with harmonised indicators of workforce characteristics, digitalisation, environmental performance and health-system outcomes. Alternatively, facility-level data could be used to investigate whether hospitals or healthcare organisations with stronger green and digital competencies achieve measurable improvements in resource efficiency, emissions, service quality or resilience.

Despite these limitations, the methodology provides a coherent basis for examining Romania's position because it combines internationally comparable quantitative evidence with institutional and policy information. This approach is particularly appropriate for an emerging research field in which the concept of green human capital in healthcare is developing more rapidly than the statistical systems designed to measure it.

4. RESULTS

4.1. Healthcare workforce capacity

The first dimension concerns the quantitative evolution of the healthcare workforce. Romania has increased the number of physicians over the last decade, but the improvement has not eliminated shortages or brought all professional categories to EU levels. The original

manuscript already identifies physician expansion alongside persistent nurse shortages and migration pressures. Table 2 summarises the most comparable benchmark evidence.

Table 2. Healthcare workforce indicators: Romania and EU benchmark

Indicator	Romania	EU	Year	Romania/EU
Practising doctors (per 1,000 population)	3.5	4.1	2021	85.4%
Nurses (per 1,000 population)	8.0	8.5	2021	94.1%
Hospital beds (per 1,000 population)	7.2	4.8	2021	150.0%

Source: OECD/European Observatory on Health Systems and Policies (2023), Romania: Country Health Profile 2023.
Note: Romania/EU values are author calculations. Higher hospital-bed density should not be interpreted automatically as superior performance because the Romanian system remains comparatively hospital-centric.

Table 2 indicates that Romania remained below the EU average in both physician and nurse density in 2021. The physician gap was larger, with Romania reaching about 85% of the EU benchmark, while nurse density reached about 94%. At the same time, hospital-bed density was 50% above the EU average. This combination is important from a health-economics perspective: relatively high physical hospital capacity coexists with workforce constraints, suggesting that sustainable performance depends on a better balance between infrastructure, staffing and primary-care development rather than on physical capacity alone (OECD/European Observatory, 2023).

The workforce problem is also spatial and organisational. National averages conceal shortages in rural and disadvantaged areas, while migration can reduce the domestic return on public and private investment in medical education. Quantitative expansion should therefore be interpreted as necessary but insufficient: retention, distribution and skill mix determine how effectively additional personnel improve access and system resilience.

4.2. Health financing and the conditions for human-capital formation

Human-capital formation is shaped by the resources available for recruitment, retention, training and technological modernisation. Romania's health-financing gap remains substantial, limiting the institutional environment in which workforce capabilities are developed and used.

Table 3. Health expenditure in Romania compared with the EU

Indicator	Romania	EU	Year	Romania/EU
Health expenditure per capita (PPS EUR)	1,800	3,832	2023	47.0%
Current health expenditure (% GDP)	5.8%	10.0%	2023	58.0%
Out-of-pocket share of health spending	23%	16%	2023	143.8%

Source: OECD/European Observatory on Health Systems and Policies (2025), Country Health Profile 2025: Romania.
Note**:** Per-capita expenditure is adjusted for purchasing-power differences. Romania/EU ratios are author calculations.

Table 3 shows that Romania's health expenditure per capita was less than half the EU average in 2023, while expenditure as a share of GDP reached only 58% of the EU benchmark. The comparatively high out-of-pocket share also indicates greater direct financial pressure on

households. These figures matter for green human capital because limited financing constrains staffing, continuous education, occupational conditions and the adoption of digital and environmentally sustainable technologies. The sustainability transition therefore cannot be separated from the broader financing capacity of the health system.

The composition of expenditure is equally relevant. The 2025 Country Health Profile reports a large inpatient-care share and relatively low expenditure on prevention and long-term care. A workforce strategy centred on sustainability should consequently support stronger primary and preventive care, where professional competencies can reduce avoidable hospital use and improve resource efficiency.

4.3. Training, digital skills and green human capital

The qualitative dimension of human capital concerns whether professional competencies evolve in line with technological and environmental change. In the original manuscript, limited lifelong learning and weak integration of green competencies were identified as important barriers. Recent European evidence supports treating this as a wider workforce challenge rather than a Romania-specific educational issue.

Table 4. Core competency domains for a climate-smart healthcare workforce

Competency domain	Examples	Expected system contribution
Climate-health literacy	Climate risks, vulnerability assessment, prevention	Adaptation and resilience
Low-carbon clinical practice	Resource stewardship, emissions awareness	Mitigation and efficiency
Sustainable operations	Waste, energy, water, procurement	Lower environmental footprint
Digital health	Telemedicine, data management, AI literacy	Access, productivity and monitoring
Communication & leadership	Risk communication, organisational change	Implementation and public trust
Continuous professional development	**Upskilling, reskilling, accreditation**	**Adaptability over the career cycle**

Source: Author's synthesis based on WHO (2020, 2026) and Schmidt et al. (2025).

Note: The table identifies competency domains recommended in international frameworks; it does not measure their current prevalence among Romanian health professionals.

Table 4 shows that green human capital is broader than environmental awareness. It combines climate-health knowledge with operational, digital, communication and continuous-learning competencies. The European Observatory notes that green-skills education in European health systems remains at an early stage and recommends systematic education and training across professional levels, including continuing professional development and accreditation (Schmidt et al., 2025). This provides a strong rationale for integrating sustainability into Romanian medical and health-professional curricula rather than treating it as optional training.

