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FINANCIAL AND INSTITUTIONAL SUSTAINABILITY OF THE PUBLIC HEALTH SYSTEM: EVOLUTIONARY AND SPATIAL-TEMPORAL PATTERNS

ABSTRACT

Ensuring the long-term sustainability of public health systems requires not only institutional reforms but also robust, equitable financing. This has become particularly urgent amid accelerating demographic aging, rising costs of healthcare delivery, and recurrent global crises such as the COVID-19 pandemic. The war in Ukraine has further highlighted the vulnerability of public health systems. This study analyses financial and institutional trajectories across 11 European countries (Switzerland, the Netherlands, Malta, Italy, Spain, Norway, France, Sweden, Portugal, Luxembourg, and Ukraine) from 2000 to 2024 to identify how financing patterns shape sustainable public health systems. Using a set of financial indicators (CHE per capita; CHE as % of GDP; government share of CHE; out-of-pocket and private shares; GGHE-D per capita; GDP per capita PPP) alongside institutional, workforce, and outcome metrics, we document large and persistent cross-country disparities. We found wide disparities in financing patterns, with wealthy countries consistently spending more and relying on stronger public contributions, while lower-resource settings such as Ukraine showed rapid but uneven growth, often accompanied by high private and household burdens. Trends reveal both convergence toward stronger public financing in some states and growing privatization or household burden in others (e.g., rising OOPE in Ukraine and Malta; increasing private share in the Netherlands). These financing patterns correlate closely with equity and outcome gaps: constrained public financing and high OOPE coincide with poorer health-outcome indicators. We conclude that financial reforms - expanding public fiscal space for health, reducing out-of-pocket exposure, stabilizing government health investments, and targeting incremental increases in GGHE-D per capita for low-resource settings - are essential to strengthen sustainability and equity. Strengthened financial data systems and coordinated, equity-oriented policy strategies are recommended to support sustainable and inclusive public health systems across Europe.

Keywords: public health system, health financing, institutional sustainability, spatial-temporal patterns, comparative analysis, regional disparities, health system performance, government health expenditure, out-of-pocket expenditure, financial sustainability

JEL Classification: I18, O11, O57, H51, H75, I15

INTRODUCTION

The sustainability of public health systems is multifaceted, encompassing both financial and institutional dimensions. Financial sustainability pertains to the system's capacity to mobilize, allocate, and manage resources effectively and equitably over time, ensuring the continuity and efficiency of healthcare provision. Institutional sustainability, in turn, relates to the robustness, adaptability, and legitimacy of governance arrangements, regulatory frameworks, and inter-organizational coordination mechanisms that underpin the health system's long-term resilience. These components are essential for safeguarding universal access, preserving service quality, and reinforcing public trust in health governance amidst ongoing social, economic, and political transitions. Among these factors, financial sustainability is particularly decisive, as the level and structure of health

financing not only condition institutional capacity but also shape equity, access, and the resilience of public health systems.

In addition to these core dimensions, workforce capacity and health outcomes represent critical determinants of system viability. The availability, equitable distribution, and retention of qualified healthcare professionals directly influence service accessibility, quality of care, and overall system responsiveness. Persistent regional disparities in staffing levels and professional competencies continue to undermine health equity and system efficiency across Europe. Concurrently, population health indicators serve as key metrics for assessing the effectiveness of public health investments and policy interventions. Evaluating these outcomes is essential to determining whether financial and institutional reforms are yielding measurable improvements in population health and system performance.

LITERATURE REVIEW

The sustainability of public health systems is intricately linked to financial capacity, institutional design, and the broader socio-economic context. Over time, scholars have explored how macroeconomic stability, public trust, and fiscal transparency influence national capacities to fund and manage healthcare systems sustainably, especially in fragile environments and during health crises. Financial and institutional determinants are increasingly viewed through both evolutionary and spatial-temporal lenses, reflecting national pathways, reform cycles, and transnational interdependencies.

Over the past two decades, the sustainability of public health systems has garnered increasing attention in academic and policy discourse, driven by the rising complexity of healthcare delivery, aging populations, and growing health inequalities across countries. This growing interest has led to diverse approaches to evaluating system performance, financing models, governance structures, and population health outcomes.

However, despite this expanding body of research, it is important to acknowledge that there is ongoing scholarly debate regarding a unified definition of the term "public health system". Interpretations vary widely depending on national contexts, institutional frameworks, and disciplinary perspectives. Table 1 presents an overview of the most cited definitions and conceptual interpretations found in academic literature.

Table 1. Methodical approaches to the interpretation of the essence of "public health system". *(Source: completed by the authors on the basis of Slabkyi, Myroniuk, Kachala, 2017; Ministry of Health of Ukraine, 2022; WHO, 2019; National Association of Chronic Disease Directors, 2025; Shi, Wang, 2020; Shen et al., 2025)*

Author(s)	Definition	Notes (definition analysis)
Slabkyi H., Myroniuk V., Kachala L.	"….is a set of tools, procedures and activities implemented by governmental and non-governmental institutions to promote public health, prevent diseases, increase the duration of active and working age, and encourage a healthy lifestyle by combining the efforts of the entire society"	The definition frames the public health system as a coordinated set of actions by governmental and non-governmental actors aimed at disease prevention, health promotion, and extending active life expectancy. It highlights the importance of societal collaboration and a shift toward a more holistic, preventive approach to public health.
Law of Ukraine "On the Public Health System"	"…are state authorities, local governments, individuals, and legal entities that carry out procedures and measures aimed at improving public health, preventing diseases, and increasing life expectancy"	The definition identifies public health actors as a broad group - including state authorities, local governments, individuals, and legal entities - engaged in actions to improve health outcomes. It emphasizes a multi-level, multi-actor approach to disease prevention and life expectancy enhancement, highlighting the shared responsibility across sectors and governance levels.
World Health Organization (hereinafter - WHO)	"…promotes greater health and well-being in a sustainable way, while strengthening integrated public health services and reducing inequalities"	The definition emphasizes the dual goal of promoting health and well-being sustainably while enhancing integrated public health services. It underscores the importance of reducing health inequalities, reflecting commitment to equity, system integration, and long-term resilience in public health policy and practice.
National Association of Chronic Disease Directors	"…all public, private, and voluntary entities that contribute to the delivery of essential public health services within a jurisdiction"	The definition highlights the inclusiveness of the public health system, encompassing public, private, and voluntary sectors. It underscores the collaborative nature of delivering essential public health services, recognizing that effective health outcomes depend on coordinated contributions across all sectors within a given jurisdiction.
Shi J., Wang H.	"… is an important part of national security, and public-health discipline is the basis of the national public-health system"	The definition positions public health as a critical component of national security, emphasizing its strategic role in safeguarding population well-being. It identifies public health as a foundational discipline underpinning the broader national health system, reinforcing its importance in both policy and preparedness frameworks.
Shen N., Zhang J., Cao Y., Zhang L., Zhang G.	"…is a complex endeavor that requires not only coordination among multiple stakeholders but also the strategic allocation of management mechanisms"	The definition portrays the public health system as a complex structure that demands both intersectoral coordination and strategic management. It highlights the need for effective governance mechanisms to align diverse stakeholders and ensure the system's efficiency and responsiveness.

The concept of the public health system has been interpreted in diverse ways across the academic and policy literature, reflecting the complexity and interdisciplinary nature of the field. The definitions analyzed in Table 1 demonstrate varying emphases on actors, functions, goals, and governance mechanisms, yet share several common conceptual threads.

Several definitions - such as those offered by Slabkyi et al. (2017), Vakhovych, Smolych (2023), the Law of Ukraine (Ministry of Health of Ukraine, 2022), and the National Association of Chronic Disease Directors (2025) – highlight the pluralistic composition of public health systems, involving governmental bodies, private entities, and civil society organizations. These formulations underscore the importance of multisectoral collaboration in the delivery of essential public health functions. Other definitions, including those from the WHO (2019) and Shen et al. (2025), emphasize strategic dimensions such as sustainability, equity, and integrated service delivery. They position the public health system not merely as a service provider, but as a foundational structure essential to social resilience, governance, and long-term health security. Meanwhile, Shi and Wang (2020) frame public health as an integral component of national security, reinforcing its relevance in both domestic and global policy arenas. Taken together, these perspectives converge on a broad yet coherent understanding of the public health system as a dynamic, multifaceted entity that extends beyond clinical care to encompass governance, coordination, and population-level health promotion.

According to the results, which were demonstrated above, it's important to summarize our definition of the public health system. A public health system is an integrated network of governmental, private, and civil society actors responsible for designing, managing, and delivering preventive and health-promoting services. It aims to protect and improve population health through coordinated actions, strategic governance, and equitable access, while ensuring sustainability, resilience, and responsiveness to emerging public health challenges. This definition reflects both the functional and institutional dimensions of public health systems and provides a conceptual foundation for analyzing their sustainability across different countries and contexts.

To gain a deeper understanding of the research landscape surrounding the concept of the public health system, a bibliometric analysis was conducted. The primary objective was to examine the relevant scientific literature, identify the main thematic directions within the field, and explore the interrelationships among them. A critical component of bibliometric analysis is the selection of a reliable and comprehensive source for data collection. For this purpose, the Scopus database (Scopus, 2025) was chosen, as it offers extensive coverage of peer-reviewed literature across health and social sciences. The search was conducted using the "Article Title, Abstract, Keywords" field in Scopus, with a focus exclusively on publications written in English. This yielded a total of 8,657 relevant publications for further examination.

Using the "Analyze search results" tool, the dataset was analyzed based on various bibliometric dimensions, including publication, author, institutional affiliation, country or territory, type, subject area, and funding sponsor. The earliest publication on the topic dates to 1907, and the chronological distribution of research output is presented in Figure 1.

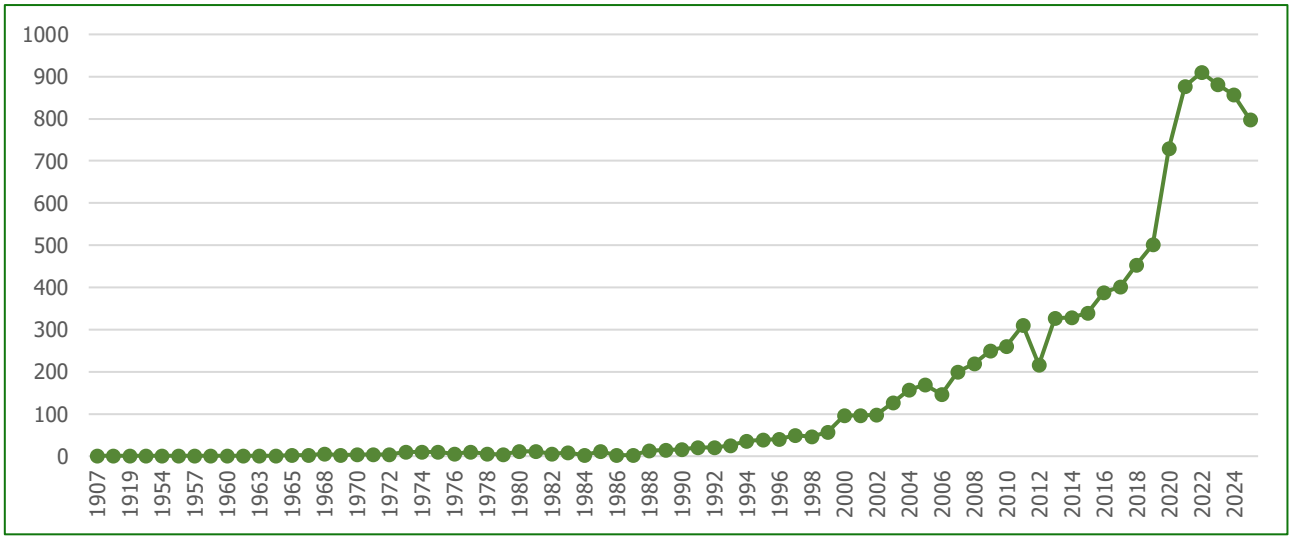

Figure 1. Dynamics of the number of publications on the keyword "public health system" from 1907 to 2025. *(Source: compiled by the authors on the basis of Scopus, 2025)*

The bibliometric analysis of publications related to the term "public health system" reveals a marked increase in academic attention over the past several decades. During the 1907-1980s years, publications on public health systems were minimal, as the field was primarily focused on medical and epidemiological issues. Broader institutional and financial dimensions of

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health systems were only beginning to emerge. Despite key developments like the creation of national health systems after World War II, academic research remained limited due to the early stage of international health policy discourse and an underdeveloped global research infrastructure. Publication activity began to rise modestly in the 1990s and early 2000s, reflecting increasing academic interest in health system reform, efficiency, and governance. From the mid-2000s onward, publication volume rose sharply, reflecting growing concerns about health system sustainability amid rising healthcare costs, population aging, and calls for universal health coverage, especially following the 2005 World Health Assembly resolution (WHO,2005). Increasing involvement of international actors such as the WHO (2025), the Organization for Economic Co-operation and Development (hereinafter OECD) (2025), and global health initiatives (e.g., GAVI (2025), Global Fund (2025)) also stimulated comparative and institutional research.

The most significant surge occurred in 2020-2021, coinciding with the COVID-19 pandemic. This unprecedented global crisis exposed vulnerabilities in health governance, financing, and emergency preparedness, triggering a wave of interdisciplinary studies on public health resilience, system capacity, and institutional response mechanisms. The visible decline in publications after 2022 is likely due to indexing delays rather than a drop in scholarly interest. Recent geopolitical and humanitarian crises, such as the war in Ukraine, climate-related disasters, and growing refugee flows, have further emphasized the need to evaluate and strengthen public health systems across different governance models.

