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Global Patterns and Evolution of Health Expenditure-Level Inequality in Major Countries between 2010 and 2021

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Abstract: This study evaluated the global pattern and evolution of health expenditure levels among major countries from 2010 to 2021. Five health-expenditure indicators were extracted for 184 countries. A unified entropy-weighted Health Expenditure Level Index (HELI) was constructed based on five indicators. Gini coefficients, Theil indices, paired Wilcoxon tests, Spearman rank correlation, and Kruskal-Wallis tests were used to assess temporal change and regional inequality. The results show that the mean HELI increased by 4.97 points from 2010 to 2021 (Wilcoxon $P \leq 0.001$), indicating that health expenditure levels increased overall between 2010 and 2021. The Gini coefficient and Theil index decreased from 2010 to 2021, indicating that between-country inequality in health expenditure levels narrowed, but the degree of differences remains significant. Countries with low HELI values need to improve both per-capita expenditure capacity and the public-financing priority assigned to health.

1. Introduction

Health expenditure is a core input for health-system capacity and progress towards universal health coverage. Global health-financing studies show that government spending, prepaid private spending, out-of-pocket payments, and development assistance vary markedly across countries, creating persistent differences in the resources available for health systems [1]. Prospective analyses further indicate that future health spending capacity is strongly constrained by national income and fiscal space, especially in low-income and lower-middle-income countries [2].

The relationship between income and health expenditure is a long-standing question in health economics. Newhouse's cross-national study showed that per capita gross national product (GNP) explained much of the variation in medical-care expenditure across countries [3]. Later panel evidence from OECD countries confirmed a close relationship between income and health expenditure while emphasizing country heterogeneity [4]. In parallel, estimates of the resources required to achieve the health Sustainable Development Goals suggest that many low- and middle-income countries need sustained increases in health-system financing [5].

However, many comparisons rely on a single expenditure measure, particularly per-capita health spending. However, a multi-indicator comprehensive index still needs to be adopted to evaluate health expenditure. This study therefore constructed a composite HELI from five indicators, separated it into two sub-indices, and measured changes in between-country inequality using the Gini coefficient and Theil index.

2. Data and methods

2.1. Data source and indicators

The data in this article is sourced from the "China Health Statistics Yearbook (2024)" edited by the National Health Commission of China. The original dataset contained 185 countries and five indicators for 2010 and 2021: Current health expenditure (% of GDP), domestic general government health expenditure (% of current health expenditure), domestic general government health expenditure (% of general government expenditure), current health expenditure per capita (US$), and domestic general government health expenditure per capita (US$). The first three indicators were assigned to the sub-domain of relative expenditure and public-financing priority, and the two per-capita indicators were assigned to the sub-domain of per-capita health expenditure capacity. All indicators were positive indicators. Missing values were not imputed. North Macedonia was excluded from the main paired analysis because the 2010 value of current health expenditure per capita was missing.

2.2. Entropy-weighted index construction

The entropy weight method was used to assign objective weights according to the dispersion of each indicator [6]. Let i denote a country-year observation and j denote an indicator. For the two per-capita indicators, the raw value was first transformed using $ln(1+x)$; for the percentage indicators, the original value was retained. The transformed value is denoted by F_{ij}.

Positive normalization was performed as follows:

$$x_{ij} = (F_{ij} - F_{jmin}) / (F_{jmax} - F_{jmin}) \quad (1)$$

where x_{ij} is the normalized value of observation i on indicator j; F_{ij} is the transformed indicator value; F_{jmin} and F_{jmax} are the minimum and maximum values of indicator j in the pooled 2010 and 2021 sample.

The proportional contribution of observation i under indicator j was calculated as:

$$P_{ij} = x_{ij} / \sum x_{ij} \quad (2)$$

where P_{ij} is the proportional value and m is the number of country-year observations. When x_{ij}=0, the corresponding entropy term was treated by its limiting value.

The entropy value of indicator j was:

$$e_j = -(1 / ln\ m) \times \sum P_{ij}\ ln(P_{ij}) \quad (3)$$

where e_j measures the information entropy of indicator j, $0 \le e_j \le 1$. A larger e_j indicates a more even distribution and a smaller contribution to differentiation.

The divergence coefficient and entropy weight were:

$$d_j = 1 - e_j \quad (4)$$

$$W_j = d_j / \sum d_j \quad (5)$$

where d_j is the divergence coefficient, W_j is the weight of indicator j.

