Assessing Health and Education Spending in an Aging World

Nomin-Erdene Munkhjargal, Fauziah Ramadhani, Patchara Pornpragit, Erlangga Gilang
Graduate School of Public Policy, University of Tokyo

Abstract

This study examines the fiscal impact of population aging on health and education spending across 55 countries over 2000–2021. Employing two-way fixed effects with country and COVID-era (2020–21) dummies, we estimate that a one-percentage-point rise in the old-age dependency ratio raises health expenditure by 0.157 percentage points ($p < 0.01$), whereas its effect on education spending is statistically insignificant. We then project health spending to 2050 using demographic forecasts and our coefficient. Finally, we construct cross-country Health–Education Performance (HEP) and Efficiency (HEE) indices, revealing that several lower-income nations deliver high efficiency despite modest outcomes, while many high-income peers underperform on cost-effectiveness.

1 Introduction

This project explores how changes in a country's demographic profile, such as population aging and youth dependency, affect the allocation and efficiency of public spending in the health and education sectors.[1]. Figure 1 underscores just how rapidly the demographic burden of an aging population is intensifying worldwide. It charts the old-age dependency ratio – the share of those aged 65+ relative to those of working age – from 1960 through present, and projects it out to 2050. Notice, for example, that Japan's dependency ratio soars past 70 percent by mid-century, a level unprecedented among large economies. Europe and China follow closely behind, each doubling their own ratios over the next three decades.

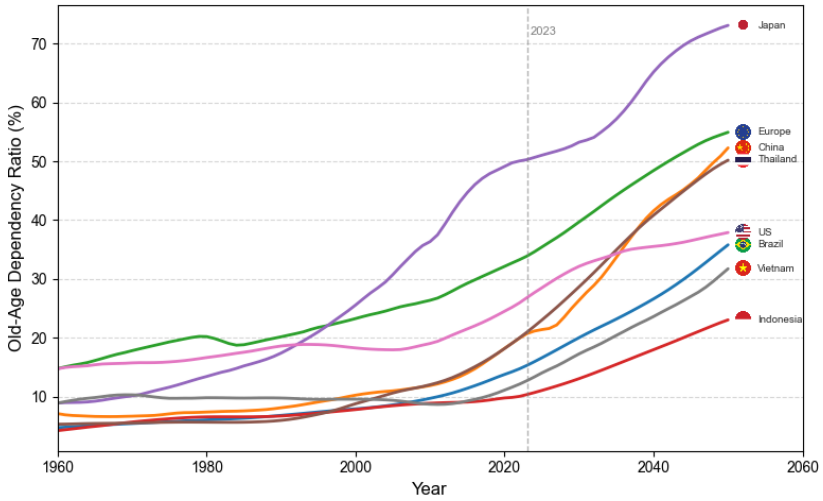

Figure 1: Old-Age Dependency Ratio Projection of Selected Countries

This looming wave of aging carries profound implications for public finance, particularly in the health and education area. As retirees consume more healthcare, pension systems strain to keep pace, and the overall tax base shrinks, governments must confront difficult trade-offs. Against this backdrop, understanding not only the level of public expenditure but how efficiently it is deployed becomes critical. If every

[1] to explore more in-depth at our research, you can access our github page here

dollar spent on health and education can be stretched further—delivering better outcomes per unit of cost—then societies will be better equipped to sustain generous support for the elderly without crowding out investments in tomorrow's workforce.

Research Objectives

- Examine how demographic structures shape fiscal priorities in health and education spending,
- Project long-term public expenditure on health and education based on demographic and economic indicators,
- Construct a cross-country Health-Education Efficiency Index (HEE) that benchmarks spending effectiveness.

Data The data set covers 55 countries from 2000 to 2022, selected based on the availability and completeness of the data. The projection models extend up to 2050[2].