These broader global dynamics are reflected in the geographic distribution of academic contributions. The bibliometric data (Figure 2) reveal that the United States leads global academic output on public health systems, followed closely by Brazil, which demonstrates significant engagement likely driven by its large population and complex public healthcare structure. The United Kingdom also ranks high, consistent with its long-standing research tradition and institutionalized public health system. European countries like Spain, Italy, and Germany show moderate publication levels, reflecting their advanced but varied healthcare governance models. Meanwhile, India and China are increasingly active, possibly due to growing investments in health system reform and global health engagement. The presence of countries such as Canada and Australia highlights the contribution of high-income nations with well-developed public health infrastructures. Overall, the chart reflects both academic capacity and policy-driven interest, with regional differences shaped by demographic, economic, and institutional factors.

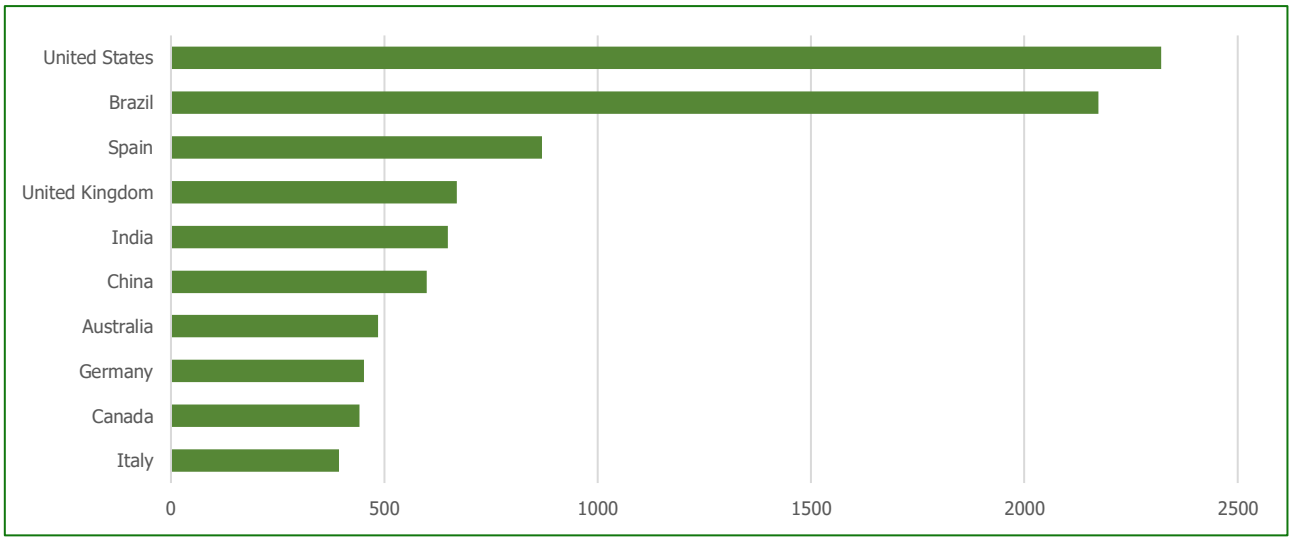

Figure 2. Distribution of the publications on "public health system" by country from 1907 to 2025. *(Source: compiled by the authors on the basis of Scopus, 2025)*

To identify the most frequently occurring keywords associated with the research topic of "public health system", a keyword co-occurrence network was generated using VOSviewer (2025) (Figure 3). The analysis was based on the top 5,000 most-cited publications, ensuring a focus on high-impact scholarly contributions in the field. The visualization reveals four primary thematic clusters, each reflecting a distinct research domain within the broader study of public health systems. These thematic areas correspond closely to the four principal categories of indicators explored in this study: financial, institutional, workforce, and health outcomes indicators.

The green cluster (Figure 3) focuses on themes such as public health administration, organization and management, government, decision-making, and health policy. It represents research on the structural and institutional dimensions of public health systems, including how governance frameworks, decentralization, and regulatory oversight influence service

delivery and system responsiveness. This thematic focus highlights the importance of the institutional indicators' research in the framework of the public health system, which is essential for understanding how effectively a system can implement reforms, manage resources, and ensure accountability – factors that are critical for long-term sustainability and equitable service delivery.

The red cluster (Figure 3) is characterized by keywords such as major clinical study, prevalence, risk factors, cohort analysis, cost-effectiveness analysis, and chronic diseases. It captures the evidence base for evaluating public health interventions and understanding population health trends. A significant portion of the analyzed publications also intersect with economic evaluations, such as cost-effectiveness and cost-utility analyses, highlighting the importance of efficient resource allocation. This underscores the need to systematically incorporate financial indicators in the analysis. Including these indicators allows for a more comprehensive assessment of how financial constraints or investments influence health outcomes and overall system performance.

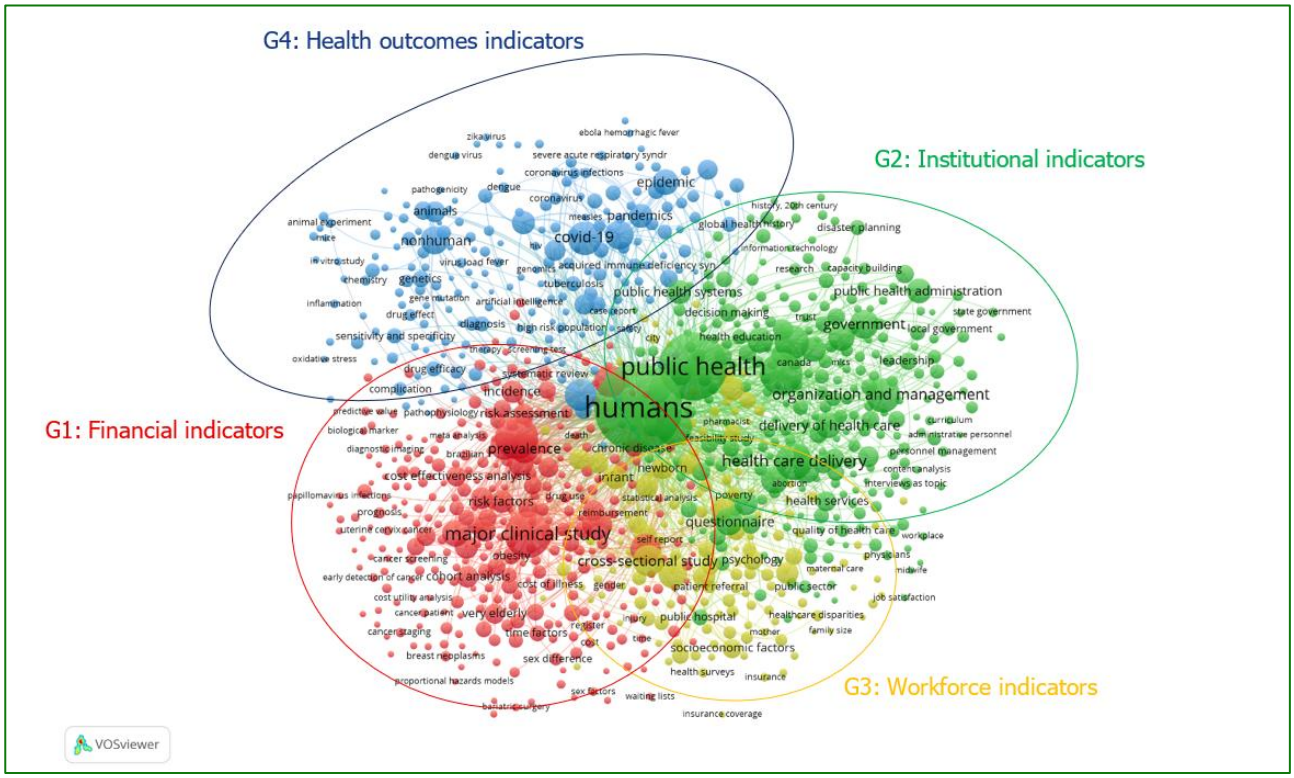

Figure 3. Visualization of the results of bibliometric analysis of scientific works devoted to the issues of the public health system, grouped by clusters for the period 1907-2025. *(Source: compiled by the authors with the VOSviewer tool on the basis of Scopus, 2025)*

The blue cluster (Figure 3) includes terms related to pandemics, epidemics, COVID-19, virus infections, and epidemiological surveillance. It reflects the surge in public health research during global health crises. The presence of viral pathogens, surveillance systems, and emergency preparedness underscores the importance of resilience and adaptability within health systems. The prevalence of keywords associated with viral pathogens, surveillance systems, and emergency preparedness highlights the growing emphasis on health system resilience and the ability to respond effectively to large-scale public health emergencies. This thematic focus strongly reinforces the necessity of incorporating health outcomes indicators into the analysis. These indicators are essential for evaluating the real-world effectiveness and impact of health system responses.

The yellow cluster (Figure 3) features terms such as health disparities, public sector, job satisfaction, workplace, maternal care, and insurance coverage. This indicates growing scholarly attention to the intersection of social determinants of health, equity in service delivery, and human resource management. It also reflects workforce-related challenges such as staff distribution, motivation, and access to care. Considering these findings, it is essential to incorporate workforce indicators into the analysis. These indicators provide a systematic assessment of the availability, capacity, and distribution of healthcare personnel, factors that are fundamental to system performance, quality of care, and the ability to meet changing population health needs.

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Financial and institutional sustainability in public health systems is shaped by fiscal capacity, governance structures, and socio-economic context. Research has highlighted the efficiency and resilience of public health systems, particularly during crises such as COVID-19, showing the relevance of economic performance assessments like DEA and the role of preparedness (Kuzior et al., 2022). Health financing, income levels, and insurance mechanisms are key to sustainable models, as demonstrated in cross-country panel analyses and studies on the reduction of disease burdens through insurance schemes (Kuzior et al., 2022; Kuzior et al., 2025).

The link between health and economic growth is evident, with improved healthcare and reduced vulnerable employment raising labour productivity (Kuzior et al., 2025; Lyeonov et al., 2025). Spatial approaches to mapping health vulnerabilities further enable comparative assessments across countries (Vysochyna et al., 2023). Government expenditure patterns reflect both fiscal priorities and institutional quality, with studies stressing how economic and political factors shape commitment to international health targets (Megbowon & Zehirun, 2025; Filipova et al., 2025; Vasylieva et al., 2023).

Health financing from the user side is explored through studies on community-based health insurance and out-of-pocket payments, revealing the importance of affordability, trust, and social impact on economic sectors such as agriculture (Otieno et al., 2025; Ukpe & Mohamadou, 2024). The demand for private instruments like life insurance also reflects broader socio-economic factors influencing health-related financial behaviour (Hasan et al., 2025). Digitalisation plays a growing role in enhancing inclusion, efficiency, and public trust, contributing to institutional sustainability and governance innovation (Maatallah, 2024; Nafei et al., 2025; Zhou, 2024; Ponomarenko et al., 2024; Prokopenko et al., 2025).

Institutional theory offers insights into the ethical and governance practices that influence sustainability across sectors. Studies show how governance in microfinance, environmental ethics, and leadership values affect financial viability and public trust (Adhikari et al., 2024; Dachi & Kasztelnik, 2024; Chetanraj et al., 2024). Meanwhile, generational behavior, such as health awareness and consumption among Gen Z and Millennials, highlights the socio-cultural side of health sustainability (Agustina et al., 2024). Finally, sustainability reporting remains essential for assessing institutional performance. Evidence from Indian infrastructure firms underlines the relevance of transparent benchmarks for tracking progress (Yadav & Yadava, 2023).

The existing literature paints a multidimensional picture of financial and institutional sustainability in public health, where economic, political, and technological factors co-evolve across temporal and spatial contexts. Institutional frameworks, governance quality, and digital innovations emerge as recurring themes shaping sustainability trajectories. Importantly, future research should consider integrative approaches that combine fiscal, institutional, and behavioral dimensions to better understand evolving patterns in public health system sustainability.

Still, systematic assessments that link financial and institutional sustainability with workforce dynamics and health outcomes across multiple countries remain limited. This study contributes to filling this gap by analyzing trends in financing structures, institutional arrangements, and performance indicators in 11 European countries from 2000 to 2024. The comparative perspective allows us to identify persistent disparities, emerging convergence, and implications for long-term sustainability.

AIMS AND OBJECTIVES

The article aims to critically evaluate the financial and institutional sustainability of public health systems in the 10-performing European countries in terms of life expectancy (Switzerland, Italy, Spain, Malta, Norway, France, Sweden, Portugal, Luxembourg, the Netherlands) and Ukraine over the period 2000 to 2024.

To achieve these aims, the article will address the following specific objectives across multiple analytical levels:

1. Examine long-term trends in public health financing and institutional governance across the selected countries.
2. Identify spatial and temporal patterns of sustainability, highlighting cross-country similarities and divergences according to 4 groups of indicators: financial indicators, institutional indicators, workforce indicators, and health outcomes indicators.
3. Assess the capacity of national health systems to adapt to systemic pressures while maintaining equitable access and service quality.
4. Provide evidence-based insights to inform health policy and support sustainable system development in diverse European contexts.

METHODS

The research adopts a quantitative and comparative analytical framework to assess the financial and institutional sustainability of public health systems. The analysis draws on secondary data sourced from publicly accessible and internationally recognized databases, including the WHO Indicators Statistics (2025), Eurostat (2025), World Bank (2025), the OECD Health Statistics (2025), and national statistical offices (Ukrstat, 2025; Worldometer, 2025). For each country and each selected indicator, arithmetic means were calculated to capture average performance over the 2000 - 2024 period. To evaluate temporal dynamics, both basic growth rates and chain growth rates were computed, providing insights into the direction and intensity of changes across time. To enable meaningful cross-country comparisons, a ranking methodology was applied to each group of indicators. Countries were ranked annually based on their performance within each indicator category, which facilitated the identification of leading and lagging systems, as well as patterns of convergence or divergence. Composite rankings were constructed to assess broader sustainability trends across the four groups of indicators analyzed: financial, institutional, workforce, and health outcomes. This methodological design ensures a structured, transparent, and replicable evaluation of both the evolutionary (temporal) and comparative (spatial) aspects of public health system sustainability. In cases where complete data were unavailable for certain years, an extrapolation method was employed to estimate missing values that ensured the continuity of time series data and preserved the integrity of temporal trend analysis. Extrapolations were based on established statistical techniques, using observed historical patterns and adjacent data points to project plausible values, while maintaining consistency with overall trends in each indicator.