Digital and green competencies are complementary. Electronic records, telemedicine and data-driven management can improve access and reduce unnecessary resource use, while digital monitoring can support energy, procurement and waste-management objectives. However, technology does not generate efficiency automatically: workforce capability,

organisational routines and leadership determine whether digital tools translate into better outcomes.

4.4. Sustainability, resilience and healthcare delivery

A sustainable health system must simultaneously protect population health, remain operational under climate stress and reduce avoidable environmental impacts. WHO estimates that healthcare contributes more than 4% of global net climate emissions and therefore has both adaptation and mitigation responsibilities. The transition requires workforce participation because decisions about prescribing, procurement, waste, energy use and service organisation are embedded in everyday professional practice.

For Romania, the implication is that sustainability policy should be connected to existing system weaknesses. Staff shortages and overwork can reduce participation in training; hospital-centred service delivery can increase resource intensity; and limited financing can delay modernisation. Green-skills initiatives will therefore have greater impact when combined with workforce retention, primary-care strengthening, digital infrastructure and investment in resilient facilities.

5. DISCUSSIONS

The findings reveal a central asymmetry in Romania's healthcare transformation. The stock of health human capital has improved, especially among physicians, but the institutional conditions required to convert this improvement into resilient and sustainable performance remain weaker. Below-EU workforce densities, low health expenditure, migration and uneven distribution continue to constrain access, while emerging green and digital competency requirements add new demands to an already pressured workforce.

This result supports H1 only in a qualified sense. More physicians and nurses increase potential service capacity, but the effect depends on where professionals work, whether they remain in the country, and whether organisational and financial conditions allow their skills to be used efficiently. Human capital quantity is therefore an incomplete measure of health-system capability.

H2 is supported conceptually by the growing importance of continuous training and digital readiness. Rapid technological change means that initial professional education cannot provide all competencies required across a career. Digital-health systems, AI-supported tools and new service models create a continuous need for upskilling. In economic terms, training raises the productivity of existing human capital when complementary technologies and organisational capabilities are present.

H3 is also supported at the conceptual and policy level, although direct Romanian green-skills data remain insufficient for statistical testing. WHO and European Observatory frameworks demonstrate that climate-health literacy, low-carbon practice, sustainable operations and risk communication are becoming explicit workforce requirements. The appropriate conclusion is therefore not that green skills have already produced measurable Romanian health outcomes, but that they represent an increasingly important capability gap that workforce policy must address.

The health-economics implication is that green human capital should be evaluated as an investment rather than a compliance cost. Better resource stewardship can reduce waste and operating costs; climate preparedness can reduce disruption; digital and preventive capabilities can improve service allocation; and workforce involvement can increase the effectiveness of infrastructure investments. These benefits are plausible channels, but future Romanian research should quantify them using facility-level or panel data.

6. POLICY IMPLICATIONS

Romania should integrate climate-health and sustainability competencies into undergraduate medical, nursing and allied-health curricula, residency training and continuing professional development. Training should cover climate-related health risks, sustainable clinical practice, healthcare waste, resource stewardship and climate-resilient service delivery.

A second priority is to connect green skills with digital transformation. Professional development should combine sustainability with telemedicine, clinical data management, cybersecurity, AI literacy and digital workflow redesign. Joint green-digital training is more likely to generate operational change than parallel programmes developed in isolation.

Third, workforce retention and territorial distribution must remain central. Green and digital upskilling cannot compensate for chronic understaffing. Incentives for underserved areas, improved working conditions, career development and stronger primary-care teams are necessary to protect the return on investment in professional education.

Fourth, healthcare organisations should create operational mechanisms for sustainability, including multidisciplinary green teams, environmental-performance indicators and staff participation in procurement, waste and energy initiatives. International evidence suggests that education has greater impact when sustainability objectives are embedded in organisational management and quality systems.

Finally, Romania needs better data. Workforce statistics should be linked with continuing-education participation, digital competencies, facility-level environmental indicators and service outcomes. Such data would allow future research to move from descriptive analysis to robust causal evaluation of whether green human capital improves efficiency, resilience and health outcomes.

7. CONCLUSIONS

This paper examined green human capital as a determinant of sustainable healthcare in Romania during 2014-2024. The evidence shows meaningful quantitative improvement in workforce capacity, but also persistent shortages, financing constraints, migration and territorial imbalances. Romania's 2021 physician and nurse densities remained below EU averages, while 2023 health expenditure was substantially lower than the EU benchmark.

The main conclusion is that sustainable healthcare depends on the quality and adaptability of human capital as much as on its quantity. Clinical expertise must increasingly be complemented by digital capabilities, climate-health literacy, resource-efficiency skills and continuous professional development. These competencies can support resilience and environmental performance, but their effectiveness depends on adequate financing, retention, organisational leadership and modern infrastructure.

The study is limited by the absence of a harmonised annual Romanian indicator of green competencies in healthcare and by differences in reference years across workforce and expenditure datasets. Consequently, the analysis is descriptive and does not claim causal effects. Future research should construct measurable green-human-capital indices, use facility-level or cross-country panel data, and test relationships with efficiency, emissions, accessibility and health outcomes.

For Romania, the policy challenge is therefore to move from workforce expansion towards workforce transformation. Green human capital should become an explicit component of health-system planning, connecting education, digitalisation, climate resilience, organisational performance and long-term financial sustainability.

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