Variables

- Key fiscal and demographic variables
  - **Age Dependency Ratio**: Ratio of dependents (ages <15 or >64) to working-age population (15–64)
  - **Health Expenditure (% GDP)**: Total current health expenditure as a % of GDP
  - **Education Expenditure (% GDP)**: Government education spending as a % of GDP
- Outcome variables
  - **Life Expectancy**: Expected years of life at birth
  - **Infant Mortality Rate**: Deaths of infants under age 1 per 1,000 live births
  - **Avg. Years of Schooling**: Mean years of education for adults aged 25+
  - **Learning Outcome Scores**: Harmonized international test scores (e.g., PISA, TIMSS)
- Control variables
  - **GDP per Capita**: GDP divided by midyear population (USD)
  - **Trade openness**: trade as a % of GDP
  - **Income Level**: World Bank income group classification

Research framework This project is organized into three main components.

1. Demographic Structure and Public Spending.
   We analyze the relationship between demographic composition and government expenditure in health and education. This includes visualizations of scatter plots between spending and demographic indicators. To empirically test this relationship, we estimate the following panel regression:

   $$Spending_{it} = \alpha + \beta_1 \,\text{DependencyRatio}_{it} + \beta_2 \,\ln\big(\text{GDPpc}_{it}\big) + \beta_3 TradeGDP_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

   where: (i) indexes countries and (t) indexes years.
2. Health and Education Expenditure Projections (to 2050)
   Using the result of the regression, we forecast future expenditure levels. The process includes:
   - log linear GDP and Trade forecasting

     $$\log(GDP_t) = \alpha + \delta \cdot t + \varepsilon_t$$

   - demographic forecasting. Using existing UN projections on dependency ratios

[2]detailed on the data and variables are presented in the appendix

– spending forecast based on coefficient of regression model

$$\widehat{Spending}_t = f(ProjectedDependencyRatio_t, \quad ProjectedGDPpercapita_t)$$

3. Health and Education Index
We construct a Health–Education Performance (HEP) index by averaging standardized proxy outcomes for health and education, and then derive a Health–Education Efficiency (HEE) index by dividing each country's HEP score by its corresponding public spending. The resulting HEE captures social returns per unit of fiscal input for cross-country comparisons.

$$HEE_i = \frac{HEP_i}{NormalizedSpending_i}$$

2 Data Overview

Table 1 provides a summary of key variables across all countries and years in the dataset. On average, countries spend 6.45% of GDP on health and 4.19% on education, with substantial variation between them (e.g., health spending ranges from 1.77% to 18.81%).

The dependency burden also varies widely. Overall dependency (young + old) averages 55.05% of the working-age population, but ranges from 26.87% to 101.75%. Breaking this down, the old-age dependency ratio averages 20.54% (min 3.85%, max 75.61%), while the youth dependency ratio averages 34.51% (min 12.07%, max 96.48%). These differences reflect how demographic structure—and the share of non-working dependents—differs dramatically across countries and over time.

Table 1: Descriptive Statistics of Key Fiscal, Demographic, and Outcome Variables

	count	mean	std	min	max
Health Expenditure	1264.00	6.45	2.76	1.77	18.81
Education Expenditure	1052.00	4.19	1.32	0.35	7.66
Dependency Ratio	2805.00	55.05	10.75	26.87	101.75
Dependency Ratio Old	2805.00	20.54	13.08	3.85	75.61
Dependency Ratio Young	2805.00	34.51	14.90	12.07	96.48
Life Expectancy	1265.00	73.44	6.54	47.14	84.56
Mortality Rate	1265.00	18.44	18.09	1.80	97.10
average schooling	1260.00	9.37	2.82	1.48	14.30
learning scores	204.00	455.70	62.02	309.02	581.00
GDP percapita	1265.00	14000.89	17657.07	109.59	106194.76
trade gdp	1208.00	81.20	56.63	19.56	437.33
gov consumption gdp	1200.00	15.06	4.47	2.36	39.84

GDP per capita ranges from just $110 to over $106 000, highlighting the diverse economic landscape. Trade openness is high on average (81.20% of GDP), with some small economies reaching extreme levels (437.33%). Government consumption averages 15.06% of GDP.