RESULTS

Building on the findings of the bibliometric analysis, which identified four dominant thematic clusters (Figure 3) in the global discourse on public health system sustainability, this section introduces the empirical results of the study. These clusters, encompassing financial, institutional, workforce, and health outcomes dimensions, provided the conceptual framework for the selection and organization of core indicators used in the cross-country analysis.

The countries selected for this analysis include the top 10 European nations with the highest life expectancy as of 2025 (Worldometer, 2025) (Table 2) – namely Switzerland, Italy, Spain, Malta, Norway, France, Sweden, Portugal, Luxembourg, and the Netherlands - as well as Ukraine, which was included for comparative purposes to reflect a distinct geopolitical, economic, and institutional context.

Table 2. Ranking of selected European countries by life expectancy in 2025. *(Source: completed by the authors on the basis of Worldometer, 2025)*

Country	Position in the ranking	Life expectancy (both sexes)	Females' life expectancy	Males' life expectancy
Hong Kong	1	85,77	88,39	83,1
…				
Switzerland	5	84.23	86.06	82.34
Italy	7	84.03	86.01	81.94
Spain	9	83.96	86.59	81.27
Malta	11	83.63	85.51	81.69
Norway	12	83.61	85.09	82.11
France	13	83.58	86.31	80.73
Sweden	14	83.58	85.34	81.84
Portugal	22	82.72	85.37	79.89
Luxembourg	24	82.49	84.06	80.91
The Netherlands	25	82.45	83.98	80.89
Ukraine	99	74.86	79.54	69.99
…				
Nigeria	201	54.78	55.12	54.45

The use of life expectancy as a selection criterion is both strategic and methodologically sound. Life expectancy is widely regarded as a comprehensive indicator of population health, capturing the cumulative effect of healthcare access, service

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quality, socio-economic conditions, preventive care, and institutional effectiveness. It reflects the long-term performance and sustainability of public health systems, particularly in terms of their ability to deliver equitable, efficient, and resilient healthcare services. By focusing on countries with the highest life expectancy, the study seeks to benchmark best practices and systemic strengths, while the inclusion of Ukraine allows for an exploration of the sustainability challenges faced by systems under stress from political instability and armed conflict.

The indicator selection was informed by established international standards and driven by data availability from authoritative sources covering the period from 2000 to 2024. The indicators were organized into four analytical groups as follows:

Group 1 – Financial Indicators (WHO Indicators Statistics, 2025):

1. Current health expenditure (hereinafter - CHE) per capita in USD.
2. CHE as a percentage of gross domestic product (hereinafter - GDP) (%).
3. Domestic general government health expenditure (hereinafter - GGHE-D) as a percentage of CHE (%).
4. Out-of-pocket expenditure (hereinafter - OOPE) as a percentage of CHE (%).
5. Domestic private health expenditure (hereinafter - PVT-D) as a percentage of CHE (%).
6. External health expenditure (EXT) as a percentage of CHE (%).
7. GGHE-D per capita in USD.
8. GDP per capita, PPP (current international USD).

Group 2 – Institutional Indicators (WHO Indicators Statistics, 2025):

1. Hospital beds (per 10,000 population).
2. Total density per 100,000 population: provincial hospitals, health posts, specialized hospitals, hospitals, health centers, district/rural hospitals.

Group 3 – Workforce Indicators (WHO Indicators Statistics, 2025):

1. Nursing and midwifery personnel (per 10,000 population).
2. Medical doctors (per 10,000 population).
3. Pharmacists (per 10,000 population).
4. Dentists (per 10,000 population).

Group 4 – Health outcomes Indicators (WHO Indicators Statistics, 2025; World Bank, 2025; Eurostat, 2025; Worldometer, 2025):

1. Life expectancy.
2. Adult mortality rate (probability of dying between 15 and 60 years old, per 1,000 population).
3. Child mortality rate for 5- to 14-year-olds (probability of dying per 1,000 children aged 5-14 years).
4. Child deaths in infants, infant mortality rate (between birth and 11 months per 1,000 live births).
5. Population.

The findings based on arithmetic averages of key health expenditure indicators (Table 3) reveal substantial cross-country variation in the level and structure of health financing.

Switzerland (USD 8,101.36), the Netherlands (USD 7,283.65), and Malta (USD 6106.55) recorded the highest average per capita health spending, while France (11.05% of GDP) and Switzerland (10.61% of GDP) demonstrated the greatest relative commitment to health in GDP terms. At the lower end, Ukraine (USD 193), Spain (USD 2,018), and Sweden (USD 2,098) exhibit comparatively limited per capita spending, signaling constrained fiscal space or prioritization. Countries such as Luxembourg, Norway, and Sweden exhibited strong public financing models, allocating over 80% of CHE through government expenditure. In contrast, Switzerland (32.96%) and Ukraine (51.20%) relied heavily on private and out-of-pocket payments, raising concerns about equity and access. GDP per capita is closely correlated with overall health investment capacity, with Luxembourg, Norway, and Switzerland leading, and Ukraine lagging significantly. Overall, the analysis

identifies Switzerland, Norway, France, and Luxembourg as consistent high-resource allocators to health systems, while Ukraine, Spain, and Portugal showed more constrained or mixed investment patterns.

Table 3. Results of the arithmetic average calculation of the groups of financial indicators for 2000-2024 years. *(Source: calculated by the authors based on: WHO Indicators Statistics, 2025)*

	Countries	Arithmetic average		Countries	Arithmetic average		Countries	Arithmetic average
CHE per capita in USD	Switzerland	8,101.36	CHE as a percentage of GDP (%)	France	11.05	GGHE-D as a percentage of CHE (%)	Luxembourg	85.08
	The Nether-lands	7,283.65		Switzerland	10.61		Norway	84.58
	Malta	6,106.55		The Nether-lands	9.87		Sweden	83.96
	Italy	5,052.02		Sweden	9.73		Italy	75.59
	Portugal	4,815.93		Portugal	9.62		France	72.87
	France	4,265.23		Norway	9.17		Spain	72.08
	Norway	2,867.85		Spain	8.76		The Nether-lands	67.75
	Luxembourg	2,458.21		Italy	8.64		Malta	65.89
	Sweden	2,097.55		Malta	8.62		Portugal	64.27
	Spain	2,018.71		Ukraine	6.91		Ukraine	51.20
	Ukraine	193.20		Luxembourg	5.91		Switzerland	32.96
	Countries	**Arithmetic average**		**Countries**	**Arithmetic average**		**Countries**	**Arithmetic average**
OOPE as a percentage of CHE (%)	Ukraine	45.13	PVT-D as a percentage of CHE (%)	Switzerland	67.04	EXT as a per-centage of CHE (%)	Luxembourg	1.34
	Malta	31.87		Ukraine	48.09		Ukraine	0.66
	Portugal	27.41		Portugal	35.67		Portugal	0.06
	Switzerland	24.34		Malta	34.11		The Nether-lands	0.05
	Italy	22.66		The Nether-lands	32.21		Norway	0.01
	Spain	21.56		Spain	27.92		Malta	0.01
	Norway	15.12		France	27.13		Switzerland	N/A
	Sweden	14.95		Italy	24.41		Italy	N/A
	Luxembourg	10.96		Sweden	16.04		Spain	N/A
	The Nether-lands	10.09		Norway	15.41		France	N/A
	France	9.22		Luxembourg	14.20		Sweden	N/A
	Countries	**Arithmetic average**		**Countries**	**Arithmetic average**			
GGHE-D per capita in USD	Norway	6,178.37	GDP per capita, PPP (current in-ternational USD)	Luxembourg	98,102.43			
	Luxembourg	5,239.92		Norway	63,560.29			
	Sweden	4,254.64		Switzerland	59,985.42			
	The Nether-lands	3,260.16		The Nether-lands	50,562.53			
	France	3,109.06		Sweden	46,189.53			
	Switzerland	2,709.11		France	39,756.26			
	Italy	2,171.00		Italy	38,446.57			
	Spain	1,775.39		Malta	35,735.02			
	Malta	1,370.37		Spain	34,869.21			
	Portugal	1,287.24		Portugal	29,602.93			
	Ukraine	98.24		Ukraine	10,311.97			

Figure 4 presents a comparative assessment of the basic growth rates in key health expenditure and economic indicators across selected European countries, using 2000 as the base year and 2024 as the reference point.

An examination of the basic growth rates in CHE per capita in USD (Figure 4a) reveals significant variation in the scale and pace of health financing developments. The most substantial relative increase was observed in Ukraine, where CHE per

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capita grew from USD 34.62 in 2000 to USD 324.65 in 2024, reflecting a growth multiple of 8.38. This dramatic rise, albeit from a low base, underscores a notable increase in national health investment relative to historical levels, likely in response to systemic reforms and international support in the post-transition period. Malta demonstrated the second-highest growth rate, with CHE per capita increasing from USD 647.10 to USD 3,553.17, equating to a 4.93-fold increase. This suggests a sustained commitment to strengthening healthcare financing, likely linked to national development and EU integration efforts. Among the high-income countries, Norway, Switzerland, and Sweden exhibited consistent yet moderate growth in per capita health expenditure. For instance, Switzerland's CHE per capita rose from USD 3,560.00 to USD 12,156.93 (2.41×), and Norway from USD 2,949.00 to USD 10,147.91 (2.44×). Countries such as Spain (2.30×), the Netherlands (2.28×), and Portugal (1.66×) displayed moderate growth, indicative of gradual health financing improvements in line with broader economic development and policy reform trajectories. In contrast, France and Luxembourg recorded the lowest growth rates in CHE per capita at 1.33 and 1.30, respectively. France increased from USD 2,162.00 to USD 5,574.95, while Luxembourg grew from USD 2,901.00 to USD 7,538.08. These lower relative increases can be attributed to already elevated levels of health expenditure in 2000, which limit the scope for proportional growth. Italy also exhibited a relatively low growth rate of 1.30×, rising from USD 1,524.00 to USD 3,502.05, suggesting potential stagnation in health investment over the period, possibly due to fiscal constraints or competing budgetary priorities.

CHE as a percentage of GDP (Figure 4b) reflects the relative priority a country allocates to healthcare within its overall economic activity. The results reveal diverse trends across European countries, with some significantly increasing the share of health in GDP and others experiencing stagnation or decline. Sweden experienced the highest increase in CHE as a share of GDP, rising from 7.33% in 2000 to 11.99% in 2024, a net growth of +0.64 percentage points (hereinafter - pp). This indicates a substantial strengthening of the role of health within the national economy. Spain increased from 6.80% to 10.47% (+0.54 pp), and Ukraine from 5.31% to 8.14% (+0.53 pp), both showing strong commitments to expanding health financing relative to economic output. Malta, the Netherlands, and Norway also registered noticeable growth (between +0.34 and +0.52 pp), suggesting gradual prioritization of healthcare spending. Switzerland, France, and Italy demonstrated modest increases in CHE as a percentage of GDP. For example, Switzerland increased from 9.13% to 12.00% (+0.31 pp) and France from 9.58% to 12.30% (+0.28 pp). These figures reflect growth from an already high baseline and indicate stable, continued investment in healthcare. Portugal saw a relatively small increase from 8.60% to 10.32% (+0.20 pp), suggesting restrained growth in health spending compared to GDP. Luxembourg was the only country with a negative change, declining from 5.93% to 4.99% (-0.16 pp). This decline may lead to faster economic growth outpacing health expenditure, or to shifts in fiscal priorities.

GGHE-D as a percentage of CHE (Figure 4c) reflects the extent to which public funding contributes to overall health spending. An increase suggests a strengthening of the public sector's role in healthcare financing, while a decline indicates a growing reliance on private or external sources. The most notable increase occurred in Switzerland, where GGHE-D rose from 28.57% in 2000 to 36.03% in 2024, representing a +0.26pp change. Financing, potentially as a response to rising healthcare costs and efforts to reduce private out-of-pocket burden. Norway and Luxembourg also recorded positive changes of +0.09 pp and +0.04 pp, respectively, reinforcing their commitment to strong public healthcare systems. These countries already had high government shares in 2000 (Norway: 81.68%, Luxembourg: 83.25%), indicating sustained public investment. Several countries maintained stable levels of public health financing with only marginal changes: France increased slightly from 72.73% to 74.87% (+0.02 pp); Italy from 72.64% to 74.77% (+0.02 pp); Sweden from 84.48% to 85.83% (+0.01 pp). These figures suggest continued support for universal healthcare systems with little deviation in financing structure over the past two decades.

Conversely, Portugal, Malta, the Netherlands, and Ukraine experienced a decrease in the share of government spending in total health expenditure. Portugal declined from 69.74% to 58.91%, a -0.16 pp change, the most substantial reduction among the group. This may signal increasing privatization or budgetary reallocation. Malta saw a drop from 71.79% to 62.43% (-0.13 pp), suggesting a growing role of private or out-of-pocket expenditure in health. The Netherlands declined by -0.03 pp and Ukraine by -0.03 pp, although these shifts were modest. Although still relatively low in comparative terms, this growth reflects an increasing role of the Swiss government in health.