The single-indicator score and composite Health Expenditure Level Index were:

$$S_{ij} = W_j \, x_{ij} \tag{6}$$

$$HELI_i = 100 \times \sum S_{ij} \tag{7}$$

where S_{ij} is the weighted score of observation i on indicator j, and $HELI_i$ is the composite score of health expenditure level. The two sub-indices were calculated by re-normalizing the weights within their corresponding sub-domains and multiplying the weighted sums by 100.

2.3. Gini coefficient

The Gini coefficient was used to measure between-country inequality in HELI [7]:

$$G=\sum_{i=1}^{n}\sum_{k=1}^{n}|S_i\text{-}S_k|/(2n^2\bar{S}) \tag{8}$$

where G is the Gini coefficient; S_i and S_k are the HELI values of countries i and k; $\bar{S}$ is the sample mean; and n is the number of countries. A larger G indicates greater inequality. The analysis used equal country weights rather than population weights.

2.4. Theil index and regional decomposition

The Theil index was used because it can be decomposed into between-region and within-region components [8]:

$$T = [\sum (S_i/\bar{S}) \, ln(S_i/\bar{S})] \, /n \tag{9}$$

where T is the overall Theil index.

2.5. Statistical analysis

HELI and the two sub-indices were summarized using medians, interquartile ranges, and means. Paired changes between 2010 and 2021 were assessed with Wilcoxon signed-rank tests. Rank stability was assessed using Spearman correlation. Regional differences were tested with Kruskal-Wallis tests, followed by Dunn-Holm post hoc comparisons. Sensitivity analyses included a raw-value entropy index, an equal-weight index, and indices excluding one per-capita indicator.

3. Results

3.1. Indicator weights

The five entropy weights ranged from 17.58% to 22.41% (Table 1). The largest weight was assigned to Current health expenditure (% of GDP), and the smallest to Domestic general government health expenditure (% of current health expenditure). This indicates that no single indicator dominated the composite index after logarithmic transformation of per-capita spending.

Table 1: Indicator system, transformations, and entropy weights

Indicator	Sub-domain	Transformation	Weight (%)
Current health expenditure (% of GDP)	Relative expenditure and public-financing priority	Original scale	22.41
Domestic general government health expenditure (% of current health expenditure)		Original scale	17.58
Domestic general government health expenditure (% of general government expenditure)		Original scale	22.16
Current health expenditure per capita (US$)	Per-capita health spending capacity	ln(1+x)	19.75
Domestic general government health expenditure per capita (US$)		ln(1+x)	18.10

3.2. Temporal change in health expenditure levels

The median HELI increased from 38.61 in 2010 to 45.59 in 2021 (Table 2). The paired Wilcoxon test indicated a significant temporal difference (P=<0.001). The Spearman correlation between the 2010 and 2021 country rankings was 0.929 (P=<0.001), suggesting substantial persistence in the global ranking of health expenditure levels.

The Gini coefficient decreased by -0.014, from 0.249 in 2010 to 0.235 in 2021. The Theil index decreased by -0.012, from 0.103 to 0.090. The contribution of between-region inequality to the total Theil index changed from 49.3% in 2010 to 51.2% in 2021.

Table 2: Health expenditure level indices and inequality measures in 2010 and 2021

Year	Countries	HELI median	HELI mean	Gini	Theil
2010	184	38.61	38.46	0.249	0.103
2021	184	45.59	43.42	0.235	0.090

3.3. Regional differences

In 2021, the highest-ranked countries included United States, United Kingdom, Germany, Sweden, Denmark, whereas the lowest-ranked countries included Benin, Republic of the Congo, Madagascar, Eritrea, Bangladesh.

Europe and Oceania generally showed higher HELI values, whereas Africa had lower values; the Americas and Asia displayed wider within-region dispersion (Table 3, Figure 1). Regional differences were statistically significant in both years. The Kruskal-Wallis H statistics were 99.53 in 2010 and 100.60 in 2021, with both P values below 0.001.