Table 2 highlights clear disparities across income groups. High-income countries spend the most on both health (8.41%) and education (4.55%) as a share of GDP, and have the best outcomes: life expectancy (78.8 years), lowest child mortality (4.98 per 1,000), and the highest average schooling (11.76 years) and learning scores (512). In contrast, low-income countries spend less on health (4.13%), and though they slightly outspend on education (4.72%), they show the worst human development outcomes: life expectancy of 59.7 years, mortality rate of 59.8, and average schooling of only 2.1 years. Their GDP per capita is extremely low ($456), with limited government consumption (9.4%) and trade openness (34.7%).

Lower- and upper-middle income countries fall in between. Interestingly, lower-middle income countries have higher trade-to-GDP ratios than upper-middle income countries but lower government consumption shares. Upper-middle income countries, while closer to high-income nations in life expectancy and schooling, still lag significantly in per capita income. These patterns underscore the importance of resource availability, but also raise questions about spending efficiency—particularly why similar spending levels

in education across groups result in vastly different learning outcomes.

Table 2: Average Fiscal Outcome by Income

$income_level$	Low income	Lower middle income	Upper middle income	High income
Health Expenditure	4.13	4.99	5.73	8.41
Education Expenditure	4.72	3.79	4.04	4.55
Life Expectancy	59.67	68.34	72.84	78.97
Mortality Rate	59.77	33.92	16.36	4.98
average schooling	2.11	7.51	8.82	11.76
learning scores	355.52	402.54	436.84	511.99
GDP percapita	456.41	2043.48	5674.55	31919.30
trade gdp	34.71	74.43	71.57	95.66
gov consumption gdp	9.40	12.96	13.90	17.82

Figure 2 shows how expenditure correlates with the dependency ratio. The left graph shows a clear positive correlation between old-age dependency ratio and health expenditure (% of GDP), especially in high-income and upper-middle-income countries. As populations age, healthcare demands tend to rise, and this is reflected in increased spending. Despite some outliers, the trend is consistent across income levels.

In contrast, the right graph—plotting health expenditure against young-age dependency ratio—shows a much weaker and more inconsistent relationship. The trend lines differ by income group, and there's no clear global pattern. This suggests that the burden of young dependents does not drive health spending as strongly or uniformly as aging populations do.

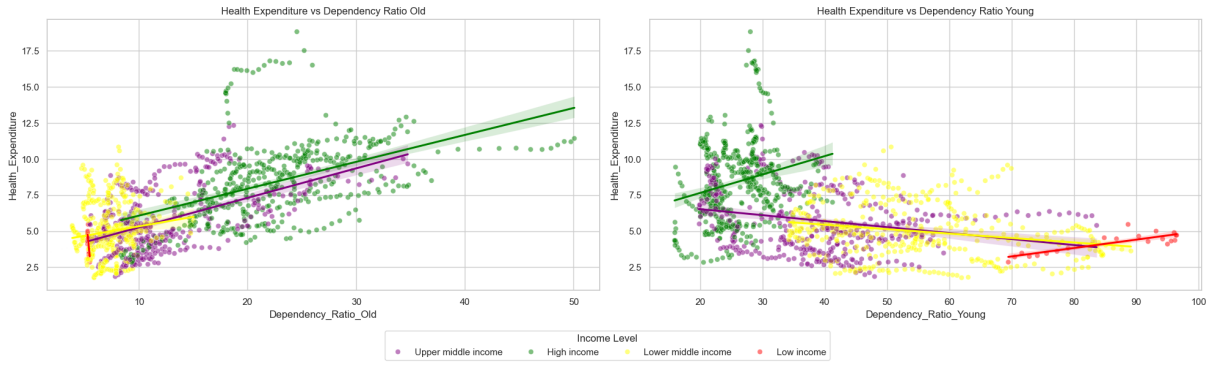

Figure 2: Health Expenditure vs Dependency Ratio

We provide a more detailed overview of public spending and demographic structure in the appendix, including visualizations of age-pyramid distributions, demographic shifts, health and education spending breakdowns, and regional correlations.