Private health spending, particularly OOP payments (Figure 4d), reflects the extent of financial protection in healthcare systems. Countries like Switzerland (67.04%) and Ukraine (48.09%) reported the highest shares of private health expenditure relative to CHE, indicating greater financial burden on households. OOP spending remained high in Ukraine, rising from 48.39% in 2000 to 51.35% in 2024, and in Malta, from 26.37% to 34.66%, suggesting increasing barriers to equitable access. In contrast, countries with strong public systems maintained lower OOP levels, France (9.22%) and the Netherlands (10.09%), with minimal increases between 2000 and 2024. These trends confirm stark contrasts in healthcare financing models across Europe, with implications for affordability and equity.

Figure 4. Dynamics of changes in a group of financial indicators during 2000-2024. *(Source: compiled by the authors based on: WHO Indicators Statistics, 2025)*

PVT-D (Figure 4e), expressed as a share of CHE, serves as a proxy for the level of household and private sector involvement in health financing. A decrease in this indicator typically signals a shift toward more public or government-supported

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healthcare systems. Malta experienced the greatest increase in the private share of CHE, contrary to the overall trend, rising from 28.21% in 2000 to 37.51% in 2024, a +9.30 pp change. This indicates a significant shift toward privatization or a relative withdrawal of public financial support. In contrast, the largest declines in private spending were observed in Portugal: from 30.22% to 41.01% (+10.79 pp), indicating an increase in private burden, again against the general trend. Switzerland showed a notable decline in private expenditure, from 71.43% to 63.97% (-7.46 pp), indicating increased public sector involvement despite its traditionally high private share. France and Spain also experienced moderate decreases (-2.14 pp and -0.72 pp, respectively), likely reflecting expansions in public health coverage and access. Nordic countries, particularly Norway (-5.00 pp) and Sweden (-1.35 pp), continued to exhibit low private spending levels, consistent with their tax-funded universal healthcare models. Italy showed a modest reduction (-2.13 pp), maintaining a relatively stable public-private balance. In contrast, some countries deviated from this trend. The Netherlands recorded a rise in private health expenditure (+2.28 pp), possibly due to structural reforms favoring private insurance mechanisms. Similarly, Ukraine's increase (+1.11 pp) suggests ongoing dependence on out-of-pocket or informal payments. These patterns highlight the complex and evolving landscape of health financing in Europe, with both convergence toward public models and persistent or growing privatization in specific contexts.

Additionally, external financing remains minimal across most European countries, indicating low dependence on international aid for healthcare. Ukraine had the highest and most variable EXT levels, peaking at 1.72% in 2015, reflecting periods of foreign assistance likely linked to economic and political instability. Luxembourg maintained the highest consistent EXT values among high-income countries, ranging from 1.53% in 2012 to 1.10% in 2022, suggesting modest but stable reliance on external sources. Portugal and the Netherlands reported minor contributions from external sources, below 0.1%, indicating strong self-financing capacity. Switzerland, Italy, Spain, France, and Sweden reported no measurable EXT throughout the period, reinforcing their fiscal independence in healthcare funding.

In terms of GGHE-D per capita (Figure 4f), all countries experienced real growth from 2000 to 2024, albeit at varying rates. The most significant increase was observed in Ukraine, with an 8.30-fold rise, reflecting a substantial governmental push from a historically low baseline. Malta (3.92), Switzerland (3.19), and Norway (2.63) also demonstrated strong growth, indicative of sustained or expanded public investment in healthcare infrastructure and services. At the other end of the spectrum, Portugal recorded the slowest growth at just 1.32 times the 2000 level, suggesting more modest government prioritization or fiscal constraints in expanding per capita public health expenditure. These disparities underscore the unequal pace of public health financing growth across Europe, shaped by national income levels, policy decisions, and historical baselines.

To assess the dynamics of financial performance over time, chain growth rates were calculated for key financial indicators. Figure 5 presents the results of the chain growth rate analysis for these indicators, providing insight into year-over-year changes and underlying trends.

High-income countries such as Switzerland, France, the Netherlands, and Luxembourg exhibited steady annual growth of CHE (Figure 5a) between 4%-10%, with mild fluctuations. Switzerland maintained consistent performance with only minor contractions. France and the Netherlands showed strong early growth (2000-2008), slight declines during the global financial crisis, and temporary surges during the COVID-19 pandemic (+13% in France, +12% in the Netherlands).

Italy, Spain, and Portugal experienced robust early 2000s growth (often >15%), followed by stagnation or contraction post-2010 due to austerity. Italy faced a significant drop in 2014 (-15%), while Portugal and Spain recovered modestly by the late 2010s. Pandemic years offered short-term boosts, but the 2020s show a weak recovery, constrained by structural budget limitations. Malta and Luxembourg demonstrated erratic growth patterns, including sharp increases (e.g., +29% in Malta, 2002) and periodic contractions. Their limited economic scale and exposure to external shocks contribute to their volatility. Norway and Sweden experienced strong early growth (e.g., +26% in Norway, 2001), followed by fiscal stabilization. Sweden recorded the highest single-year increase (+44% in 2010), possibly reflecting policy or statistical adjustments. Pandemic-era growth remained within managed bounds. Ukraine displayed the most volatile profile, with exceptional growth in the early 2000s (+38% in 2004, +30% in 2002), severe contractions during crises (-24% in 2014), and a resurgence in 2020 (+40%) linked to emergency funding and systemic shocks. The pattern indicates profound structural transformations influenced by persistent geopolitical instability.

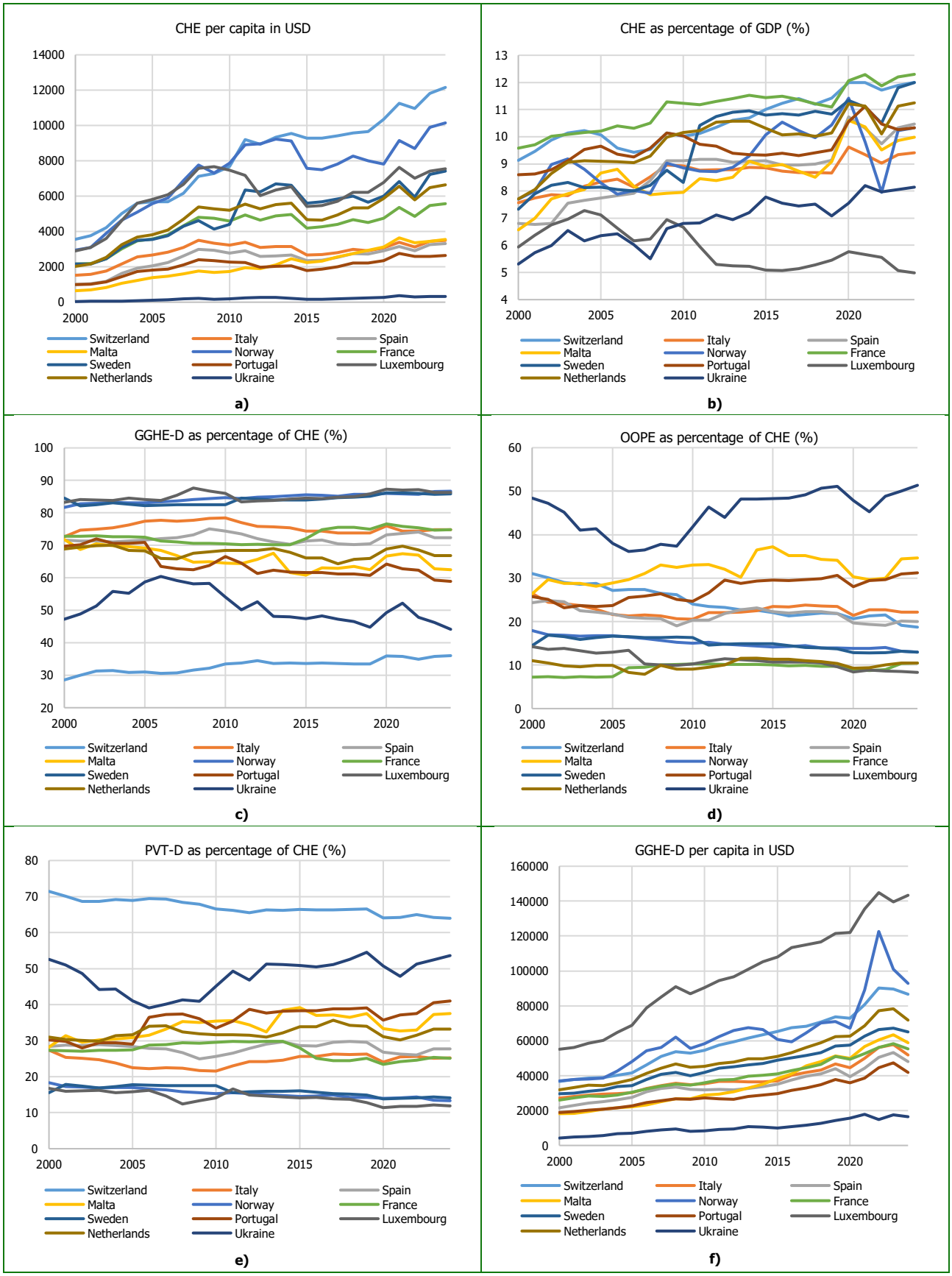

Figure 5. Chain growth rate by the financial indicators during 2000-2024. *(Source: compiled by the authors based on: WHO Indicators Statistics, 2025)*

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As a result of CHE as a percentage of GDP (Figure 5b), most countries exhibit relatively stable fluctuations within ±0.05%, reflecting consistent health spending relative to GDP. Notable exceptions include Malta, Norway, and Ukraine, which display greater volatility, with spikes up to 0.29% (Norway, 2022) and 0.20% (Ukraine, 2008), alongside significant negative changes (e.g., Norway -0.19% in 2021). Spain and Sweden show moderate positive spikes, such as 0.18% (Spain, 2019) and 0.25% (Sweden, 2010). Luxembourg experienced pronounced negative changes around 2010-2011 (-0.11%). These fluctuations likely reflect economic cycles, policy shifts, and external shocks such as the COVID-19 pandemic. Overall, the data indicate relative stability in CHE as a share of GDP with episodic deviations linked to country-specific contexts.

GGHE-D as a percentage of CHE from 2000 to 2024 (Figure 5c) demonstrates mostly modest fluctuations, typically within ±0.03%, indicating relatively stable government contributions to health spending across most countries. Switzerland shows small positive changes peaking at 0.07% in 2019, while Italy and Spain exhibit near-zero annual variations with occasional minor increases or decreases. Malta and Ukraine demonstrate higher volatility, with Ukraine reaching a peak change of 0.09% in 2002 and Malta experiencing a sharp negative change of -0.09% in 2013. Norway maintains remarkable stability with changes consistently near zero. Portugal shows occasional negative shifts, notably -0.11% in 2005, while France and Luxembourg display limited variability. The Netherlands and Sweden report mostly negligible changes. These results suggest that, unlike total health expenditure relative to GDP, government health spending as a share of CHE remains comparatively steady, with sporadic deviations likely reflecting policy adjustments or fiscal pressures.

OOPE as a percentage of CHE (Figure 5d), annual changes from 2000 to 2024 reveal greater variability compared to government health expenditure. Most countries experience fluctuations within ±0.05, reflecting moderate shifts in the financial burden borne directly by households. Noteworthy exceptions include Malta with pronounced positive spikes (0.13 in 2000, 0.21 in 2013, and 0.15 in 2023), suggesting periods of increased out-of-pocket costs. Sweden and France also exhibit occasional large fluctuations, such as 0.17 in 2000 (Sweden) and 0.27 in 2005 (France). Luxembourg shows a significant negative change of -0.23 in 2006, indicating a sudden reduction in the out-of-pocket share. The Netherlands displays notable volatility, including a sharp increase of 0.26 in 2007 and a large decrease of -0.16 in 2005. Ukraine experiences mixed changes with spikes up to 0.12 in 2009 and 0.11 in 2010.

Analysis of chain growth rate in PVT-D as a percentage of CHE (Figure 5e) shows stable trends with limited fluctuations predominantly within ±0.05. Switzerland, Italy, Spain, Norway, France, and Sweden demonstrate minor year-to-year variations, typically ranging from -0.07 to 0.07, indicating steady private sector involvement in health financing. Notable exceptions include Malta, which exhibits significant positive deviations reaching 0.18 in 2013 and 0.13 in 2023, implying occasional surges in private expenditure shares. Portugal experienced a notable spike of 0.26 in 2005, followed by moderate fluctuations thereafter. Luxembourg shows sharp decreases, such as -0.16 in 2007 and variable changes thereafter, reflecting volatility in private expenditure contributions. Ukraine demonstrates mixed variations with peaks up to 0.10 in 2009 and 0.09 in 2010.

Changes in GGHE-D per capita display consistent positive trends with moderate year-to-year fluctuations, ranging between -0.2 and +0.5 USD per capita. Switzerland, Italy, Spain, France, Norway, and Luxembourg exhibit steady increments mostly between +0.01 and +0.3, signifying gradual growth in government health investment over the studied period. Ukraine shows higher variability with spikes up to +0.48 (2020) and a marked dip of -0.27 (2014), reflecting economic and political instability impacting health funding. Sweden and the Netherlands show stable increases punctuated by occasional negative adjustments (e.g., Sweden -0.15 in 2014, the Netherlands -0.19 in 2014), tied to budgetary realignments. Malta's values are moderate, with few fluctuations such as +0.28 in 2002 and -0.10 in 2014. Portugal and Luxembourg reveal minor volatility, mostly within ±0.1, with occasional negative changes indicating brief spending contractions.

Following the assessment of financial trends in health expenditure over the study period, the subsequent analysis focuses on institutional indicators.