Table 3: Regional distribution of HELI

Region	Countries	HELI median (2010)	HELI median (2021)
Asia	44	32.87	41.14
Oceania	16	45.25	48.73
Europe	39	58.23	62.30
Americas	34	41.14	49.64
Africa	51	20.22	23.35

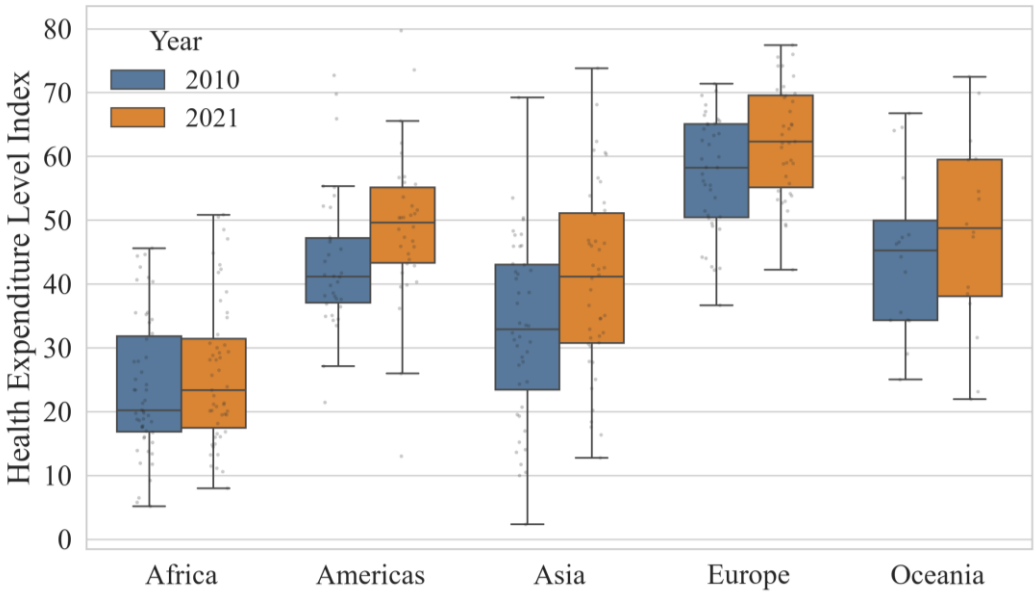

Figure 1: Regional distribution of the Health Expenditure Level Index.

Country-level changes were heterogeneous (Table 4, Figure 2), indicating that the evolution of health expenditure levels was not a uniform global increase but reflected differences in fiscal capacity, expenditure structure, and health-system priorities.

Table 4: Countries with the largest HELI changes between 2010 and 2021

Country	Change in HELI	Change type
Singapore	23.68	Increase of TOP5
Cyprus	22.10	Increase of TOP5
Timor-Leste	21.89	Increase of TOP5
Guyana	18.79	Increase of TOP5
Indonesia	17.35	Increase of TOP5
Zimbabwe	-16.00	Decrease of TOP5
Jordan	-15.30	Decrease of TOP5
Venezuela	-15.14	Decrease of TOP5
Madagascar	-15.07	Decrease of TOP5
Sudan	-13.09	Decrease of TOP5