3 Findings and Analysis

Regression Table 3 reports the summary of regressions specifications estimating the effect of the old-age dependency ratio on health spending as a share of GDP. Column (1) presents a simple pooled regression, Columns (2) and (3) add country and year 2020 adn 2021 to account for covid fixed effects, Column (4) repeats the two-way FE model with standard errors clustered by country, and Column (5) augments the clustered FE model with a one-year lag of the dependency ratio. All regressions control for log GDP per capita and trade openness.
In our view, column 4 ("Country Covid FE (clustered)") is the cleanest baseline. It includes both country and covid fixed effects, and its standard errors are clustered by country to allow for within-country serial correlation, with the specification:

Table 3: Regression Summary on Health Expenditure

	(1)	(2)	(3)	(4)	(5)
Dependency Ratio (Old)	0.118***	0.180***	0.157***	0.157***	0.564***
	(0.010)	(0.011)	(0.012)	(0.025)	(0.211)
Lagged Dependency Ratio (Old)					-0.425*
					(0.217)
Log GDP per capita	0.792***	0.359***	0.342***	0.342**	0.315**
	(0.062)	(0.057)	(0.056)	(0.150)	(0.155)
Trade-to-GDP	-0.010***	-0.003**	-0.002	-0.002	-0.002
	(0.001)	(0.002)	(0.002)	(0.005)	(0.005)
R-squared	0.503	0.925	0.926	0.926	0.927
R-squared Adj.	0.502	0.921	0.922	0.922	0.923
Observations	1,155	1,155	1,155	1,155	1,155
R-squared	0.503	0.925	0.926	0.926	0.927
Country FE	No	Yes	Yes	Yes	Yes
Covid FE	No	No	Yes	Yes	Yes

$$HealthExp_{it} = \alpha + \beta_1 \,\mathrm{DepOld}_{it} + \beta_2 \,\ln\!\big(\mathrm{GDPpc}_{it}\big) + \beta_3 TradeGDP_{it} + \mu_i + \lambda_{2020} + \lambda_{2021} + \varepsilon_{it}$$

Across specifications, the coefficient on the old-age dependency ratio is positive and highly significant which in our main specification is at 0.157 (SE = 0.026). That means a 1 percentage point rise in the aging ratio is associated with a 0.157 percentage point increase in health spending as a share of GDP, holding other variable constant. Its magnitude and significance are only slightly attenuated when we move from Pooled OLS → Country FE → two-way FE, which speaks to the robustness of this demographic effect.

Log GDP per capita retains a strong positive association (0.337 **, SE = 0.054) in the clustered-SE model, implying wealthier countries spend more on health. Trade-to-GDP turns slightly negative (– 0.002) and is no longer significant once we soak up fixed effects and clustering, suggesting openness matters less for health budgets once you control for demographics and income. Column 5 adds a one-year lag of the old-age dependency ratio and tells a classic partial-adjustment story. The coefficient jumps to 0.558 (SE = 0.216), while the lag is – 0.416 (SE = 0.221). In other words, health spending overshoots when the demographic shock hits (year t) and then "gives back" a portion in year t+1. This dynamic suggests policymakers front-load their budget response to aging but then adjust downward as the new dependency structure becomes permanent.