According to the calculated arithmetic average for the period 2000-2024 (Table 4), Ukraine and France exhibit the highest hospital bed density, indicating either a more extensive inpatient infrastructure or a slower transition toward outpatient care models. Malta and Luxembourg demonstrate strong per capita bed availability, likely reflecting sustained investment in hospital-based services. In contrast, Sweden reports the lowest average density (25.69 beds per 10,000 population), consistent with Nordic healthcare systems that emphasize outpatient care, short hospital stays, and preventive services. Italy and Spain fall within the mid-range, suggesting more balanced healthcare delivery models.

Table 4. Results of the arithmetic average calculation of the groups of institutional indicators for 2000-2024 years. *(Source: calculated by the authors based on: WHO Indicators Statistics, 2025)*

	Countries	Arithmetic average		Countries	Arithmetic average		Countries	Arithmetic average
Total density per 100,000 population: Provincial hospitals	Italy	1.84	Total density per 100,000 population: Health posts	Portugal	3.07	Total density per 100,000 population: Specialized hospitals	Luxembourg	0.77
	Spain	0.31		Malta	2.13		The Netherlands	0.77
	Malta	0.24		Switzerland	N/A		Malta	0.24
	Luxembourg	0.20		Italy	N/A		Spain	0.16
	Switzerland	N/A		Spain	N/A		Italy	0.14
	Norway	N/A		Norway	N/A		Switzerland	N/A
	France	N/A		France	N/A		Norway	N/A
	Sweden	N/A		Sweden	N/A		France	N/A
	Portugal	N/A		Luxembourg	N/A		Sweden	N/A
	The Netherlands	N/A		The Netherlands	N/A		Portugal	N/A
	Ukraine	N/A		Ukraine	N/A		Ukraine	N/A
	Countries	**Arithmetic average**		**Countries**	**Arithmetic average**		**Countries**	**Arithmetic average**
Total density per 100,000 population: Hospitals	Italy	2.08	Total density per 100,000 population: Health centers	Malta	1.89	Total density per 100,000 population: District/rural hospitals	Spain	0.59
	Spain	1.63		Switzerland	N/A		Malta	0.24
	Luxembourg	1.13		Italy	N/A		Luxembourg	0.10
	Malta	0.93		Spain	N/A		Italy	0.06
	The Netherlands	0.76		Norway	N/A		Switzerland	N/A
	Switzerland	N/A		France	N/A		Norway	N/A
	Norway	N/A		Sweden	N/A		France	N/A
	France	N/A		Portugal	N/A		Sweden	N/A
	Sweden	N/A		Luxembourg	N/A		Portugal	N/A
	Portugal	N/A		The Netherlands	N/A		The Netherlands	N/A
	Ukraine	N/A		Ukraine	N/A		Ukraine	N/A
	Countries	**Arithmetic average**						
Hospital beds (per 10,000 population)	Ukraine	79.91						
	France	67.34						
	Malta	52.27						
	Luxembourg	51.74						
	Switzerland	50.34						
	Norway	40.72						
	The Netherlands	37.74						
	Italy	35.29						
	Portugal	34.43						
	Spain	31.14						
	Sweden	25.69						

Italy stands out with a significantly higher average density of provincial hospitals (1.84 per 100,000 population) compared to other countries, potentially reflecting its highly decentralized healthcare system. Spain (0.31) and Malta (0.24) follow, though with lower values. Luxembourg reports an exceptionally low density (0.02), attributable to its small geographic

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size and centralized healthcare provision. For countries such as Switzerland, Norway, Sweden, and France, data on provincial hospital density are unavailable, limiting direct comparison. Among the countries with available data, Portugal and Malta report the highest average densities of health posts per 100,000 population, at 3.07 and 2.13, respectively. These figures suggest a stronger investment in primary-level or community-based healthcare infrastructure in these two countries. Luxembourg and the Netherlands report the highest average density of specialized hospitals per 100,000 population (both at 0.77), indicating a comparatively robust capacity for providing advanced or niche medical services. Malta (0.24), Spain (0.16), and Italy (0.14) follow with notably lower densities, which may reflect a more integrated approach to specialized care within general hospitals or centralized service delivery models. Italy reports the highest average hospital density per 100,000 population (2.08), followed by Spain (1.63) and Luxembourg (1.13). Malta and the Netherlands show lower densities at 0.93 and 0.76, respectively, suggesting more consolidated hospital networks or higher reliance on outpatient and primary care services. The high figures for Italy and Spain may reflect broader hospital infrastructure or decentralized service models. Among the countries analyzed, only Malta reported a measurable density of health centers, with 1.89 health centers per 100,000 population. Available data indicate relatively low densities of district or rural hospitals across the few reporting countries. Spain reports the highest figure at 0.59 per 100,000 population, followed by Malta (0.24), Luxembourg (0.10), and Italy (0.06). The arithmetic average across these four countries is approximately 0.25.

The basic growth rate analysis (Figure 6a) indicates a universal decline across all observed countries. Italy (-0.10) decreased from 47.06 to 26.01, representing the most moderate reduction among the group. Switzerland (-0.15) and Malta (-0.25) followed, maintaining relatively higher retention of the 2000 levels. Sweden (-0.27), Norway (-0.35), and Ukraine (-0.36) showed more substantial declines. Ukraine dropped from 88.82 to 64.69, remaining high in absolute terms but still declining by over one-third. Portugal (-0.41), Luxembourg (-0.43), France (-0.45), Spain (-0.47), and the Netherlands (-0.50) experienced the steepest reductions. For example, the Netherlands halved its value from 49.29 in 2000 to 26.01 in 2024.

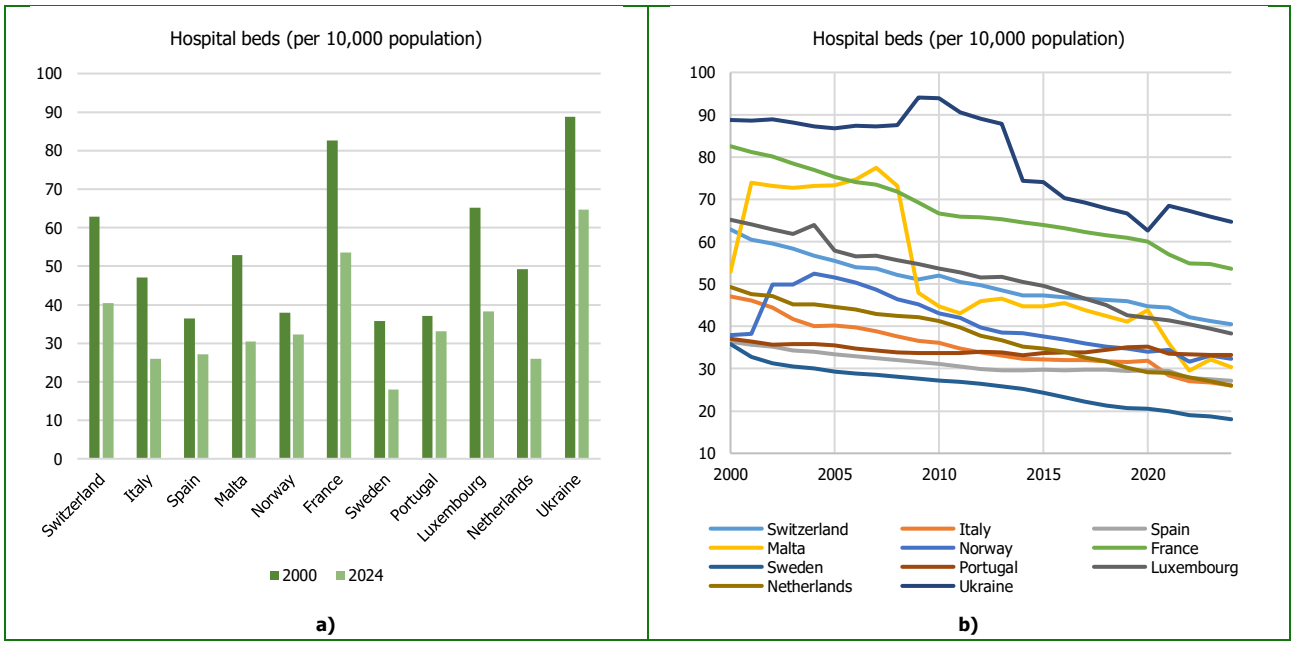

Figure 6. Dynamics of changes in a group of institutional indicators and chain growth rate during 2000-2024. *(Source: compiled by the authors based on: WHO Indicators Statistics, 2025)*

The findings (Figure 6b) reveal a general trend of gradual decline, reflecting ongoing health system reforms and a shift toward outpatient care. Most Western European countries, including Switzerland, France, and Spain, exhibited consistent but moderate annual reductions (typically between -0.01 and -0.04), indicating controlled downsizing. Italy and the Netherlands followed a similar trend with occasional sharper contractions, notably in 2002 (-0.06 in Italy) and during the COVID-19 pandemic (-0.11 in Italy, -0.04 in the Netherlands in 2020). Malta and Ukraine demonstrated significant volatility. Malta showed extreme fluctuations, including a +0.40 increase in 2000 and -0.34 in 2008, reflecting its small system's sensitivity to structural changes. Ukraine's bed density remained stable in early years, followed by abrupt declines during crisis periods (-0.15 in 2013), and a pandemic-related rebound in 2020 (+0.09). Nordic countries such as Sweden and Norway, and Luxembourg, pursued steady declines, with Sweden undergoing the most pronounced structural reduction (e.g., -0.05 in 2016 and 2021). Temporary growth was observed in several countries during the pandemic (e.g., Portugal and Ukraine in

2020), but most returned to pre-pandemic trajectories by 2022. Overall, the data reflect a sustained regional movement toward reducing inpatient capacity in favor of more efficient and community-based models of care, with notable variation driven by national health policy contexts and economic resilience.

While institutional capacity provides insight into the structural elements of healthcare delivery, the human resources for health represent a more dynamic and increasingly critical dimension of system performance. Workforce indicators, including physician and nurse density, not only reflect the availability of care but also help assess system resilience, access, and quality of services. Accordingly, the next stage of the analysis turns to the arithmetic averages of workforce indicators over the 2000-2024 period, as presented in Table 5, to evaluate long-term trends and inter-country differences in healthcare human resource capacity.

From 2000 to 2024, the highest average densities of nursing and midwifery personnel were recorded in Norway (160.36) and Switzerland (156.87), reflecting strong investment in nursing resources. Luxembourg, Sweden, and the Netherlands also exceeded one hundred per 10,000 population, indicating robust healthcare support. In contrast, Southern and Eastern European countries like Portugal (60.32), Italy (57.77), Spain (53.04), and Ukraine (68.30) showed lower averages, suggesting a need for improved nursing workforce development. These differences point to regional imbalances in healthcare capacity and underline the importance of strategic workforce planning.

Portugal has the highest density at 44.22 doctors per 10,000 population, followed by Norway (41.27), Italy (40.35), and Switzerland (40.18). Luxembourg exhibits the lowest density with 26.80 doctors per 10,000. The arithmetic mean across all countries is 36.41 doctors per 10,000 population. Southern European countries tend to have higher doctor densities, while France (32.77), the Netherlands (32.02), Ukraine (31.96), and Luxembourg fall below the average. These disparities in medical workforce availability suggest varying levels of healthcare access and underline the need for targeted health policy interventions.

Table 5. Results of the arithmetic average calculation of the groups of workforce indicators for 2000-2024 years. *(Source: calculated by the authors based on: WHO Indicators Statistics, 2025)*

	Countries	Arithmetic average		Countries	Arithmetic average
Nursing and midwifery personnel (per 10,000 population)	Norway	160.36	Medical doctors (per 10,000 population)	Portugal	44.22
	Switzerland	156.87		Norway	41.27
	Luxembourg	114.90		Italy	40.35
	Sweden	114.56		Switzerland	40.18
	The Netherlands	104.87		Sweden	39.13
	France	85.73		Spain	37.87
	Malta	70.52		Malta	35.73
	Ukraine	68.30		France	32.77
	Portugal	60.32		The Netherlands	32.02
	Italy	57.77		Ukraine	31.96
	Spain	53.04		Luxembourg	26.80
	Countries	**Arithmetic average**		**Countries**	**Arithmetic average**
Pharmacists (per 10,000 population)	Malta	13.01	Dentists (per 10,000 population)	Norway	8.68
	Italy	10.83		Portugal	8.34
	Spain	10.43		Sweden	8.08
	France	10.25		Luxembourg	7.96
	Sweden	7.69		Italy	6.96
	Portugal	7.46		France	6.78
	Luxembourg	7.01		Spain	6.47
	Switzerland	6.52		Ukraine	5.29
	Norway	6.46		Switzerland	5.03
	The Netherlands	1.98		The Netherlands	4.86
	Ukraine	0.30		Malta	4.58

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Malta leads with 13.01 pharmacists per 10,000 population, followed by Italy (10.83), Spain (10.43), and France (10.25). Ukraine has the lowest density at 0.30 pharmacists per 10,000. The overall arithmetic mean is 7.11 pharmacists per 10,000 population. Western and Southern European countries exhibit higher pharmacist densities, while the Netherlands (1.98) and Ukraine show significantly lower ratios. The pronounced disparities highlight differences in pharmaceutical workforce distribution, which may influence healthcare accessibility and policy priorities across the region.

Norway has the highest dentist density at 8.68 per 10,000, followed closely by Portugal (8.34) and Sweden (8.08). Malta records the lowest density with 4.58 dentists per 10,000 population. The arithmetic average among the countries is 6.67 dentists per 10,000. Northern and some Western European countries tend to have higher dentist densities, while Southern and Eastern countries show lower figures. These variations reflect disparities in dental healthcare workforce distribution, potentially affecting oral health service accessibility and guiding regional health policy decisions.