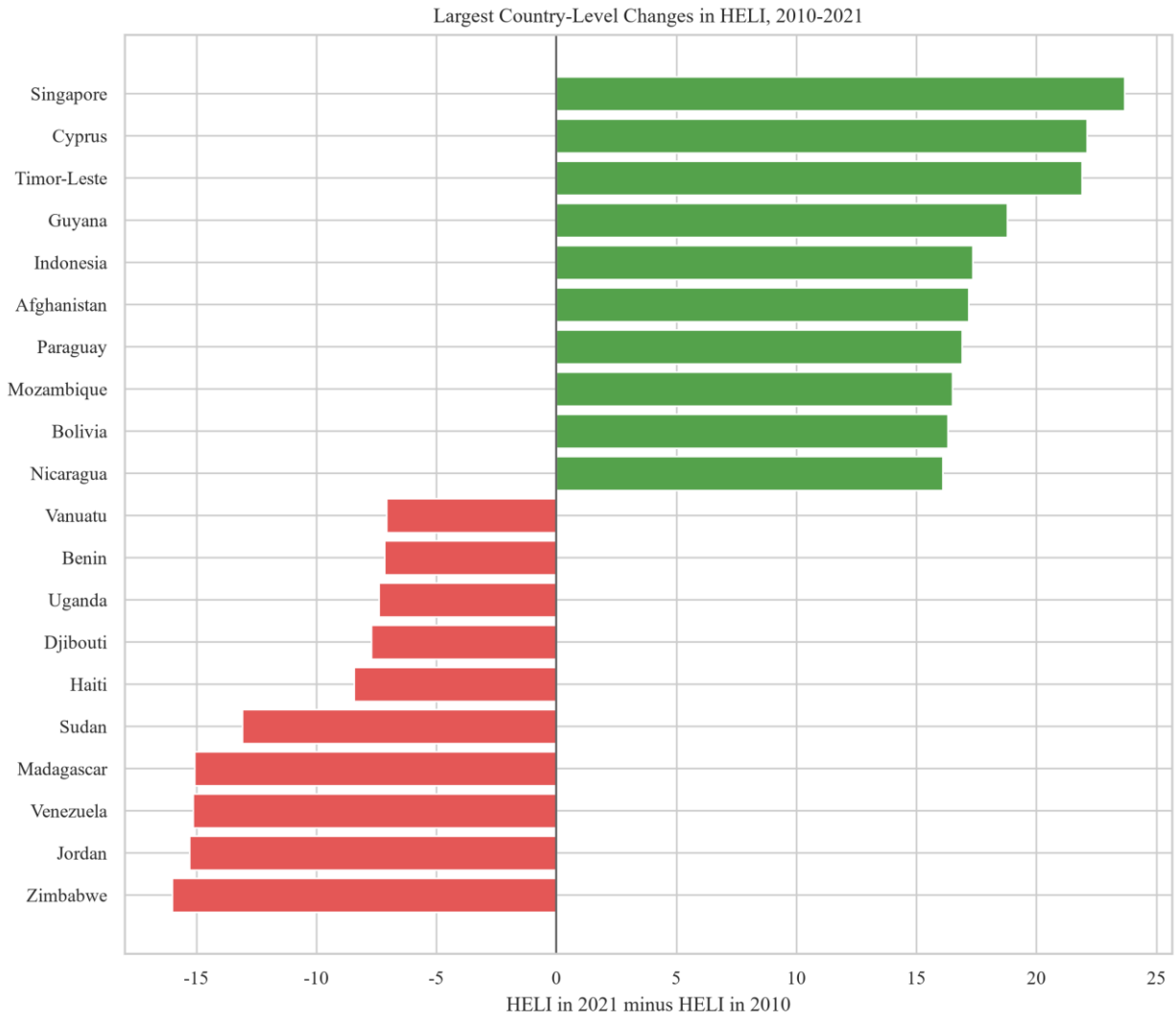

Figure 2: Countries with the largest changes of TOP 10 in the Health Expenditure Level Index between 2010 and 2021.

4. Discussions

This study found that health expenditure levels increased overall among 184 major countries between 2010 and 2021, while between-country inequality measured by both the Gini coefficient and Theil index decreased. Nevertheless, regional disparities remained significant. The health-financing transition framework suggests that economic development is commonly accompanied by increased public financing capacity [9]. Our findings add that per-capita expenditure capacity and relative public-financing priority are related but distinct dimensions. Some countries may allocate a relatively large share of national or government resources to health despite limited per-capita expenditure, whereas others may have higher per-capita expenditure without ranking equally high in relative priority.

The inequality results also have implications for financial protection. Cross-country evidence on catastrophic health spending shows that financing structure is closely related to household financial risk [10]. Progress towards universal health coverage is associated with better population health, but the translation of spending into health gains depends on governance and service coverage [11-12]. Therefore, the HELI should be interpreted as an input-side expenditure index rather than as a direct

measure of health outcomes.

This study has limitations. First, it compares two cross-sectional years and cannot capture the full annual trajectory between 2010 and 2021. Second, 2021 coincided with the COVID-19 period, during which emergency health spending and GDP changes may have affected the indicators. Third, the analysis used equal country weights rather than population weights; the results therefore describe inequality across countries, not across the global population.

5. Conclusions

The entropy-weighted HELI provides a composite measure of health expenditure level. From 2010 to 2021, health expenditure levels increased overall among major countries, and between-country inequality narrowed according to both the Gini coefficient and Theil index. However, substantial regional and within-region differences persisted. Policy attention should focus not only on increasing per-capita health expenditure in low-HELI countries, but also on strengthening stable public financing and the priority assigned to health in government budgets.

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