Table 4: Regression Summary on Education Expenditure

	(1)	(2)	(3)	(4)
Dependency Ratio (Young)	0.008**	0.006	0.006	0.006
	(0.004)	(0.007)	(0.007)	(0.020)
Log GDP per capita	0.302***	0.234***	0.241***	0.241
	(0.042)	(0.060)	(0.060)	(0.160)
Trade-to-GDP	-0.001*	-0.003**	-0.003**	-0.003
	(0.001)	(0.001)	(0.001)	(0.005)
R-squared	0.071	0.774	0.774	0.774
R-squared Adj.	0.069	0.760	0.760	0.760
Observations	983	983	983	983
R-squared	0.071	0.774	0.774	0.774
Country FE	No	Yes	Yes	Yes
Covid FE	No	No	Yes	Yes

Table 4 reports the summary of regressions specifications estimating the effect of the young-age dependency ratio on education spending. In the simple pooled OLS (Column 1), we observe a small but significant positive association between the young-age dependency ratio and education spending. However, once we add country fixed effects in Column 2 and then year dummies in Column 3, the point estimate shrinks and is no longer distinguishable from zero. In two-way FE model with clustered standard errors (Column 4), the coefficient remains 0.006 but with SE = 0.020 ($p > 0.1$), indicating no robust

relationship. This pattern suggests that, unlike health expenditure, education budgets may be far less responsive to year-to-year shifts in the number of young age population. Instead, education spending appears driven more by long-run fiscal frameworks, rather than short-term demographic fluctuations.

Projections In order to project future trends in public health financing, we combine our previously estimated panel-data model with long-term demographic and macroeconomic projections. Specifically, we employ the UN's population-by-age forecasts to obtain annual values of the old-age dependency ratio and complement these with log-linear forecasting of GDP per capita and trade-to-GDP projections. Our health-expenditure equation, estimated with country fixed effects μ_i is given by:

$$\widehat{\text{HealthExp}}_{it} = 3.4107 \; + \; 0.157\,\text{DepOld}_{it} \; + \; 0.342\,\ln(\text{GDPpc}_{it}) \; - \; 0.002\,\text{TradeGDP}_{it} \; + \; \mu_i$$

We use our clustered two-way fixed-effects model (Country FE + COVID dummies, clustered SEs) to project Health Expenditure (% of GDP) out to 2050. Figure 3 shows the line graph of the projections. The vertical dashed line marks the start of out-of-sample projections in 2023, while the shaded band highlights the COVID years (2020–21). Prior to the pandemic, most countries exhibit relatively stable health shares clustered between roughly 5% and 12% of GDP, with the United States notably outlier at around 15%–18%. The COVID shock produces a one-off spike in spending—captured by our 2020–21 dummies—before the budget share settles back toward its long-run trend.