All countries recorded increases, though at varying rates, in the results of nursing and midwifery personnel (Figure 7a). The most substantial growth occurred in Luxembourg (+87.3%), Switzerland (+67.5%), Malta, and Portugal (both nearly doubling). Spain also showed notable progress (+82.7%), while Italy and Ukraine had more modest gains. Countries such as Norway, Sweden, and the Netherlands maintained already elevated levels of nursing and midwifery staffing with moderate growth. These trends highlight divergent national strategies and capacities in strengthening the nursing and midwifery workforce. Persistent disparities call for targeted health workforce policies to promote equity and sustainability across Europe.

All analyzed countries experienced growth in the density of medical doctors per 10,000 population (Figure 7b). The most significant increases occurred in Sweden (from 30.3 to 47.1) and Portugal (32.1 to 59.4), indicating substantial investment in physician workforce expansion. Malta and Spain also showed marked improvements, nearly doubling their physician density. Switzerland, Norway, the Netherlands, and Luxembourg reported moderate but consistent growth. Notably, Ukraine saw only a modest increase (from 29.9 to 36.8), while France showed a slight decline (from 33.3 to 31.7), suggesting divergent national trajectories. These trends indicate evolving health system priorities and varying capacities in the training, retention, and employment of medical professionals across Europe.

From 2000 to 2024, the availability of pharmacists per 10,000 population increased in most analyzed countries, though growth patterns were uneven (Figure 7c). Southern European countries such as Spain (7.1 to 13.6) and Portugal (4.1 to 10.8) saw notable increases, reflecting strengthened pharmaceutical services. Norway nearly doubled its pharmacist density, and moderate growth was observed in Switzerland, Sweden, and the Netherlands. Interestingly, Malta experienced a significant decline (from 18.8 to 8.5), due to workforce migration or restructuring of pharmaceutical services. France and Italy maintained elevated levels despite modest shifts. Ukraine remained well below European averages, with only a marginal increase from 0.29 to 0.33 per 10,000. These tendencies highlight persistent regional disparities and the evolving role of pharmacists within health systems.

During the analyzed period, the density of dentists per 10,000 population rose significantly across most observed countries, indicating expanded access to oral health services (Figure 7d). Southern European countries experienced marked growth: Portugal tripled its density (4.3 to 12.5), while Spain and Italy nearly doubled theirs. Luxembourg and Malta also saw notable increases. Nordic countries like Norway and Sweden maintained prominent levels, with modest changes. France slightly declined despite already high baseline figures. Switzerland and the Netherlands saw moderate increases, and Ukraine rose from 4.5 to 5.9 per 10,000, remaining below EU averages. These developments indicate broader improvements in dental workforce availability and suggest a potential shift in health policy priorities across Europe.

During the examined period, most countries exhibit modest yet positive increases in nursing and midwifery personnel (Figure 8a), indicating gradual workforce growth over the 24 years. Spain, Portugal, and Malta demonstrate higher increments, with Spain consistently recording positive increases in the range of 0.03 to 0.05 per year. In contrast, Switzerland, Italy, Norway, France, and Sweden display more moderate or variable changes, with increments often near zero and occasionally dipping slightly below zero in certain years. Data from Ukraine is incomplete and characterized by significant negative spikes and missing values following 2014, reflecting the impact of socio-political instability on workforce reporting.

The medical doctor workforce (Figure 8b) demonstrates relative stability, with most countries showing steady, modest annual increments. Norway, Sweden, and Portugal exhibit consistent growth, with increments ranging between +0.02 and +0.10 per 10,000 population annually. Italy, however, displays notable volatility, highlighted by a significant spike in 2001 (+1.68), followed by large negative increments in subsequent years (e.g., -0.50 to -1.20), potentially indicative of data irregularities or changes in workforce reporting or health policy reforms. Malta's data reflect fluctuating trends, with increments varying from -0.05 to +0.10 per year. Ukraine's data remains incomplete and highly erratic from the mid-2010s onward, showing missing values and extreme fluctuations.

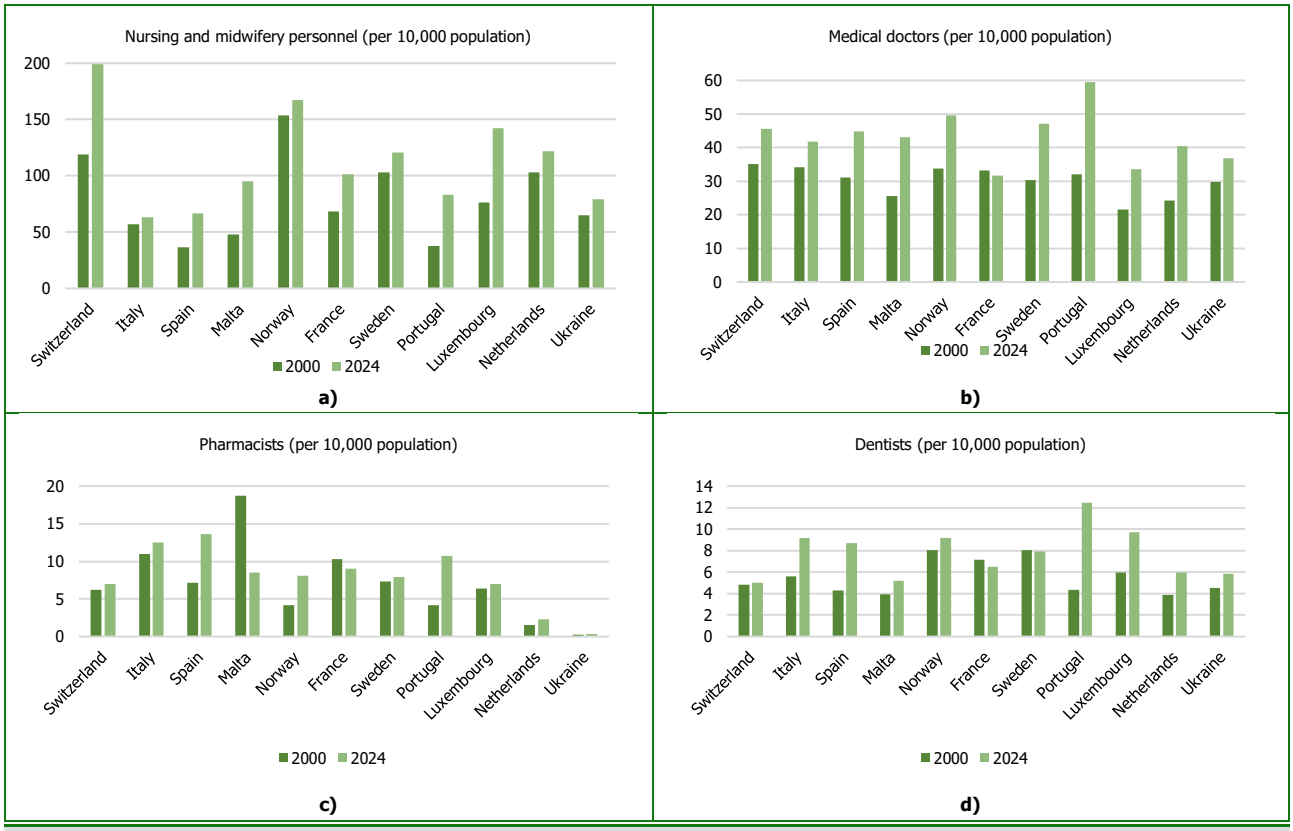

Figure 7. Dynamics of changes in the group of workforce indicators during 2000-2024. *(Source: compiled by the authors based on: WHO Indicators Statistics, 2025)*

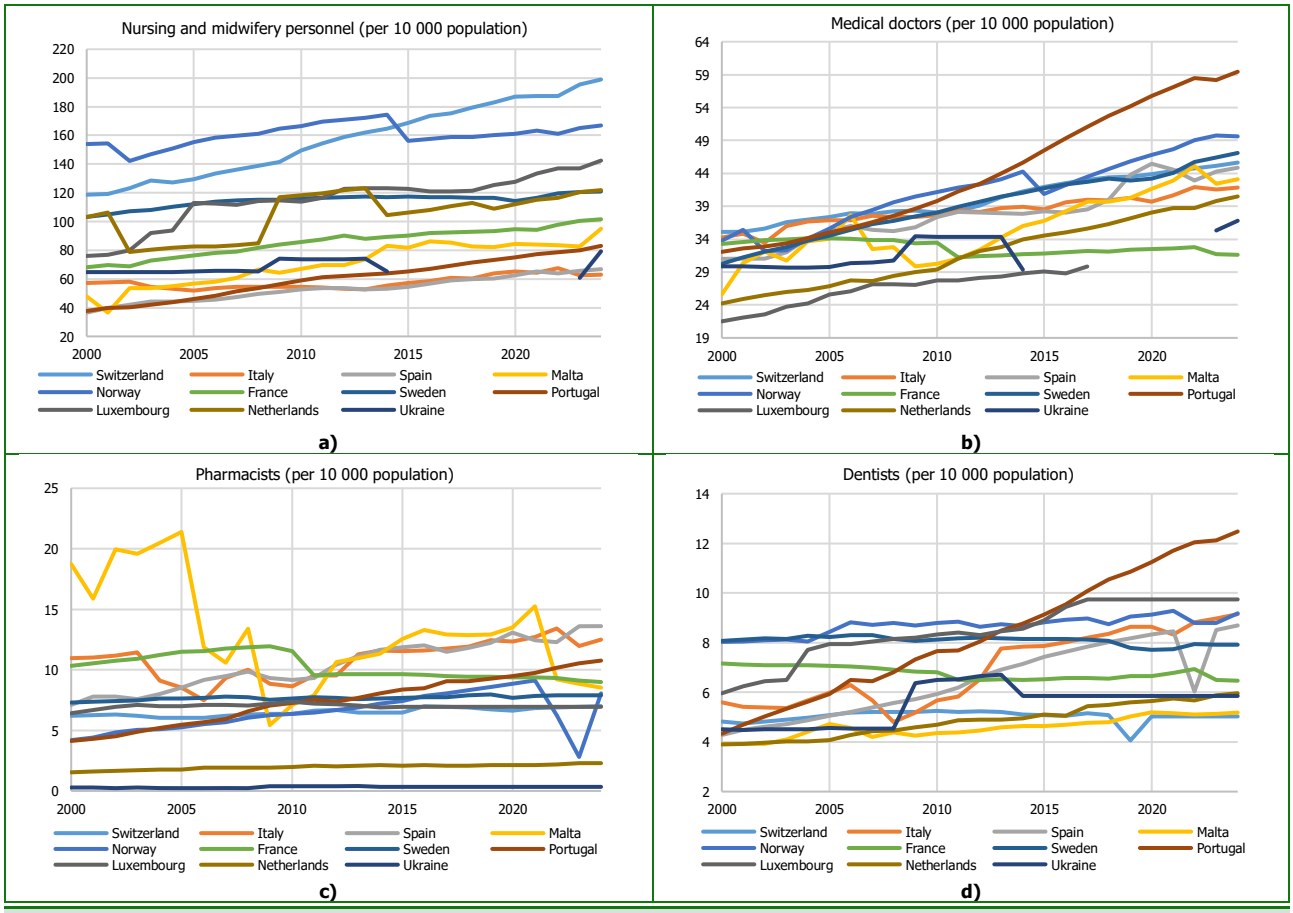

Figure 8. Chain growth rate of the workforce indicators during 2000-2024. *(Source: compiled by the authors based on: WHO Indicators Statistics, 2025)*

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Pharmacist workforce growth (Figure 8c) exhibits small and stable increments across most countries, with many showing modest positive increases indicative of gradual expansion. Portugal, Norway, Spain, and Italy demonstrate sustained positive increments over multiple years, typically ranging from +0.01 to +0.10 per 10,000 population annually. Malta and Ukraine present irregular patterns characterized by large negative values and intermittent missing data. Notably, Norway records unusually large negative increments in 2021 and 2022 (-0.32 and -0.55, respectively), followed by a pronounced positive rebound in 2024 (+1.87), which may reflect either data anomalies or significant shifts within the workforce.

The dentist's workforce (Figure 8d) demonstrates stable but slow growth across most countries, with annual increments generally ranging from 0.00 to +0.05 per 10,000 population. Portugal, Spain, and Italy exhibit consistent positive increments, typically between +0.01 and +0.04 annually. Switzerland and Sweden experience minor fluctuations, including occasional negative increments around -0.01 to -0.03, though these changes remain small in magnitude. Luxembourg and Ukraine show missing or irregular data patterns beginning in the mid-2010s, limiting trend interpretation for these countries.

While workforce indicators offer valuable insights into the capacity and dynamics of healthcare delivery, understanding the ultimate impact of these resources requires examining health outcomes. Health outcomes indicators provide a crucial perspective on the effectiveness and quality of care, reflecting how well the system translates its input into improved population health.