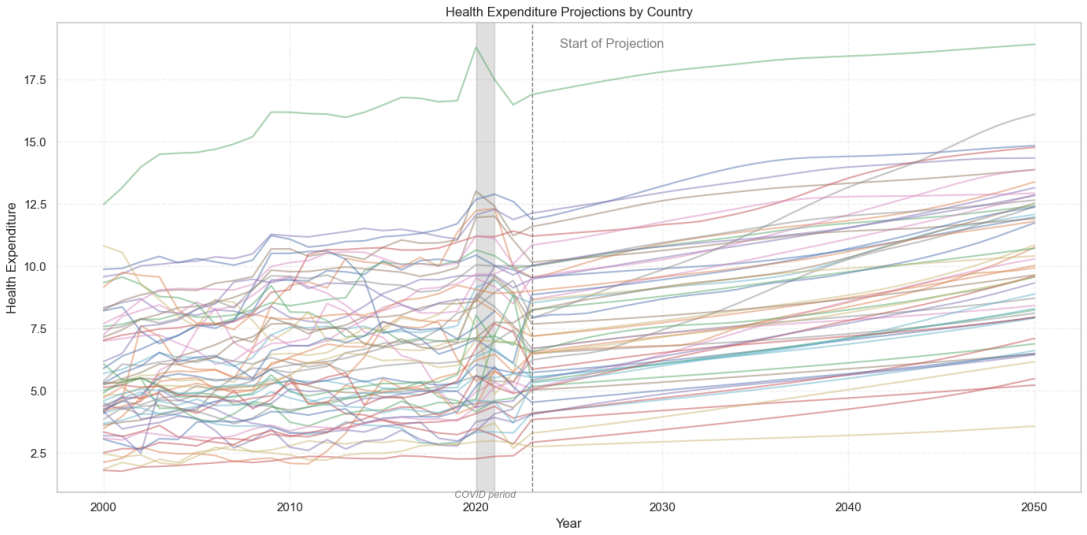

Figure 3: Health Expenditure Projections

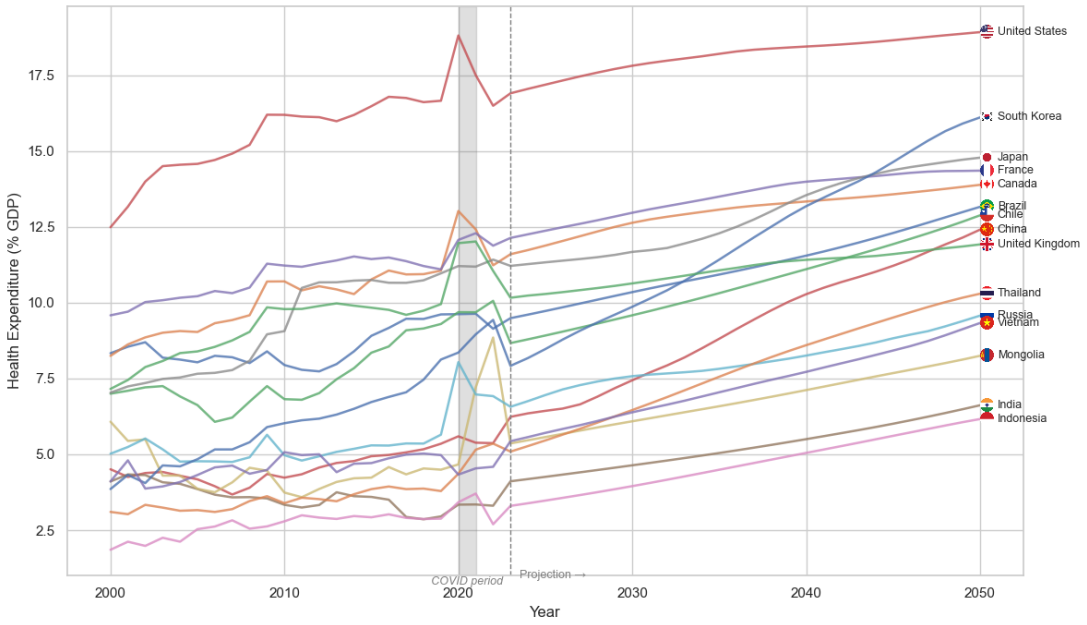

Figure 4: Health Expenditure Projections for Selected Countries

Looking at the post-2022 forecasts, the model predicts a gradual increase in health outlays across the board, driven mainly by rising old-age dependency and income effects. As shown in the figure 4, South Korea, in particular, shows one of the steepest projected upticks: having hovered near 8 % of GDP pre-2020, it climbs above 12 % by 2050. This pronounced rise reflects Korea's rapidly aging population (one of the fastest-growing old-age dependency ratios in our sample) coupled with high income elasticity of health spending.

Building index To construct our composite performance and efficiency indices, we begin by standardize four proxy outcome indicators—life expectancy, infant mortality (inverted so that higher values always denote better health), average years of schooling, and learning assessment scores. To make these sub-indices comparable across countries, each is rescaled by dividing by its overall sample mean to get the indices mean equals to zero, yielding the final health and education performance scores.

Next, we merge these sectoral performance scores into a single Health–Education Performance (HEP) index by taking their arithmetic mean. In parallel, we normalize each country's per-capita health and education expenditures by dividing by the sample mean spending, then compute sectoral efficiency ratios by dividing the respective performance score by its normalized spending. Averaging the Health Efficiency (HEE_Health) and Education Efficiency (HEE_Edu) ratios produces the overall Health–Education Efficiency (HEE) index.

Figure 5 shows the familiar clustering of high-income economies (marked in orange) on the right side of the chart, confirming that wealthier countries tend to deliver higher average Health–Education Performance (HEP). What's particularly striking, however, is that many lower- and middle-income countries (green and blue points) sit above their wealthier peers on the vertical HEE axis—that is, they achieve greater efficiency in converting public spending into outcomes. In other words, while these countries may not yet match high-income nations in raw performance, they are often more efficient when it comes to health and education expenditure.

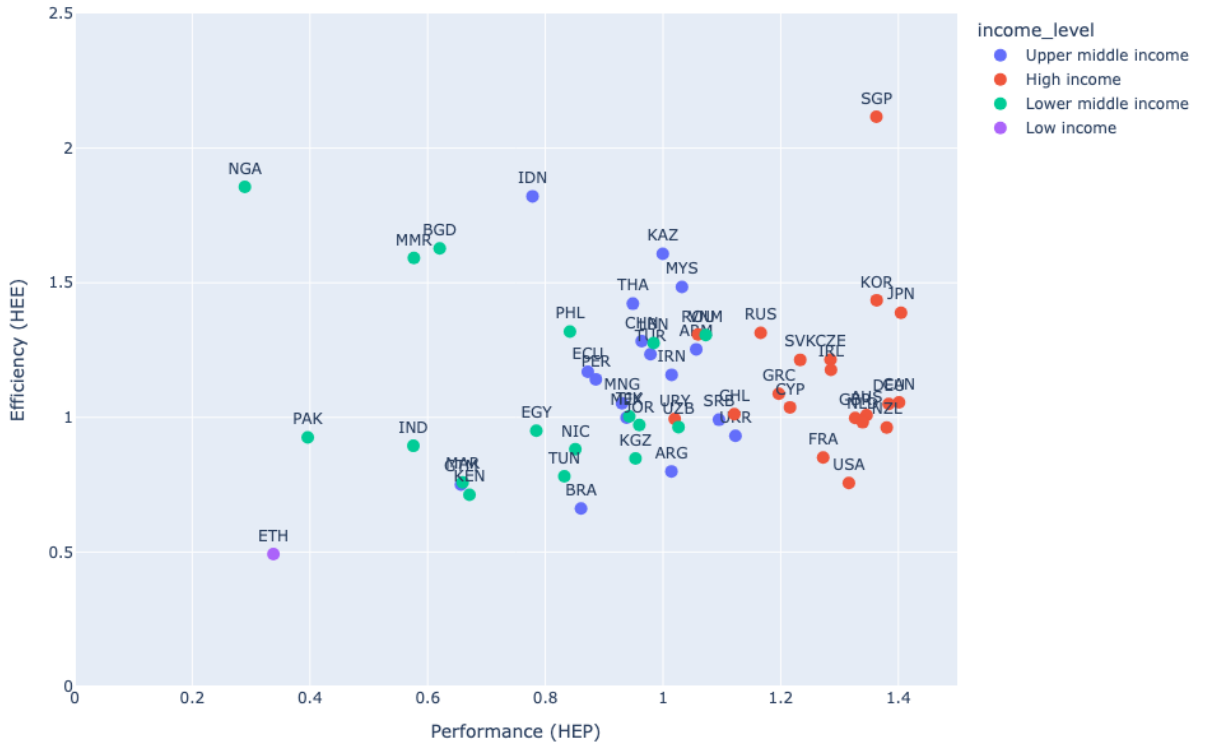

Figure 5: HEE vs HEP (average 2000 - 2025)

Turning to Figure 6, where average HEP and HEE are shown side by side, the same pattern becomes even more concrete. Indonesia and Nigeria, for instance, register relatively low performance bars but surprisingly tall efficiency bars—indicating that despite constrained resources, they are extracting strong value from each dollar spent. By contrast, several high-income countries (such as the United States and Germany) display high performance yet only moderate efficiency, suggesting room to optimize how funds are allocated and used.