Table 6. Results of the arithmetic average calculation of the groups of health outcomes indicators for 2000-2024 years. *(Source: calculated by the authors based on: WHO Indicators Statistics, 2025; World Bank, 2025; Eurostat, 2025; Worldometer, 2025)*

	Countries	Arithmetic average		Countries	Arithmetic average		Countries	Arithmetic average
Adult Mortality rate (probability of dying between 15 and 60 years old, per 1,000 population)	Ukraine	217.07	Child mortality rate for 5- to 14-year-olds (probability of dying per 1,000 children aged 5-14 years)	Ukraine	2.58	Child deaths in infants, infant mortality rate (between birth and 11 months per 1,000 live births)	Ukraine	11.07
	Portugal	83.74		Portugal	1.26		Malta	5.82
	France	80.19		Spain	1.02		Switzerland	3.91
	Spain	65.29		Malta	1.01		The Netherlands	3.89
	The Netherlands	63.88		The Netherlands	0.95		France	3.32
	Luxembourg	62.53		France	0.93		Portugal	3.27
	Norway	60.95		Italy	0.92		Italy	3.25
	Malta	58.67		Norway	0.92		Spain	3.16
	Italy	58.23		Switzerland	0.90		Norway	2.60
	Sweden	57.32		Sweden	0.87		Sweden	2.53
	Switzerland	54.80		Luxembourg	0.56		Luxembourg	2.48
	Countries	**Arithmetic average**		**Countries**	**Arithmetic average**			
Life Expectancy	Switzerland	81.84	Population	France	65,316,543.61			
	Italy	81.48		Italy	59,077,157.40			
	Spain	81.30		Ukraine	45,881,368.25			
	Sweden	81.28		Spain	45,607,642.63			
	Norway	81.08		The Netherlands	16,813,587.42			
	France	81.00		Portugal	10,433,103.48			
	Malta	80.74		Sweden	9,626,789.88			
	The Netherlands	80.26		Switzerland	8,018,238.78			
	Luxembourg	79.80		Norway	5,002,909.71			
	Portugal	79.58		Luxembourg	541,043.01			
	Ukraine	70.3		Malta	445,078.86			

The findings reveal that the arithmetic average calculation of the groups of health outcomes indicators (Table 6) shows significant disparities among the countries, with Ukraine consistently exhibiting the highest mortality rates: adult mortality at 217.07 (mean: 80.61), child mortality at 2.58 (mean: 1.20), and infant mortality at 11.07 (mean: 4.13). In contrast, countries such as Switzerland, Sweden, and Luxembourg report the lowest rates across most categories, with Switzerland recording adult mortality of 54.80, child mortality of 0.90, and infant mortality of 3.91. These patterns underscore the impact of healthcare system performance, socioeconomic stability, and public health policies on population health outcomes. While infant and child mortality rates remain low across most of the region, adult mortality demonstrates greater variability, indicating broader structural health and lifestyle determinants. The results emphasize the need for targeted interventions in countries with elevated mortality risks, particularly Ukraine. The arithmetic average life expectancy across the eleven countries is 79.42 years. Switzerland (81.84 years) ranks highest, followed closely by Italy, Spain, and Sweden, all exceeding 81 years. Most Western and Northern European countries cluster near or slightly above the average, indicating consistent longevity across the region. Ukraine (70.3 years) is a clear outlier, with life expectancy more than 9 years below the average, highlighting substantial public health and socioeconomic challenges. Excluding Ukraine, the adjusted average rises to 80.78 years, showing a narrower and healthier distribution among the remaining countries.

Across all indicators, there is a clear and consistent decline in mortality rates between 2000 and 2024 (Figure 9a), demonstrating substantial improvements in public health, medical technology, and social conditions in Europe. In 2000, adult mortality rates varied widely, with Ukraine showing an exceptionally high rate (258), far exceeding other countries where rates ranged from 71 (Malta) to 110 (Portugal). By 2024, all countries will exhibit a substantial decline in adult mortality, with Switzerland and Luxembourg showing the lowest rates (~36), while Ukraine, although improved, remains significantly higher (~155) compared to others. This indicates progress in healthcare, lifestyle, and social conditions across Europe, but persistent health challenges remain in Ukraine. In 2000, child mortality was low across countries, with rates below 4 per 1,000, except Ukraine, which had a notably higher rate (3.8) (Figure 9b). By 2024, child mortality rates had decreased further, with most countries below 1 per 1,000, highlighting improvements in pediatric healthcare and living conditions. Ukraine again shows higher mortality than others (1.45), though markedly improved compared to 2000. Infant mortality rates (deaths between birth and 11 months per 1,000 live births) in 2000 were also low, ranging from 3.39 (Sweden) to 6.7 (Malta), except for Ukraine's significantly elevated rate of 17.6 (Figure 9c). By 2024, infant mortality had decreased across all countries, with Norway achieving the lowest rate at approximately 1.44. Ukraine demonstrated improvement to 5.76, yet this figure remained higher than in most other countries, highlighting ongoing disparities, particularly notable in Ukraine and Malta.

In 2000, the global average life expectancy stood at 66.4 years, while the selected European countries exhibited significantly higher figures, ranging between approximately 67.8 years (Ukraine) and 79.8 years (Switzerland). Ukraine's life expectancy was notably close to the global average, reflecting underlying health and socioeconomic challenges at the time. By 2024, global life expectancy had increased to 71.9 years, showing steady but moderate progress worldwide. In contrast, the European countries experienced more pronounced gains, with life expectancy rising to an average range between 73.3 years (Ukraine) and 83.2 years (Norway).

The highest life expectancies in 2024 were observed in Norway (83.2 years), Sweden (82.4 years), and Switzerland (83.1 years), highlighting their advanced healthcare systems and favorable living conditions (Figure 9d). Analysis of the bar chart reveals that France had the largest population in both 2000 and 2024, while Luxembourg had the smallest; notably, Ukraine experienced the most significant population decrease among the countries displayed (Figure 9e). Despite an increase in life expectancy from 67.8 years in 2000 to 73.3 years in 2024, Ukraine still lags behind other European nations by a considerable margin, reflecting persistent challenges related to health infrastructure, lifestyle, and socioeconomic factors.

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Figure 9. Dynamics of changes in the group of health outcomes indicators during 2000-2024. *(Source: compiled by the authors based on: WHO Indicators Statistics, 2025; World Bank, 2025; Eurostat, 2025; Worldometer, 2025)*

The adult mortality rate (Figure 10a) exhibited negative annual growth rates across most countries, indicating a gradual decline in mortality risk among adults aged 15-60. For example, Switzerland showed consistent reductions with rates mostly between -0.02 and -0.07, with notable improvements in 2021 (-0.13) and 2022 (-0.04). Italy and Spain also experienced mostly negative growth rates, with occasional slight positive fluctuations (Italy: up to 0.06 in 2020; Spain: 0.06 in 2019). Ukraine showed more volatility with growth in early years (0.03 in 2001) and sharp negative shifts post-2020 (-

0.17 in 2022). Child mortality rate for 5- to 14-year-olds (Figure 10b) demonstrated more pronounced and consistent reductions, with countries such as Portugal and Luxembourg showing substantial decreases, reaching -0.42 and -0.16, respectively, by 2024. Most Western European countries exhibited intermittent zero or slightly negative values, highlighting gradual improvements, e.g., Switzerland showed up to -0.18 in 2024.

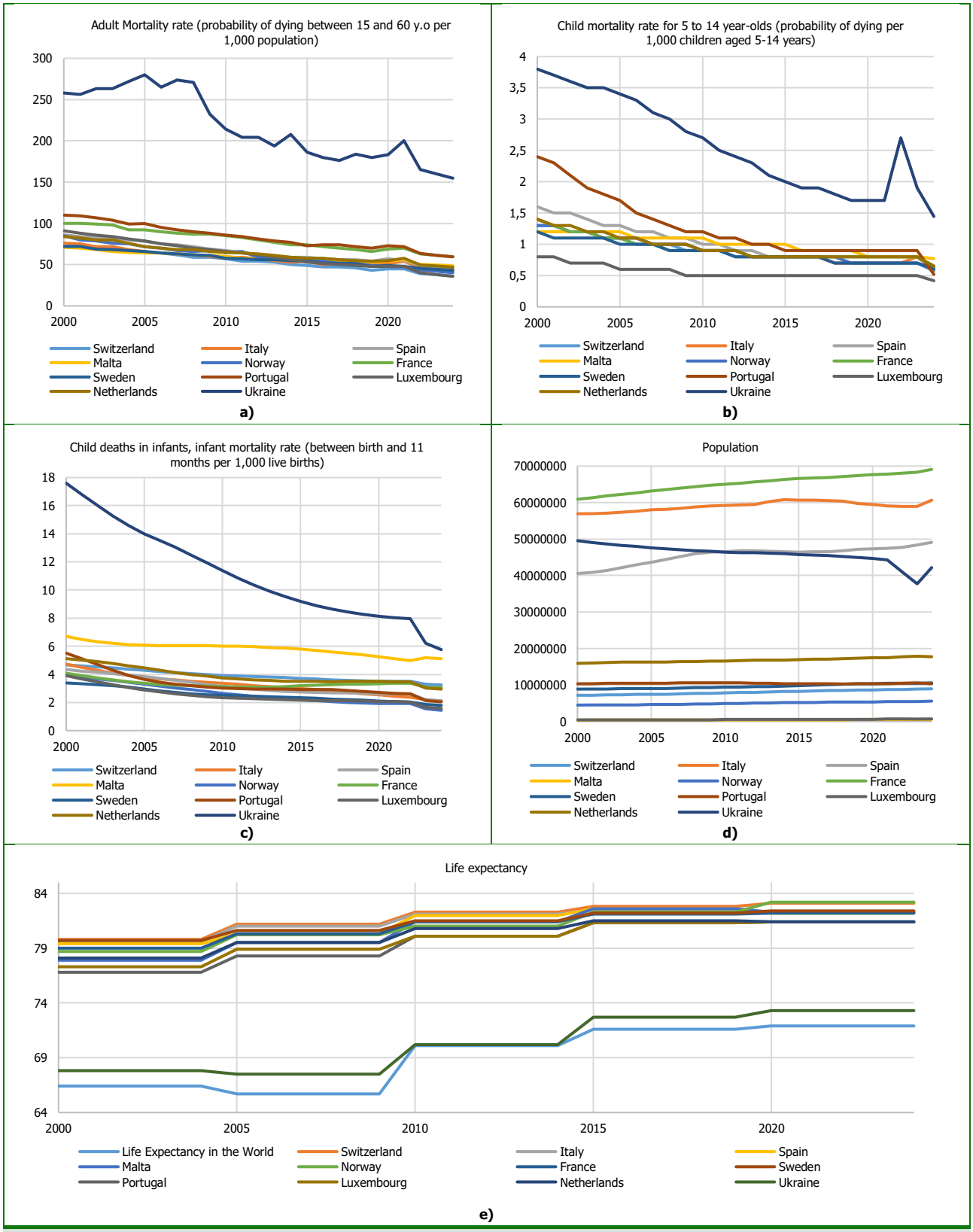

Figure 10. Chain growth rate by the health outcomes indicators during 2000-2024. *(Source: compiled by the authors based on: WHO Indicators Statistics, 2025; World Bank, 2025; Eurostat, 2025; Worldometer, 2025)*

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Infant mortality (Figure 10c) trends also confirmed a steady decline with yearly reductions between -0.01 and -0.09. Portugal experienced a notable acceleration in improvements, recording a rate of -0.18 in 2022. France and Norway showed smaller but consistent declines. Ukraine's infant mortality rate declined steadily with growth rates between -0.01 and -0.22 by 2022, signaling ongoing improvements despite earlier higher mortality risks. Overall, the data reveal consistent downward trends in mortality rates across all age groups and countries, with variations reflecting differences in health system performance, socioeconomic factors, and the impact of recent crises. These findings underscore continued progress in reducing mortality risks but highlight the need for targeted interventions in countries with volatility or slower improvements.

The analysis of life expectancy chain growth rates revealed minimal but consistent increases (Figure 10d). All countries showed a modest one-time rise in 2004 (e.g., +0.02 in Switzerland, Italy, France, Portugal, the Netherlands), followed by exceedingly small or no annual changes through 2024. Ukraine had slightly higher gains in 2009 (+0.04) and 2014 (+0.04), reflecting episodic recovery periods. Overall, life expectancy gains appear stagnant since 2010, suggesting that further gains may be constrained by slower improvements in health determinants, aging populations, or residual effects from recent health crises (e.g., COVID-19 or conflict-related strain in Ukraine).

Population growth rates remained mostly stable or slightly positive in Western countries (e.g., Switzerland: +0.01 annually; Norway, France: +0.01) (Figure 10e). Italy, Spain, and Portugal experienced near-zero or slightly negative growth in certain years, reflecting aging demographics and emigration trends. Malta and Luxembourg had higher population growth (+0.02 to +0.04), linked to immigration. Ukraine experienced negative or stagnant growth throughout, with steep declines in recent years (-0.07 in 2022, -0.08 in 2023), driven by conflict-related displacement and demographic aging.

The study reveals substantial disparities in health expenditure levels, growth, and financing structures across 11 European countries between 2000 and 2024. High-income countries like Switzerland, the Netherlands, and Luxembourg consistently allocate greater resources to health both in per capita terms and as a share of GDP, confirming prior findings on health investment correlating with economic capacity. Average CHE per capita ranged from USD 8,101 (Switzerland), USD 7,283 (Netherlands), and USD 6,107 (Malta) to USD 193 (Ukraine). France (11.05%) and Switzerland (10.61%) devoted the largest shares of GDP to health, while government financing dominated in Luxembourg and Norway (government share of CHE ≈85%), contrasting with high private and out-of-pocket burdens in Switzerland and Ukraine (private shares >45% in places). Ukraine recorded the largest relative CHE growth (≈8.4× from a low base), whereas high-spending countries showed smaller proportional increases. Countries like Ukraine and Malta showed the most rapid relative growth, albeit from a lower baseline, reflecting systemic reforms and EU integration pressures. Private spending remains significant in Switzerland and Ukraine, raising concerns about equity and financial protection. Conversely, Nordic countries continue to demonstrate strong public financing, aligning with established models of universal coverage. The shift toward increased public spending in some countries (e.g., Switzerland) contrasts with growing privatization in others (e.g., Malta and Portugal), revealing diverging policy trajectories. Despite overall growth in health investment, persistent gaps in financing models and equity remain. Economic strength strongly influences health spending capacity, but policy choices also play a critical role. Countries moving toward privatization risk widening access gaps, while those maintaining strong public systems show greater financial protection. Continued monitoring and policy coordination at the EU level may help reduce disparities and promote more sustainable, equitable health systems across Europe. These cross-country differences highlight that financial sustainability is not only a matter of economic capacity but also of fiscal policy and governance choices. Countries that protect health financing through stable public revenues demonstrate stronger equity and resilience, whereas reliance on out-of-pocket payments or volatile private spending exposes households to financial hardship and amplifies inequality. Thus, the financial architecture of health systems emerges as a central determinant of both system sustainability and population health equity across Europe.

The results show significant variation in hospital infrastructure across countries. Ukraine and France maintain high hospital bed densities, while Sweden reports the lowest, reflecting its outpatient-focused model. Italy stands out for its high density of provincial hospitals, linked to its decentralized system. Community-level facilities are strongest in Portugal and Malta, while specialized hospitals are more concentrated in Luxembourg and the Netherlands. From 2000 to 2024, all countries saw a decline in hospital bed availability, reflecting reforms aimed at efficiency and outpatient care. The decline was steepest in the Netherlands and Spain, while Italy and Switzerland experienced slower reductions. Temporary increases during the COVID-19 pandemic were observed but not sustained. Volatility in Malta and Ukraine highlights structural sensitivity and crisis impacts. These trends align with prior studies showing Western Europe's move toward outpatient services and challenges in Eastern Europe. So, Europe's health systems are shifting toward less hospital-centric care. Future research should explore subnational patterns and link structural trends to health outcomes and equity.

The analysis of healthcare workforce indicators from 2000 to 2024 reveals persistent regional disparities across Europe. Northern and Western countries, particularly Norway, Switzerland, and Luxembourg, report high densities of nursing, medical, and dental personnel, reflecting sustained investment. In contrast, Southern and Eastern countries such as Ukraine, Italy, and Spain exhibit lower values, indicating capacity gaps and the need for strategic workforce development. Growth trends are positive, with notable increases in Portugal, Spain, and Sweden. However, data inconsistencies, particularly in Ukraine and Malta, and abrupt fluctuations in countries like Italy and Norway, suggest challenges in reporting and system stability. These findings align with prior studies highlighting the uneven distribution of human resources for health across Europe and the growing shift toward strengthening primary care and outpatient services. That research showed that while most countries show progress in workforce expansion, significant disparities remain. Coordinated policy action is needed to ensure equitable distribution, improved data systems, and integration of workforce planning with broader health system goals.

The analysis of health outcomes from 2000 to 2024 reveals significant disparities among European countries. Western and Northern countries like Switzerland, Sweden, and Luxembourg show the lowest adult, child, and infant mortality rates, alongside the highest life expectancies (81–83 years). In contrast, Ukraine consistently records the poorest outcomes, with adult mortality averaging 217.07, child mortality 2.58, infant mortality 11.07, and the lowest life expectancy (70.3 years).

Overall, there is a clear downward trend in mortality rates and rising life expectancy across the region, reflecting improvements in healthcare and living conditions. However, Ukraine's slower progress and recent declines in population growth highlight ongoing challenges, including conflict, economic instability, and healthcare gaps. While most European countries demonstrate strong health improvements, Ukraine requires urgent attention. Future efforts should focus on closing these health gaps and addressing broader social determinants to sustain long-term progress.

DISCUSSION

This study advances the literature on public health system sustainability by integrating financial, institutional, workforce, and outcome indicators within a unified evolutionary (2000-2024) and spatial–temporal comparative framework across eleven European countries, explicitly including Ukraine as a lower-resource, crisis-affected comparator. Whereas prior research typically isolates single dimensions (financing, governance, workforce, or outcomes) or focuses predominantly on high-income systems, our approach demonstrates how financing composition, particularly the public share of current health expenditure (GGHE-D) and out-of-pocket expenditure (OOPE), conditions institutional capacity, human resources, and population outcomes over time.

Our findings align with comparative evidence linking strong public financing to resilience, equity, and improved performance (e.g., Kuzior et al., 2022; Kuzior et al., 2025), and with WHO/OECD positions on the centrality of government financing for universal coverage and financial protection. Consistent with Vysochyna et al. (2023), we confirm pronounced spatial heterogeneity in vulnerability; and in line with Megbowon & Zehirun (2025), Filipova et al. (2025), and Vasylieva et al. (2023), we observe that fiscal capacity and governance quality shape the priority accorded to health in public budgets. Our evidence that high OOPE erodes equity is compatible with user-side studies emphasizing affordability and trust (e.g., Otieno et al., 2025; Ukpe & Mohamadou, 2024) and with research on insurance uptake and household risk (e.g., Hasan et al., 2025). Finally, our observation that digitalization and governance innovation support institutional sustainability accords with work highlighting inclusion, efficiency, and transparency (e.g., Maatallah, 2024; Nafei et al., 2025; Zhou, 2024; Ponomarenko et al., 2024; Prokopenko et al., 2025) and with institutional-ethics perspectives on stewardship and trust (e.g., Adhikari et al., 2024; Dachi & Kasztelnik, 2024; Chetanraj et al., 2024).

This study extends the literature on health system sustainability in Europe by offering three main contributions. First, through a four-pillar synthesis, it links financing structures current health expenditure, government and compulsory schemes, out-of-pocket payments, and private shares to institutional resources (bed and facility densities), workforce capacity (physicians, nurses, pharmacists, dentists), and health outcomes (mortality, life expectancy). This integrated comparative panel demonstrates that financing composition is the proximate correlate of equity gaps, even after accounting for institutional and workforce variations. Second, by covering crisis-sensitive trajectories between 2000 and 2024, the analysis identifies structural breaks associated with austerity, the COVID-19 pandemic, and the war in Ukraine. These shocks reveal bifurcating patterns: some countries strengthened public financing, while others experienced growing privatization and rising household burdens (e.g., out-of-pocket increases in Ukraine and Malta, expanding private shares in the Netherlands). Third, through the inclusion of a conflict-affected system, the study situates Ukraine alongside high-life expectancy systems, documenting rapid yet uneven expenditure growth from a low baseline and persistent outcome deficits, an underexplored perspective in EU-centric benchmarking research.

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This study qualifies and refutes several prevailing claims in the literature on health system sustainability. First, we contest infrastructure sufficiency claims, showing that higher hospital bed density does not guarantee superior outcomes: Ukraine, despite high inpatient capacity, records poorer results, while Nordic systems with leaner infrastructures but robust public financing achieve stronger performance. Second, we challenge market-led sustainability claims, finding that greater household or private financing is associated with weaker outcomes and wider equity gaps, as higher out-of-pocket expenditure amplifies household financial risk. Third, we nuance the EU-wide convergence thesis: while partial convergence is evident, divergent trajectories persist, with some countries consolidating public financing and others experiencing intensifying privatization.

We build on prior scholarship by extending Kuzior et al. on efficiency and preparedness, Vysochyna et al. on vulnerability, and governance: innovation studies, demonstrating that financing composition conditions the effectiveness of institutional, workforce, and digital innovations. In contrast to infrastructure-centric work, our findings establish financial protection, low out-of-pocket payments, and stable government financing as the critical pathway to resilience and equity.

Theoretically, the results support a financing-led model of sustainability, whereby predictable public fiscal space underpins equitable and shock-resilient health systems even with modest physical capacity. Methodologically, the study advances a replicable four-pillar spatial-temporal framework covering financing, institutions, workforce, and outcomes using levels, growth rates, and comparative rankings across 2000–2024.

Our conclusions diverge from prior work due to broader indicator integration, a longer crisis-spanning horizon, the explicit inclusion of a conflict-affected lower-resource system, and diagnostics that disentangle level effects from change dynamics. Overall, the analysis substantiates that equitable, predictable public financing, rather than infrastructure abundance or market reliance, is the decisive determinant of sustainable and inclusive public health system performance.

CONCLUSIONS

The article examines the evolving academic discourse on public health systems through a bibliometric analysis of 8,657 English-language publications indexed in Scopus. Findings reveal a significant increase in research activity since the early 2000s, peaking during the COVID-19 pandemic, which intensified interest in system resilience, governance, and equity. Keyword co-occurrence analysis identified four core thematic clusters: institutional structures, financial sustainability, workforce capacity, and health outcomes, highlighting the multidimensional nature of public health system sustainability. Based on these insights, the study proposes a comprehensive definition of public health systems as integrated networks of governmental, private, and civil society actors focused on health promotion, equity, and strategic governance. Limitations include language bias, database scope, and reliance on citation metrics. The research underscores the need for interdisciplinary approaches and context-sensitive indicators to evaluate and strengthen public health systems globally.

Institutional analysis highlights varied hospital infrastructure, with a general shift toward outpatient care and reduced hospital bed availability. Workforce indicators reveal persistent regional imbalances, with Northern and Western countries maintaining higher staff densities. Health outcomes have improved overall, though Ukraine lags markedly behind due to structural and geopolitical challenges. The study emphasizes the need for coordinated, equity-focused policies, improved data harmonization, and further research into subnational disparities and the qualitative drivers of system performance.

Financial sustainability stands out as the foundation upon which institutional capacity, workforce development, and health outcomes ultimately depend. Ensuring predictable, equitable, and sufficient public funding - while reducing excessive reliance on out-of-pocket and private contributions - should be prioritized in future reforms. Strengthening the fiscal base for health is therefore not only a technical matter of budgeting but also a strategic policy choice critical to advancing long-term resilience and equity in European public health systems.

Future research should aim to overcome several methodological and empirical constraints identified in this study. First, extending bibliometric analyses beyond English-language publications indexed in Scopus would mitigate language and database biases, thereby incorporating a broader spectrum of regional and non-indexed scholarship. Second, reliance on citation-based metrics should be complemented with alternative evaluative measures to avoid disproportionate emphasis on highly cited fields and to better capture emerging or context-specific research agendas. With respect to health expenditure, infrastructure, and workforce indicators, future investigations should seek to enhance data availability, quality, and harmonization, particularly for countries such as Ukraine and Malta, so as to strengthen cross-national comparability. Addressing temporal gaps and inconsistencies in time-series data, especially during episodes of systemic reform or crisis (e.g., the COVID-19 pandemic, armed conflict), remains essential for ensuring the robustness of longitudinal analyses. Furthermore, the use of simple arithmetic averages across heterogeneous national contexts risks obscuring subnational

heterogeneity; advanced statistical approaches capable of capturing structural and regional variation would provide greater analytical precision. The integration of qualitative evidence, including insights into policy implementation processes and cultural determinants, would also enrich the interpretation of quantitative trends. Finally, future work should extend beyond macro-level indicators to systematically examine intra-country inequities such as urban rural divides and socioeconomic disparities—in order to generate a more nuanced and comprehensive understanding of health system sustainability.

ADDITIONAL INFORMATION

AUTHOR CONTRIBUTIONS

All authors have contributed equally.

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CONFLICT OF INTEREST

The Authors declare that there is no conflict of interest.

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ФІНАНСОВО-ІНСТИТУЦІЙНА СТІЙКІСТЬ СИСТЕМИ ГРОМАДСЬКОГО ЗДОРОВ'Я: ЕВОЛЮЦІЙНІ ТА ПРОСТОРОВО-ЧАСОВІ ПАТЕРНИ

Забезпечення довгострокової стійкості систем громадського здоров’я вимагає не лише інституційних реформ, а й надійного та справедливого фінансування. Це завдання набуло особливої актуальності в умовах прискореного демографічного старіння, зростання вартості медичних послуг і повторюваних глобальних криз, зокрема пандемії COVID-19. Війна в Україні додатково оголила вразливість систем охорони здоров’я. У дослідженні проаналізовано фінансові та інституційні траєкторії 11 європейських країн (Швейцарія, Нідерланди, Мальта, Італія, Іспанія, Норвегія, Франція, Швеція, Португалія, Люксембург, Україна) протягом 2000–2024 років із метою з’ясування, як моделі фінансування формують стійкість систем громадського здоров’я. Використовуючи набір фінансових показників (поточні витрати на охорону здоров’я на душу населення; їх частка у ВВП; частка уряду в загальних витратах; обсяги приватних і домогосподарських витрат; державні витрати на охорону здоров’я на душу населення; ВВП на душу населення за ПКС) у поєднанні з інституційними, кадровими та результативними метриками, ми задокументували значні та стійкі міжкраїнні відмінності. Виявлено суттєві диспропорції у фінансуванні: заможні країни стабільно витрачають більше та покладаються на сильніші державні внески, а країни з обмеженими ресурсами, зокрема Україна, демонструють швидке, але нерівномірне зростання, що супроводжується високим фінансовим тягарем для домогосподарств. Тренди свідчать і про поступову конвергенцію в напрямі посилення державного фінансування в окремих країнах, і про посилення приватизації або зростання навантаження на населення в інших (зокрема зростання частки витрат домогосподарств в Україні та на Мальті; збільшення приватної частки в Нідерландах). Такі фінансові моделі тісно корелюють із розривами в показниках справедливості та результативності: обмежене державне фінансування та високі прямі витрати домогосподарств асоціюються з гіршими результатами охорони здоров’я. Ми робимо висновок, що фінансові реформи — розширення бюджетного простору для охорони здоров’я, зниження частки прямих витрат населення, стабілізація державних інвестицій у галузь і поступове підвищення показників державних витрат на охорону здоров’я на душу населення в країнах з обмеженими ресурсами — є критично важливими для зміцнення стійкості та справедливості. Рекомендуємо посилення систем збирання фінансових даних і впровадження скоординованих, орієнтованих на справедливість політичних стратегій задля підтримки стійких та інклюзивних систем громадського здоров’я у Європі.

Ключові слова: система громадського здоров'я, фінансування охорони здоров’я, інституційна стійкість, просторово-часові закономірності, порівняльний аналіз, регіональні диспропорції, ефективність системи охорони здоров’я, державні витрати на охорону здоров’я, прямі витрати домогосподарств, фінансова стійкість

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