Only Singapore manages to score highly on both dimensions, topping the HEP ranking while also remaining among the very most efficient spenders. This dual success highlights the payoff of both robust investment and smart resource management. More broadly, these charts underscore an important policy takeaway: lower-income countries may offer valuable lessons in cost-effective delivery, and high-income states could look to them for strategies to boost efficiency without sacrificing results.

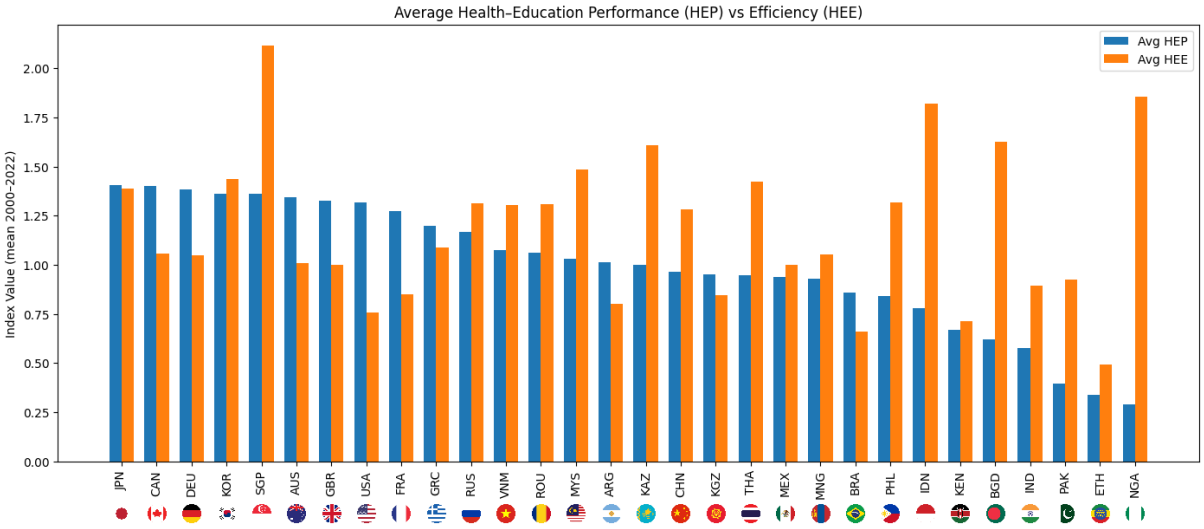

Figure 6: HEE vs HEP (average 2000 - 2025)

4 Conclusion and Policy Implications

Our two-way fixed-effects analysis demonstrates that demographic aging exerts a marked upward pressure on public health outlays—each one–percentage-point increase in the old-age dependency ratio raises health expenditure by roughly 0.157 pp—while leaving education spending statistically unchanged. Projecting this relationship forward to 2050 implies a substantial rise in aggregate health budgets across all major economies. At the same time, our Health–Education Performance (HEP) and Efficiency (HEE) indices give insights that several lower-income countries achieve high efficiency despite modest absolute outcomes, whereas many high-income peers underperform on cost-effectiveness. Policymakers should prepare for looming health-care fiscal burdens by bolstering system efficiency—adopting best practices from highly efficient middle-income peers, investing in preventive and primary care, and deploying performance-based budgeting.

References

Afonso, A., Schuknecht, L. & Tanzi, V. (2005). Public sector efficiency: an international comparison. *Public Choice*, 123(3–4), 321–347. DOI: 10.1007/s11127-005-7165-2

Temsumrit, N. (2023). Can aging population affect economic growth through the channel of government spending? *Heliyon*, 9(9), e19521. DOI: 10.1016/j.heliyon.2023.e19521